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Chili (*Capsicum* spp.) Food Chain Analysis: Setting Research Priorities in Asia

Mubarik Ali
EDITOR

AVRDC
The World Vegetable Center

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AVRDC – The World Vegetable Center is an international not-for-profit organization committed to ensuring the world's food security through research, development, and training.

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Foreword

Chili is an important commodity used as a vegetable, spice, medicinal herb, and ornamental plant by billions of people everyday. It is also used as an ingredient in industrial products. The diversity in its uses, forms and shapes brings complexity into its production and distribution systems. Such diversity makes it difficult to implement a commodity-based research and development agenda, especially at the international level, since this would require information on all aspects as the commodity is produced in the farmers' field and moves to the consumers' table. Understanding how various ecosystems and socioeconomic factors interact in its production, distribution, and consumption systems are also of utmost importance. This study provides such information by analyzing the chili industry at the various food chain levels in four selected major chili producing countries of Asia: China, India, Indonesia and Thailand. Extensive surveys and discussions of various stakeholders involved in the chili food chain were conducted in these countries. Understanding the diversity in the ecosystem where these surveys were conducted is necessary to appreciate the role of environmental and socioeconomic factors in the food chain structure itself as well as the associated research and development issues.

This technical bulletin analyzes recent trends in the chili sector including production, trade, price, and per capita availability. It estimates the farm and retail values of chili; provides information on the socioeconomic and physical environments where it is grown; elaborates its production systems, and prioritizes the production constraints. It also synthesizes information about recent technological innovations in the production of modern chili varieties and analyzes the economics of their production, identifies the attributes preferred by consumers, producers and marketing agents in selecting chili and its products, depicts the market flow, and quantifies the consumption pattern for chili and its products. The comparative data from the four selected major chili-producing countries of Asia provides an important insight into the variation in the socioeconomic environments where it is produced, marketed and consumed. The quantification of the role of chili in socioeconomic development is a useful contribution of the study. I would like to thank the leaders of GTZ-chili project and all the members of the team for providing a comprehensive review of the chili sector and I encourage researchers to conduct similar analyses for other vegetables.

Thomas A. Lumpkin
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Chili Fact Sheet in Asia

Parameter (unit)	Value
AREA, PRODUCTION, YIELD, AND FARM-LEVEL AVAILABILITY	
Area planted to chili, 2003 (million ha)	2.5
Percentage of the world chili area in Asia, 2003	67
Percentage of area	
Fresh	40.4
Pimento	59.6
Total chili production, in 2003 (million t)	22.4
Percentage of the world chili production in Asia, 2003	67.8
Percentage of chili production, consumed as	
Fresh	66.7
Pimento	33.3
Per ha yield of fresh and green chili, 2003	15.1
Per ha yield of pimento (in fresh weight), 2003	5.1
Annual average growth rate (%) of chili production, 1991-2003	6.4
Fresh	8.5
Pimento	3.5
Annual average growth rate (%) of chili area, 1991-2003	2.7
Fresh	4.7
Pimento	1.7
Annual average growth rate (%) of chili yield, 1991-2003	3.7
Fresh	3.8
Pimento	1.8
Annual average growth rate (%) of per capita availability of chili, 1991-2003	4.1
Fresh	7.1
Pimento	0.9
VALUE OF PRODUCTION	
Farm value of chili, 2003 (billion US$)	4.8
Percentage of farm value, consumed as	
Fresh	75.4
Pimento	24.6
Retail value of chili (billion US$)	9.5
IMPORT AND EXPORT IN 2003	
Total export of chili from Asia (thousand t)	1,210
Total export value of chili from Asia (million US$)	396
Total import of chili in Asia (thousand t)	773
Total import value of chili in Asia (million US$)	268
Export price of chili in Asia (US$ per t)	302

Cont…, Fact sheet

Parameter (unit)	Value
Import price of chili in Asia(US$ per t)	346
Share of fresh chili in the total value of chili trade in Asia (%)	45
Share of fresh chili in the total volume of chili trade in Asia (%)	16
Share of fresh chili in the total value of chili trade in the world (%)	83
Share of fresh chili in the total value of chili trade in the world (%)	52
CHILI IN THE PRODUCTION SYSTEM	
Average chili area per farm (ha)	0.72
Chili area as a percentage of total area under all crops on chili-growing farms (ha)	36
Total farm families engaged in chili production (million)	4.2
Total full-time employment in chili production (million workers)	3.8
Percentage of chili area intercropped (%)	20
ADVANCED MANAGEMENT PRACTICES ADOPTED ON CHILI	
Area under open pollinated improved variety (% of total area)	15
Area under hybrids (% of total area)	50
Purchased seed (% of total)	59
Seed treatment (% of farmers)	22
Soil treatment in the field (% of chili farmer)	23
Plowing with tractor (% of parcels)	51
Raised bed or furrows (% of parcels)	65
Straw and sawdust mulching (% of parcels)	11
Plastic mulching (% of parcels)	10
Sprinkle irrigation (% of parcels)	2
Use of inorganic fertilizer (% of parcels)	96
Irrigated parcels (% of parcels)	69
Advanced method of inorganic fertilizer application (% of parcels)	70
Use of pesticide (% of parcels)	100
Number of harvesting	7
PER HA FARM LEVEL YIELD OF CHILI	
Hybrid (t)	20.9
Open pollinated (t)	16.8
Traditional varieties (t)	5
INPUT USE IN CHILI PRODUCTION	
Seed rate (kg/ha)	1.8
Fertilizer (nutrient per ha)	472
Manure (t per ha)	11
Irrigation (number per ha)	18
Pesticide (number of sprays)	20

Cont…,Fact sheet

Parameter (unit)	Value
Labor (days per ha)	340
Land preparation (%)	13
Management (%)	51
Harvesting (%)	25
Post-harvesting (%)	11
DEVELOPMENT IMPACT OF CHILI	
Additional demand for seed (million US$)	150
Additional demand for fertilizer (nutrient t)	511
Additional demand for labor (million days)	2.49
Additional demand for manure (million t)	19
Additional demand for pesticide (million US$)	566
Additional income generated (billion US$)	3.31
Percentage of female labor used in chili cultivation	57.6
IMPACT OF PRIVATE/PUBLIC RESEARCH (million US$ in 2003)	
Consumer surplus	776.9
Producer surplus	248.6
Total	1,025.5

Note: Chilies (including hot chili and bell pepper) and Jamaica pepper (allspice) are included in "fresh" grouping when they are harvested for consumption as vegetables and not processed into spices; dried or powdered products are considered to be spices and classified as "pimento". All production, yield, and trade quantity data related to pimento were multiplied by four to convert dry weight into fresh output. The study believes that Jamaica pepper has very small contribution to total production and trade.

Synthesis

Chili (*Capsicum* spp.) Food Chain Analysis for Setting Research Priorities in Asia: A Synthesis

Mubarik Ali

Importance

Depending upon its use, chilies are classified as vegetables, spices, medicinal herbs, or ornamental plants in different parts of the world. They come in different forms, shapes, sizes, and colors. Based on flower and fruit characteristics, cultivated chilies *(Capsicum spp.)* are classified into five main species, *C. annuum, C. frutescens, C. chinense*, *C. pendulum,* and *C. pubescens*; the first three being the most commonly-grown in Asia. The first species is divided into the non-pungent group, such as sweet bell pepper (used as fresh), and the pungent group called hot chili (used as fresh or dry and powder). The other two species are always pungent and can be used in fresh or dry form. The size and color of chili vary depending upon its type and use.

Chili is used as spice, salad, complementary dish, medicine, industrial product, or as decoration. It is consumed in various forms such as fresh, dry, powder, paste and sauce. It enhances food palatability, inducing the consumption of other foods. It is also rich in Vitamin C.

Chili is an important component in the cropping system in Asia. In terms of area, it is ranked as first and third most important vegetable in Asia and the world, respectively (Table 1). Therefore, it has the potential to provide jobs to a large number of people in its production, marketing, processing, and distribution activities.

Table 1. Area planted to important vegetables in the world and Asia, 2003

Name of vegetables	Area (000 ha)		Relative rank	
	World	Asia	World	Asia
Total vegetables	49,948	35,786	-	-
Green peas	6,509	2,036	1	4
Tomato	4,201	2,385	2	2
Chili (fresh and pimento)	3,668	2,458	3	1
Cabbages	3,188	2,348	4	3
Onion dry	3,006	2,025	5	5
Cucumber	2,253	1,765	6	6
Eggplant	1,647	1,547	7	7

Source: FAOSTAT database.

The importance of chili in the Asian diet and production system necessitates research and development efforts for the sector. However, diversity in production and consumption across regions as well as inadequate information complicates these efforts. This study provides a comprehensive analysis of the issues at various food chain levels in four selected major chili-producing countries of Asia: China, India, Indonesia, and Thailand.

It is expected that these countries will provide enough coverage and variation such that the results can be applied to the whole of Asia. We hope that as a result of this analysis the efficiency of resource allocation in the chili sector will improve, which will in turn enhance the competitiveness of the sector and help millions of chili-growing farmers and billions of chili consumers all over the world.

Objectives

The main objectives of this study were to analyze the chili food chain at the production, distribution, and consumption levels, and to prioritize its socioeconomic, biotic and abiotic constraints. More specifically, the study focused on:

- Estimating trends in chili production, per capita availability, and trade in selected major chili-producing countries in Asia;
- Characterizing chili farmers in comparison with non-chili farmers;
- Elaborating management practices adopted in chili production;
- Identifying chili diseases, insects and weeds, and quantifying yield losses due to each;
- Estimating the economic viability and efficiency of resources used in chili production in comparison with competing crops;
- Prioritize the biotic, abiotic and socioeconomic constraints at various food chain levels;
- Elucidating the marketing system for chili;
- Quantifying the consumption pattern for chili and its products;
- Prioritizing important chili attributes in selection at the production, consumption, and distribution levels;
- Quantifying the development impacts of the chili sector; and
- Suggesting policy measures to improve the efficiency of the sector and expand its poverty-reducing impact.

Data Collection

To attain these objectives, primary and secondary data were collected in close collaboration with national partners in each target country. Secondary data provided insights on the trends in area, production, yield, per capita availability, regional distribution, seasonality in prices, and international trade in chili. Primary sources collected through production, consumption, and marketing surveys provided a comprehensive sketch of the production to the consumption chain of the whole chili sector.

Sampling Design

A planning workshop attended by all collaborating researchers of the chili project was held in May 2002 in Bangkok, Thailand. The workshop discussed sampling of respondents, including, sampling size, sampling technique and strategy, taking into consideration the resources available for the survey.

Each participating country had 250-300 farmers and their husbands/wives as respondents, identified via a purposive three-stage stratified random sampling technique. In the first stage, two to three major chili-growing regions/provinces or states were selected based on their share to the total chili area of the country, as well as their logistical convenience. The total sample was allocated to each region proportionate to their chili area. In the second stage, two to five major chili growing districts or administrative units were selected. In the final and third stage, two to three main chili growing villages from each district or administrative unit were selected with the assistance of the extension agents, and village leaders in the area, as well as resource persons knowledgeable on the sites.

Ten (10) to twenty-five (25) chili farmers were randomly selected in the chosen village depending upon their availability. To compare chili and non-chili farmers, five to ten percent non-chili farmers were also randomly selected from the same village. This sampling method enabled us to better understand the development impacts of chili cultivation. Farmers' housewives (defined as anyone responsible for family cooking, regardless of sex) were interviewed for data on consumption. About 40 to 60 urban housewives were also randomly selected from nearby towns. To understand the marketing system and the preferred chili attributes, four to five market agents involved in the collection and marketing of chili from the selected villages and one to two chili-processors in the nearby towns were randomly selected and included in the survey.

Survey Method

To generate the required information, separate interview schedules were designed for each of the five types of respondents:

- Producers
- Farm housewives
- Urban housewives
- Market agents
- Chili processors

The interview schedules contain structured and unstructured questions. AVRDC experts provided comments and suggestions before these were mailed to the researchers in the participating countries for their additional comments. Pre-testing was done before these were finalized.

One of the major objective of the survey was to identify and prioritize the insects and pests affecting chili production. To help farmers in the identification, colored photographs of major insects and diseases were printed and distributed to the members of the survey team (Appendix 1). The interview schedule for the producers also contained questions on farm-related characteristics; farm management practices; input quantities and cost; output harvested by grade, their prices, and marketing channels; farmers' perception of production and marketing constraints; and farming-related information sources. Data on cropping patterns and variety were collected at the parcels level (defined as a contingent piece of land under one crop and its variety), but input-output data were collected and analyzed for only one major parcel of each chili and competing crop. Input use and economics of chili cultivation were reported for those parcels cultivated as single crop only.

The consumption survey sought information for monthly consumption and expenditure on various food items, itemized consumption and expenditure on various chili types and its products and their sources of supply, consumer preferences for various attributes of different chili types and the packaging of various chili products, and their reaction in changing prices in terms of adjusting consumption (i.e. perceived demand elasticity).

The market and processing survey obtained information on the supply sources, business constraints, and the preferred attributes for various chili types in which they have business.

The questionnaires were translated into the language of the participating country. Interviews were conducted by field enumerators at the respondents' premises, except in China where they were assembled at the community centers; the enumerators distributed and explained the questionnaires to the respondents, and later collected from them once these were filled out. A "Survey Orientation Workshop" was organized for two to three days in each country to train the field teams with the sampling procedures, tools and techniques to be adopted during the survey. This also helped in building team spirit and enhancing mutual understanding among team members.

The distribution of the sample by type of respondent per country is presented in Table 2. A total of 1,095 chili-producing farmers, 1,018 chili farmers' housewives, 150 non-chili farmers, 168 non-chili farmers' housewives, 212 city household wives, 77 market agents and 19 chili processors were interviewed.

Table 2. Distribution of sample by respondent type and country

Country	Province/ State/ Region	Sample type and size							
		Chili farmer	CFHHW*	Non-chili farmer	NCFHHW**	CHHW+	Market agent	Processor	Total
China	Hunan, Sichuan and Guangdong	293	300	29	29	60	45	6	762
Indonesia	West, Central and East Java	256	243	50	46	62	16	6	679
India	Karnataka and Andhra Pradesh	291	256	41	45	50	5	4	692
Thailand	North, North-east & Central Thailand	255	219	30	48	40	11	3	606
Total		1,095	1,018	150	168	212	77	19	2,739

* CFHHW = Chili farmer household wife; ** NCFHHW = Non-chili farmer household wife;
+ CHHW = City household wife.

Reporting Procedure

Commercial Production

This study covers only commercial production of chili. Commercial production is defined as a large-scale (>500m^2) activity and produced mainly (>75%) for sale. Hence, chili production in the home garden and on the agricultural field sides were not included in the survey. The project does not have the exact estimate of home garden production, however, it is safely assumed that this will not exceed more than five percent of chili production in any of the surveyed country.

Chili Types

Based on its appearance, chili was first divided into hot-chili and sweet (bell) pepper, irrespective of the consumption style of the former as fresh or dried.[1] After consulting with breeders in each country, the hot-chili varieties grown by the sample farmers were grouped into hybrids, open pollinated (improved varieties by the public or private sector), and local (unimproved local races). Averages were computed for all variables (such as input use, costs, returns, and others.) and management practices for all four types.[2] In countries where sweet pepper-growing farmers were included in the sample, the input use and economics of chili production for these varieties were also aggregated into a category called "hot-chili", and reported separately from sweet pepper. In this report, unless otherwise indicated, the term "chili" is used to represent all of its forms and types.

Chili Grades

The grades of chili output and their respective prices were estimated. Although these grades were mainly based on farmers' perception, farmers were briefed on these grades according to the set standards in each country. No further analysis based on grades was pursued.

Soil Types

Farm soils were classified into three groups based on farmers' perceptions rather than laboratory tests. These classifications are light, medium, and heavy soils. Most farmers understood these soil categories in their broader terms. In cases of confusion, the following definition of soil categories were explained:

"Immediately after heavy rain or irrigation when water has just drained out from the field, take some soil and make a ball in your hand. If the ball disintegrates upon opening of the fist, it is light soil. If it stays balled up but disintegrates with a slight touch, the soil is medium. If it does not disintegrate with slight touch, it is heavy soil".

[1] The FAOSTAT-Agricultural data grouped chili based on the final consumption under pimento (FAOSTAT code 689) and green and fresh chilies (FAOSTAT code 0401). Pimento refers to dried hot-chili, while fresh and sweet chili include hot chili consumed as fresh as well as sweet pepper. In our classification sweet (bell) pepper is kept as a separate group from hot-chili.

[2] The word "chili type" and "chili variety" are used interchangeably in this report.

The distribution of soil types was compared between chili and non-chili farms. The purpose was to test if such distribution is a factor in the adoption of chili cultivation on the two farms.

Drainage Status of the Field

The land type of a farm field was defined into three categories according to its drainage status. These included good, medium, and poor drainage. Well-drained lands are those in which water drains out from the field immediately after a heavy rain; medium-drained are those where water drains out within 24 hours; and poor-drained are those in which water takes more than 24 hours to drain from the field after rain stops. The purpose of comparing the drainage status between chili and non-chili farms was similar to that of comparing the soil types.

Quantification of Input Use

All the inputs and number of operations done on chili and its competing crops were recorded for one cropping season. In cases where chili was intercropped, inputs were equally divided for all the crops planted.

Fertilizer and Manure

Fertilizer quantities applied to chili types and their competing crops were converted into active ingredients of nitrogen, phosphorus, and potassium using the standard nutrient conversion rates specific for each fertilizer type available in each country. Total soil nutrients applied were reported on a per ha basis. Organic fertilizer (manure) was not converted into nutrients, and was reported in raw quantities. Application of zinc was included under inorganic fertilizer.

Pesticide

Pesticide use was reported as number of sprays and raw quantities applied on a per ha basis, and was not converted into active ingredients.

Labor Use by Type

Labor employed in crop production was divided into four major activities. These are:

- Land preparation includes plowing, furrowing, and harrowing;
- Crop management includes sowing; input application such as fertilizer (including manure), pesticide, and irrigation; and operations before crop maturity such as weeding, staking, and mulching;
- Harvesting includes harvesting and seed extraction; and
- Post-harvest, includes cutting, packing, grading, transporting, and selling (for activities performed on the farm only).

Animals working with human labor were not counted as labor time.

Food and Chili Consumption

Consumption by Major Food Groups

Monthly food consumption patterns of all households were quantified to see how chili-growing farmers differ from non-chili growing farmers and urban consumers. Food was divided into six main groups: cereals, livestock products, vegetables, fruits, sea and water food, and others. The classification was made by the housewives. Hence, the classification may vary from country to country, but would be expected to be similar within a given survey area. The monthly food consumption of the household was reported on a per capita basis by dividing total household consumption by the number of family members.

Per Capita Consumption and Expenditure on Chili

The consumption of chili and its products was studied in more detail. The monthly consumption of and expenditures for different types of chili and its products were reported on a per capita basis by dividing these by the number of family members staying in the house.

Demand Elasticities

The demand elasticity for chili was estimated through the farmers' perception about their willingness to change the quantity of chili consumed with different changes (both increase and decrease) in price level, expressed in percentage. Simple averages of these perceptions were made across the whole sample to estimate the average elasticity over the price range offered to the consumers.

Data Processing and Descriptive Analysis

The macro and survey data were entered on spreadsheets by the national collaborator. They were cleaned, processed, and analyzed under the supervision of the senior socio-economist at AVRDC.

Input quantities, costs, and returns were converted into per ha basis. Simple averages were then computed for each chili type and for the aggregate, as well as for the chili-competing crops. Frequencies of parcels receiving important inputs and operations (in percentage) were also estimated.

Trends and Growth Rates

Linear trends in chili area, production, and yield for the world, Asia, and the four selected countries of Asia were presented in graphical form. Trends in per capita availability at the farm level (estimated as total production divided by population), imports and exports were also estimated. Their growth rates were estimated by using the log-linear trends.

Cropping Intensity

Cropping intensity indicates the extent by which cultivated area was used for cropping, and was estimated in percentage as follows:

CI = {TCA/CA} x100

where

CI = Cropping intensity in percentage

CA = Total cultivated area

TCA = Area of all crops in one year

Scoring Orders for Pests and Production Constraints

In the questionnaire, chili farm-respondents were asked to identify the important pests. Respondents were also requested to rank separately the five most important diseases, insects, and weeds according to the average yearly magnitude of losses incurred by each. The ranking order of a pest was recorded at the scale of 1-5: 1 being the most important and 5 the least important. The number of farmers who gave the rank of '1', '2', '3', '4', and '5' for each pest were counted. The weighted average of these frequencies were estimated by assigning the weights of '5', '4', '3', '2', and '1' for each rank, respectively. The highest number obtained was considered as the most important pest.

This can be expressed in notation form for the *j*th pest as follows:

$$W_j = \sum_{i=1}^{5} X_{i.j} D_i \qquad (1)$$

where

W_j = Weighted score of the jth pest

i = The ranking order (1 the most important rank and 5 the least important)

X_i = Frequency of farmers who gave the ith rank to the jth pest

D_i = Weight of the ith rank, which is 5 for i=1, 4 for i=2, and so on.

The higher the weighted score of a pest, the greater is its importance. The same methodology was used in ranking the different production constraints in chili cultivation.

Individual Input Costs

The individual cost items include labor, seed, fertilizer, manure, irrigation, pesticide, structures, and others (including land rent, taxes, and interest). Individual inputs are either purchased or family-owned. The family-owned inputs are valued at the market opportunity cost in the same village, district, province, or the whole sample level depending upon the availability of these market prices. The individual input cost not only includes market price, but also its market and transportation cost. Application cost was included in the labor cost. The cost of irrigation water was evaluated at its market rate if it is from the family-owned pump and charges or taxes paid to government for water if it is from public canal or pump. Land rent was estimated based on the length of time the crop was planted and also that of another crop for the remaining period of the year, if any. Interest on cash cost was included based on the prevailing interest rate in the survey area and the crop duration.

Total and Cash Cost

Total production cost for each crop was estimated by adding the individual cost items. Cash cost includes the cost of fertilizers and chemicals, hired labor, purchased seeds and materials, and irrigation. In the country reports, the cost was reported in their local currency. For comparison purpose, these were converted into US dollars in the Synthesis chapter. The share of each cost item (factor share) in the total cost was estimated in percent. The factor shares for labor, seed, fertilizer, manure, irrigation, pesticide, and others (including staking, mulching, land, and interest rate) were computed. In estimating these shares, the cost of labor used to apply an input was excluded and was aggregated into the labor cost.

Gross and Net Revenues

Gross revenue was estimated as outputs (main and by-products) produced from a piece of land in a season multiplied by their respective market prices. Parallel to opportunity cost of family-owned inputs, family-consumed outputs were evaluated at their respective average market prices in a district, province, or whole sample. Net revenue is estimated as gross revenue less total costs.

Economic Efficiency in Production

Various measures of economic efficiency used in this study were:

- *Input use efficiency or partial input productivity (PIP)*. This is estimated as:

$$PIP = (GR - VC) / Q \qquad (2)$$

where GR = per ha gross revenue

VC = per ha variable input cost

Q = per ha input quantity.

In estimating the partial productivity of variable inputs, say labor or fertilizer, the cost of all other inputs is assumed fixed; only the cost of that input is considered variable.

- *Benefit-cost ratio*. This was estimated as net return (as defined above) divided by all costs multiplied by one hundred. The costs of all inputs including family-owned resources were treated as variable in this case.
- *Cost per unit of output*. This was estimated as per ha cost divided by per ha yield in kilograms. It is used to compare the relative efficiency of different chili types within and across countries.

Risk in Production

Risk in chili production was quantified by estimating the coefficient of variation (CV) of the per ha yield. For comparison purposes, the CVs were estimated separately for each chili types. The CVs of major competing crops in the sample area were also compared.

Statistical Tests

Frequencies across crop and farmer groups were compared using the Chi-Square (χ^2) Test. Farm characteristics of chili and non-chili farms having continuous parameter values were compared using unpaired *t*-test. Per ha yield, input use, costs, and partial productivity of vegetables were compared across chili varieties and average of chili with competing crops using the same *t*-test. These parameters for major competing crops were also compared across farm types, i.e., chili and non-chili farms.

Estimation of Consumer and Producer Surplus

The Marshallian concepts of consumer and producer surplus can be applied to quantify the welfare generated through research and development, in this case chili varieties in a year, 2003. As a result of high-yielding technology developed by research, the aggregate supply curve in Figure 1 shifts from S_0 to S_1. Assuming linear supply and demand functions and a closed economy regime[3], a parallel shift in the supply curve will produce a change in the consumers' surplus by the area P_0abP_1. The same supply shift will cause a change in the producers' surplus by the area P_1bI_1 minus P_0aI_0. The total economic surplus (producers' plus consumers' surpluses) will be the shaded area of aI_0I_1b. These effects due to technological development can be expressed algebraically as follows (Alston et al. 1995):

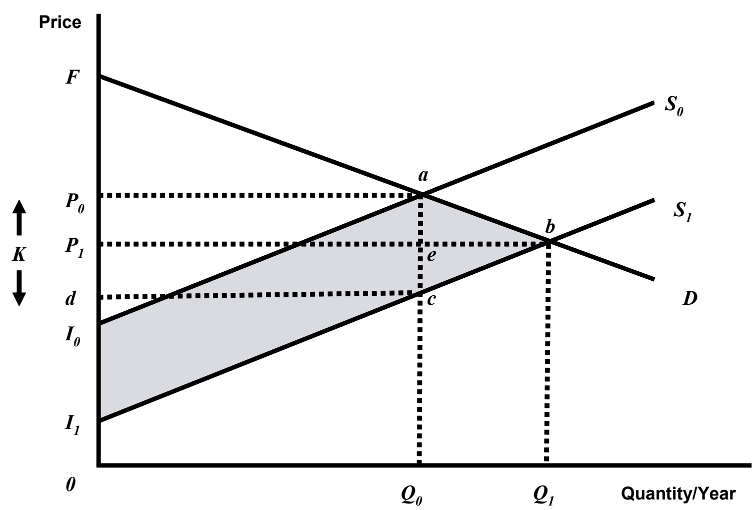
[3] Only a small proportion of chili production (3-4%) is traded in the world market. Moreover, estimates of the supply and demand elasticities for the global market, required in the estimation, are not available.

$$\text{Consumers' surplus} = \Delta CS = P_0 Q_0 Z\,(1+0.5Z\eta) \quad (3.1)$$

$$\text{Producers' surplus} = \Delta PS = P_0 Q_0 (k-Z)(1+0.5Z\eta) \quad (3.2)$$

$$\text{Total surplus} = \Delta TS = \Delta CS + \Delta PS = P_0 Q_0 k(1+0.5Z\eta) \quad (3.3)$$

where P_0 and Q_0 are original price and quantity (without technological innovation), respectively, $Z = k\varepsilon/(\varepsilon+\eta)$ is the decrease in price after the supply shift, η and ε are the absolute values of demand and supply elasticities, respectively, and k is the downward vertical shift in the supply curve expressed as a proportion of the initial price. The k is estimated as the product of *pcA*, where p is the probability of success, c is the net percentage decrease in the cost of producing one unit of output (cost saving per output equal to c percent of initial price), and A is the adoption rate.



Source: Alston, J.M., G.W. Norton and P.G. Pardey. 1995. Science under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting. Ithaca, NY: Cornell University Press.

Figure 1. A supply and demand model to measure the impact of modern technologies

In the above specifications of 3.1-3.3, the data for chili production and its prices before technical innovations are needed, i.e., production and prices had there been no innovations. However, these data were gathered when modern varieties had already been introduced. The production and prices without innovations were estimated by specifying the linear supply and demand function for after innovation period as follows:

$$\text{Supply function:} \quad Q_{s1} = \alpha_0 + \beta_1 PP_1 \quad (3.4)$$

$$\text{Demand function:} \quad Q_{c1} = \gamma_0 + \delta_1 PC_1 \quad (3.5)$$

All parameters in these equations are for after the innovation period. The estimated slope and intercept parameters of these equations are as follows:

$$\text{Slope of supply function } (\beta_1) = \varepsilon * Q_1/PP_1 \quad (3.6)$$

$$\text{Intercept of supply function } (a_1) = (1 - \varepsilon) * Q_1 \quad (3.7)$$

$$\text{Slope of demand function } (\delta_1) = \eta * Q_1/PC_1 \quad (3.8)$$

$$\text{Intercept of demand function } (\gamma_1) = (1 - \eta) * Q_1 \quad (3.9)$$

where Q_{s1} and Q_{c1} are quantity produced and consumed with innovations (they will be equal in the equilibrium situation, so connoted by Q_1 in the later equations), respectively, η and ε are demand and supply elasticities as defined before, PP_1 is producers' price and PC_1 is consumers' price both after the innovations (the values of all these parameters except the slope and intercept of supply and demand curves were either known or assumed), so equation 3.6-3.9 can be solved for β_1, a_1, δ_1, and γ_1. After estimating the slope and intercept of the supply and demand functions (with innovations), a_1 was multiplied with (1-k) to generate a parallel supply function before the innovations, while demand curve and slope of the supply curve were assumed to be the same before and after the innovation. The supply and demand functions before the innovations were then solved for the price and quantity without innovations.

Macro Data Analysis and Trends

The analysis in the following section is based on FAOSTAT-Agricultural Data (Agricultural Production-Crops Primary, and Agriculture & Food Trade-Crops and Livestock Primary & Processed).

Extent and Spread of Production

Chili is cultivated on 3.7 million ha worldwide, producing about 33 million t in fresh weight output. About two-thirds of this area and production come from Asia. The annual farm value of chili production in Asia is estimated at US$4.8 billion. With the estimated ratio of farm to retail prices at two, the retail value of chili and its products in Asia stands at around US$ 9.6 billion.

About 45% of the world chili area grows the product that is freshly-consumed without any processing or drying. When production of dry or ground chili is converted into fresh weight, the freshly consumed chili claims about 70% share in production. The area and production shares of this form of chili are almost equally divided in Asia (Table 3).

Table 3. Area, production, yield and value of fresh and pimento chili by major producing countries of Asia in 2003

Chili type	Country/region	Area[1] (ha)	Fresh production[1] (t)	Yield[1] (t/ha)	Value (000 US$)[2]
Fresh					
	China	602,593	11,528,723	19.13	944,455
	Turkey	88,000	1,790,000	20.34	567,721
	Indonesia	176,264	552,679	3.14	593,568
	Korea (South)	63,150	350,174	5.55	148,514
	Japan	3,760	151,300	40.24	336,045
	Israel	2,300	117,700	51.17	81,168
	Iran	4,000	105,000	26.25	17,078
	Korea (North)	25,000	59,000	2.36	5,110
	Kazakhstan	3,000	54,000	18.00	7,887
	India	5,500	50,500	9.18	19,620
	Others	18,741	191,202	10.20	66,285
	Total for Asia	992,308	14,950,278	15.07	3,638,504
	Total for World	1,640,830	23,150,381	14.11	-
Pimento					
	India	940,000	4,400,000	4.68	775,408
	China	36,000	920,000	25.56	140,188
	Bangladesh	169,970	548,000	3.22	101,359
	Pakistan	48,800	385,600	7.90	57,085
	Viet Nam	50,000	308,000	6.16	36,297
	Myanmar	108,000	280,000	2.59	13,098
	Thailand	24,000	152,000	6.33	17,913
	Turkey	9,000	80,000	8.89	21,217
	Nepal	17,500	56,000	3.20	3,958
	Others	62,108	342,824	5.52	13,226
	Total for Asia	1,465,378	7,472,424	5.10	1,184,061
	Total of World	2,027,059	9,926,612	4.90	-
Pimento + fresh					
	Total for Asia	2,457,686	22,422,702	9.12	4,822,565
	Total for World	3,667,889	33,076,993	9.02	-

[1]Source: FAOSTAT data.

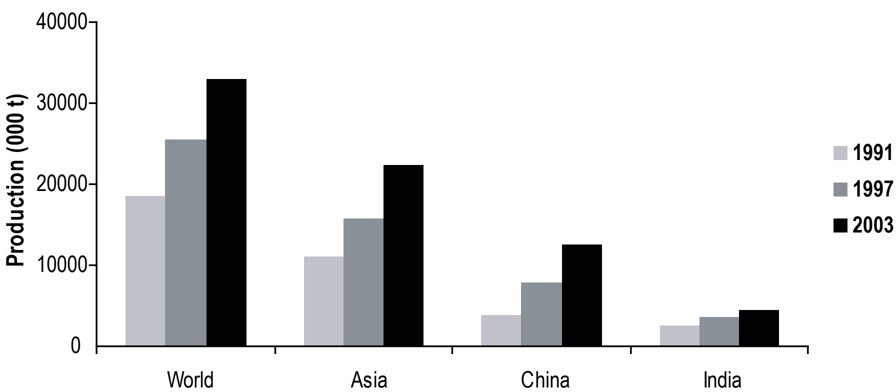
[2]Estimated using producers' prices in 2002 as reported in FAOSTAT data (producer prices-crop primary). Local price units were converted into US$ by using the annual average exchange rate reported on www.fftc.agnet.org (various issues). Missing prices for some countries were approximated from the neighboring country or succeeding year.

Chili is grown in most Asian countries. The continent contributes about 60% to the total world area and 65% of world production of fresh chili. The major producers are China, Turkey, and Indonesia, contributing an aggregate of around 87% of total area, 93% of production, and 58% of value. Asia also contributes about three-fourths of world area and production of pimento chili that is consumed either as dry or ground. India is the major producer, contributing about 64% of area and 59% of production. China is the next major producer, followed by Bangladesh and Myanmar (Table 3).

The per ha yield of freshly-consumed chili is higher than pimento with bell type sweet pepper constituting the major share compared to the freshly-consumed hot chili. Wide variation in yields of pimento and fresh chili can be observed across countries. Japan had the highest yield for fresh chili at 40 t/ha (mainly sweet bell pepper), while North Korea had the lowest yield at 2 t/ha. For pimento, the highest yield is attained in China at 25 t/ha, and lowest in Myanmar, Bangladesh and Nepal at 2-3 t/ha.

Trend in Production

The total world fresh weight production of chili in 2003 was 33.1 million t, up from 18.5 million t in 1991. Of this, 22.4 million t was produced in Asia, a rise from 11.0 million t in 1991 (Figure 2). These trends gave an average growth rate of 5.2% in the world and 6.4% in Asia. Due to these, the share of Asia in chili production increased from 59% to 68% in the same period.



Source: FAOSTAT-Agricultural Data (Agricultural Production-Crop Primary)

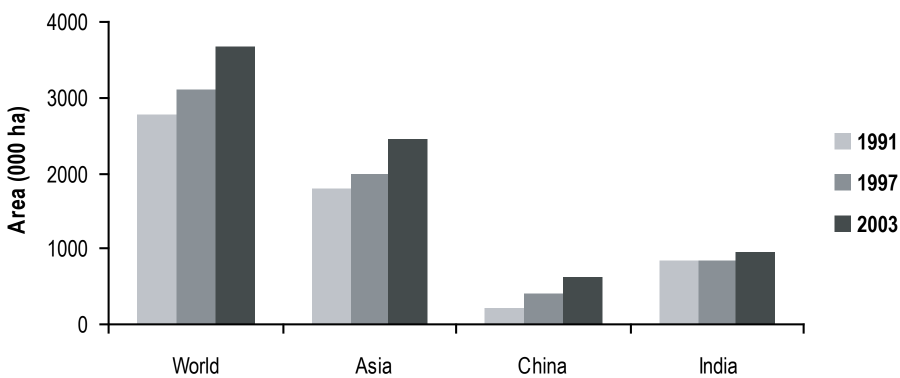
Figure 2. Chili production in Asia and the world in 1991, 1997, and 2003

The increase came mainly from China where production more than tripled at the rate of 9.7% per annum from 3.9 million t in 1991 to 12.4 million t in 2003. India, another major chili producing country, also increased its production from 2.5 million t in 1991 to 4.5 million t in 2003 at an annual rate of 3.7%.

In Asia, about 33% of total chili production in 2003 was for pimento. This share, however, was decreasing due to fast increasing trend of fresh-chili production. In 1991-2003, the growth rate in fresh chili production was 8.5%, compared to 3.5% in pimento chili. At the world level, growth rates were 6.7% and 2.6% for fresh and pimento, respectively. The share of pimento was highest in India at 99% in 2003, where growth rates were 1.7% and 3.8%, respectively.

Trend in Area

In 2003, 3.7 million ha were used for chili cultivation worldwide, an increase from 2.8 million ha in 1991 (Figure 3). Most of this area (2.5 million ha), was in Asia. Sixty and fifty-five percent of the total area were occupied by pimento type in Asia and in the world, respectively. Chili area increased at the annual rate of 2.7% in Asia and 2.4% in the world. Half of the increase of total production worldwide was due to expansion in area and the other half due to yield improvement, while in Asia the contributions of area and yield were at 42% and 58%, respectively. The fresh chili and pimento area increased at annual rate of 4.7% and 1.7%, respectively in Asia.



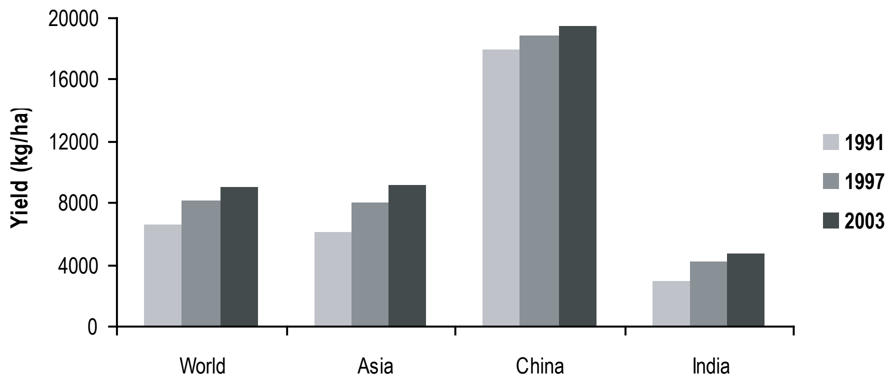
Source: FAOSTAT-Agricultural Data (Agricultural Production-Crop Primary)

Figure 3. Area under chili in Asia and the world in 1991, 1997, and 2003

Due to similar trends in chili area in Asia and the world, the relative share of Asia in total chili area remained about the same at 65-67% in 1991-2003. The major source for the increase in area was China, where expansion was at the rate of 9.5% per annum during the said period. The share of China in total chili area in Asia increased from 12% in 1991 to 26% in 2003. On the other hand, the chili area in India increased only at the rate of 0.5% per annum, hence its share in area decreased from 47% in 1991 to 39% in 2003.

Trend in Yield

The per ha yield of chili in the world and Asia stood at about 9.0 t in 2003 (Figure 4). For 1991-2003, yield increased at the annual rates of 2.8% and 3.7% in the world and Asia, respectively. In India and China, yields also improved at an annual rate of 3.2% and 0.2%, respectively. Despite the high growth rate, the yield in India remained far below the yield achieved in China. The fresh chili and pimento yield in Asia increased at 3.8% and 1.8% per annum, respectively



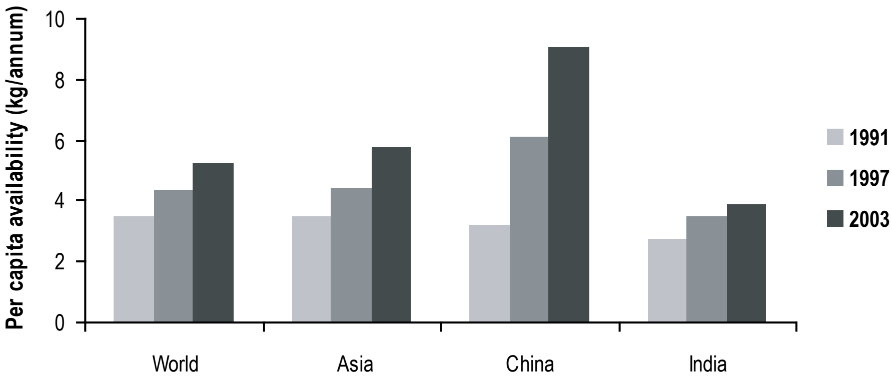
Source: FAOSTAT-Agricultural Data (Agricultural Production-Crops Primary)

Figure 4. Chili yield in Asia and the world in 1991, 1997, and 2003

Per Capita Availability

The annual per capita availability of chili increased both in Asia and the world at an annual rate of 4.1% and 3.1%, respectively, in 1991-2003 (Figure 5). Due to the high growth rate, the chili availability in Asia had surpassed the availability in the world. In 2003, per capita availability stood at 5.75 kg and 4.74 kg in Asia and the world, respectively. Most of the improvement was in fresh chili, which increased from 1.70 kg in 1991 to 3.87 kg in 2003 (or an average annual growth rate of 7.1%), while per capita availability of pimento increased from 1.69 kg to 1.88 kg only (or average annual growth rate of 0.89%) in the same period. Similar trends in fresh and pimento chili were observed worldwide.

The increase in the farm-level availability of chili came mainly from China, where it almost tripled from 1990-2003, with an annual growth rate of 8.6%, while in India it increased at 1.5% per annum. Per capita availability for the rest of the world also increased but at a slow rate of 1.8% per annum.



Source: Estimated from the production data reported in FAOSTAT-Agricultural Data (Agricultural Production-Crop Primary), and population reported in FAOSTAT-Agricultural Data (Population)

Figure 5. Per capita availability of chili in Asia and the world in 1991, 1997, and 2003

Trade

Wide variations in producers' prices (estimated from Table 3 by dividing value with production) for each type of chili can be observed,[4] suggesting international disconnectivity of chili markets on one hand, and big profits in trade on the other hand. Trade can help to even out these prices across countries by lowering prices in some countries like Japan, Indonesia, and Israel and increasing prices in others like Myanmar, Nepal, and Vietnam.

Chili is traded in two forms: fresh green (including hot-chili and sweet pepper) and dry-red or ground (pimento). Asia is net exporter of both types. In terms of value, the shares of pimento and fresh green chili in the total value traded are almost the same; in terms of volume, however, pimento (converted into fresh) takes about 83% share in the quantity traded from Asia in 2003. Japan, United Arab Emirates, and Singapore are the major importers of fresh green chili, while Malaysia, Sri Lanka, and Thailand are the major importers of pimento. On the other hand, China, Israel, and Turkey are the major exporters of fresh green chili, while China and India are the major players in the export of pimento.

In 2003, a total of about 6.3 million t of fresh weight equivalent chili worth US$5.7 billion was traded internationally (Table 4). In terms of fresh quantity the share of Asia in chili trade was 31%, while it earns only 12% share in traded value implying that lower value chili is traded from Asia.

[4] Some of the variation, of course, is due to difference in quality and water content in fresh output. The variations in producers price are smaller in case of pimento because of its long storability and transportability, and uniformity in output quality.

Table 4. Trend in international trade in chili, 1991-2003

Year	Asia								World trade[1]			
	Quantity(000t)		Value (mil. US$)		Total trade[1]		Price (US$/t fresh weight)[2]		Quantity	Value	Price (US$/t fresh weight)[2]	
	Import	Export	Import	Export	Quantity (000t)	Value (mil. US$)	Fresh	Pimento	(000t)	(million US$)	Fresh	Pimento
1991	416	471	119	152	887	271	577	283	2,797	2,376	1,304	395
1992	517	549	165	178	1,065	343	540	301	3,135	2,660	1,302	405
1993	422	639	116	158	1,061	274	583	228	3,179	2,442	1,185	336
1994	399	585	110	142	984	253	660	218	3,304	2,778	1,295	326
1995	400	622	174	215	1,022	388	720	344	3,549	3,208	1,297	428
1996	444	538	218	239	982	457	892	410	3,804	3,386	1,175	492
1997	400	591	169	214	991	383	950	303	3,924	3,549	1,263	429
1998	427	611	180	200	1,038	380	994	265	4,346	3,835	1,274	377
1999	590	640	215	213	1,230	428	1,044	261	4,628	3,703	1,147	355
2000	570	694	217	227	1,263	444	1,126	232	4,688	4,002	1,266	339
2001	650	868	223	267	1,518	490	1,053	210	5,278	4,287	1,256	315
2002	781	1,040	245	288	1,821	533	856	198	6,035	4,388	1,122	297
2003	773	1,310	267	396	2,083	664	957	219	6,323	5,710	1,438	322
Growth rate (%)	**5.1***	**5.9***	**6.4***	**6.3***	**5.6***	**6.4***	**5.6***	**-2.6***	**6.5***	**6.3***	**-0.1^{ns}**	**-1.9***

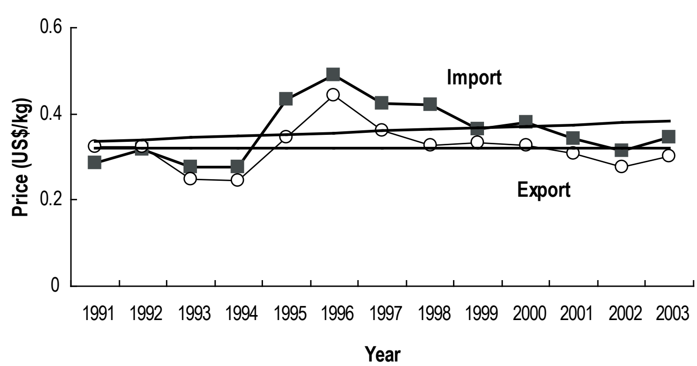
Source: FAOSTAT data.

[1] The total trade was estimated as import plus export, both in quantity and value. The import and export quantities of pimento were multiplied by four to convert it into fresh weight equivalent.

[2] The average price was estimated as value of total trade divided by fresh-weight equivalent quantity of the trade separately for pimento and fresh chili.

Note: The * on the growth rate figures imply that the growth is statistically significant, and ^{ns} implies that the parameter is not significant at 10% level.

The trade in chili is on a steep rise. The quantity and value of chili traded internationally grew at the annual rates of 6.5% and 6.3%, respectively, from 1991 to 2003 (Table 4). The growth rate in quantity of trade is lower in Asia than the rest of the world.



Source: Estimated from import and export quantity and value data in Table 4.

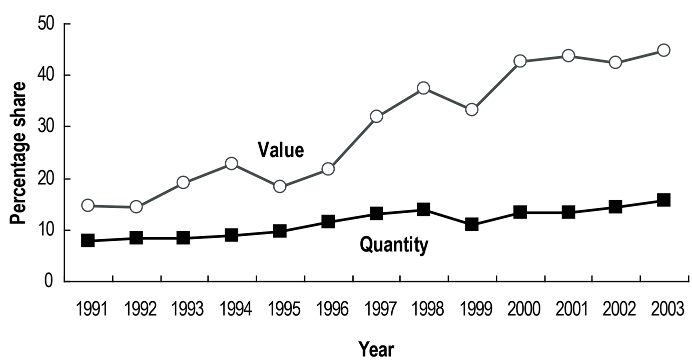
Figure 6. Trend in import and export prices of chili in Asia, 1991-2003

In Asia, the growth in quantity of chili imports was lower than exports, but the growth was similar in terms of value (Table 4). This suggests that export price was falling relative to import price, as reflected by the widening gap in import and export prices since mid 1990's (Figure 6). This implies that the continent was gaining in comparative advantage in international chili trade.

Despite the spectacular increase in international chili trade in the 1990s, the share of trade in total chili production was small both in Asia and the world at 8.8% and 19.1%, respectively. This suggests that most of the increase in chili production in Asia was consumed domestically. This suggests that most of the increase in chili production in Asia was consumed domestically.

Although no significant trend was observed in international chili prices in 1991-2003, both import and export prices were on the declining trend since they reached their peak in 1996 (Figure 6). These trends may reflect improvements in chili production and marketing technologies, as well as free trade regime. If such trends continue, the share of the continent in world trade is expected to rise in the near future as international trade becomes more liberalized.

What types of chili will be traded more than others in the future? The past trends in Asia suggest increasing shares of fresh chili in international trade and declining share of pimento (Figure 7). The share of fresh chili in total quantity traded in Asia increased from 7.8% in 1991 to 15.7% in 2003, while its share in total value traded jumped from 14.7% to 44.8% in the same period. The higher increase in value than in quantity of fresh chili traded suggests an improvement in its prices both in absolute and relative terms compared to pimento chili prices. The prices of fresh chili traded from Asia (weighted average of import and export prices) steadily increased from US$ 0.58/kg in 1990 to around US$ 0.96/kg in 2003, while the price of pimento (in fresh weight) was fluctuating between US$ 0.20/kg to US$ 0.41/kg during this period without exhibiting any significant trend (Table 4). This also implies that fresh chili is increasingly becoming a high-value product in international market.[5]



Source: Estimated from import and export quantity and value for pimento and fresh chili trade data of FAO.

Figure 7. Share (%) of fresh chili in total chili traded in Asia, 1991-2003.

[5] These statistics, however, do not point the relative importance of fresh sweet bell pepper and hot-chili sold as fresh.

Farm Perspective (Summary of Survey Results)

Chili Farm Characterization

Chili farmers had average resources. They had similar farms families and household sizes with the non-chili farmers. Both had more or less the same level of schooling. The proportion of chili farmers who owned water pump for irrigation, as well as farms with light soils generally recommended for chili cultivation was not significantly higher than the non-chili farmers. Chili farmers were also not cultivating better-drained soils (Table 5).

Table 5. Chili farm characteristics in comparison with non-chili farms in selected chili-producing countries of Asia, 2002

Characteristics	China	India	Indonesia	Thailand
Larger farm size	No	Yes	No	No
Larger family size	No	No	Yes	No
Bigger house size	No	No	No	No
Better education of household head	No	No	No	Yes
Higher percentage of farmers owning water pumps	No	No	No	Yes
Higher percentage of light soils	No	No	No	No
Higher percentage of land with good drainage	No	No	No	No
More number of livestock owned	Yes	Yes	No	Yes
Higher off-farm income	Yes	-	No	Yes
Higher loan obtained	-	Yes	No	Yes

Then what makes them different from the non-chili growing farmers? Why do they choose chili cultivation, while others confine themselves to planting subsistence crops like rice or wheat? Two differences were observed in this study. First, chili farmers had higher off-farm income than non-chili farmers, except in Indonesia where non-chili farmers planted other vegetables. This not only suggests that they had better links with the market, but also indicated their ability to take on higher risks. The off-farm cash income allowed them to purchase cash inputs, and improved their ability to bear higher cost for improved management practices, as well as materials such as staking, mulching, etc. The higher off-farm income also improved their link with the markets, enabling them to better understand the input-output price regimes and thus enhanced their market efficiency. Second, chili farmers had better linkage with the government institutes as indicated by their ability to borrow higher amount of loans compared to non-chili farmers (again with the exception of Indonesia). This again indicated their ability to better understand the local institutions. These characteristics provided chili farmers enough resources and ability to take necessary risks and finances for chili cultivation. As chili farmers are opportunity seekers, they owned more livestock that enabled them to earn even higher income.

Chili in Farming System

The average chili area in each farm ranged from 0.2 ha in China to 1.0 ha in India. Based on total area under chili in each country, the estimated total number of chili farmers in Asia was 4.2 million, 40% of which come from China. On average, chili occupied 36% of the total crop area in chili farms, with the highest share in India and the lowest in Thailand (Table 6).

Chili is not always grown singly; it can also be intercropped. On average, about one-fifth of the total chili area in Asia was intercropped, with the highest proportion in Indonesia and lowest in China. Many rotations of chili existed, but it was mainly grown in rotation with rice.

Table 6. Chili in the cropping system of major chili-producing countries of Asia, 2002

Item	China	India	Indonesia	Thailand	Asia
Total chili area in the country (000ha)	337	946	176	72	2,458
Chili area per farm (ha)	0.20[1]	1.0[1]	0.38	0.26	0.72[2]
Number of chili farmers (000)	1,685	946	463	277	4,242[3]
Chili area planted (% of all crop area on chili farms)	30	42	28	9	36[2]
Chili area intercropped (% of chili area)	0	20	58	13	20[2]
Major chili cropping pattern	Chili-Chili	Chili-Chili	Chili - Fallow – Chili	Chili - Rice - Chili	-

[1] Although the average chili area per farm in the sample area in China was only 0.1 ha, the figure was adjusted after personal discussions and communications with chili researchers across the country. Similar adjustment was made for India from 1.96 ha in the sample area to 1.0 ha for the whole India.

[2] Estimated as weighted average of each country data using their relative share in chili area as weights.

[3] The number of farmers for "other" Asian countries was estimated by dividing the total chili area in these countries with the chili area per farm for Asia (0.72 ha).

Overall, half of the chili area in Asia was planted to hybrid varieties, and another one-third was devoted to local land race varieties. Only 15% of the area was planted with open pollinated (OP) improved varieties (Table 7). Public sector institutes must serve a large number of poor farmers growing local varieties who cannot afford the expensive hybrid seed by providing them improved OP seed. In Thailand, where the largest share of OP was cultivated, these institutes had been successful in reaching out to small farmers in providing OP seeds. Most state-owned companies in China focus exclusively on developing and supplying hybrid varieties.

Table 7. Hot chili type and home-produced seed (% of parcels) in selected chili-growing countries of Asia, 2002

Chili type	China	India	Indonesia	Thailand	Overall[1]
Hybrid	90 (0)	34 (8)	77 (34)	5 (0)	50 (9)
Open pollinated	10 (97)	14 (31)	5 (56)	86 (95)	15 (51)
Local land races	-	52 (76)	18 (80)	9 (100)	35 (61)

[1]Estimated by weighing each country figure with its relative share in total area under chili in four countries.
Note: Figures in parentheses are percentage of parcels where home-produced seeds were used.

Insects and Diseases

Mites and thrips were the most devastating insects in chili fields, having been ranked as first or second important insect, except in China and Thailand where chili farmers ranked tobacco budworm and caterpillar as first. Another important insect was the aphid. Insect attack on chili was almost a regular phenomenon, as serious attacks happened in almost every three to five out of five years. For 1998-2002, average annual losses due to insects as perceived by farmers varied from 7% in China to 56% in India. Good management practices could have resulted to low losses in China. One disturbing trend in chili production was a significant increase in yield –losses overtime due to insects, as perceived by farmers in all major chili-producing countries of Asia except China (Table 8).

Table 8. Major chili insects as perceived by farmers in selected chili-producing countries of Asia, 2002

Country	Rank				Occurrence (year out of 5)		Average annual losses (%)	
	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
China	W	M	A	T	5	5	8	7
India	M	T	C	A	3	3	48	56
Indonesia	T	M	A	C	4	4	11	25
Thailand	C	T	M	A	5	4	13	24

Note: A=Aphids (*Aphis gossypii* and *Myzus persicae*); C= Caterpillar (*Helicoverpa armigera* and *Spodoptera litura*); M=Mites (*Polyphagotarsonemus latus*); T=Thrips (*Scirtothrips dorsalis*); W=Tobbaco budworm (*Heliothis sp.*).

Different chili diseases were ranked differently in the survey countries. Viruses were the most serious problem in Indonesia, anthracnose in Thailand, powdery mildew in India, and Phytophthora blight in China (Table 9).[6] Anthracnose was ranked second in the disease priority list in all the survey countries, except in Thailand where fusarium wilt was the second-ranking disease. Viruses were ranked as number one in Indonesia, while farmers in other countries ranked it third. Bacterial wilt was ranked fourth, except in India where Cercospora leaf spot was ranked fourth.

According to farmers, average losses due to disease infestation ranged from 7% in China to 43% in India from 1998-2002. Again, good management practices and relatively moderate temperature where chili was cultivated might have contributed to the low losses in China. Average annual losses due to serious disease attacks, as perceived by farmers, increased in all the survey countries, except China. The frequency of occurrence of serious disease attacks also increased in India and Thailand. These trends are more disturbing despite the increased use of hybrids and improved open pollinated varieties.

Table 9. Major chili diseases as perceived by farmers in selected chili-producing countries of Asia, 2002

Country	Rank				Occurrence (years)		Average losses (%)	
	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
China	PH	AN	VR	BW	5	5	8	7
India	PM	AN	VR	LS	2	3	34	43
Indonesia	VR	AN	PH	BW	4	4	29	38
Thailand	AN	FU	VR	BW	2	4	15	31

Note: AN=Anthracnose (*Colletotrichum acutatum*, *C. capsici* and *C. gloeosporioides*); BW=Bacterial wilt (*Ralstonia solanacear um*);FU=Fusarium wilt (*Fusarium oxysporum f. sp. Capsici* and *Fusarium solani*); PH=Phytophthora blight (*Phytophthora capsici*); VR=Viruses; PM=Powdery mildew (*Leveillula taurica*, asexual stage: *Oidiopsis sicula*); LS= Cercospora leaf spot (*Cercospora capsici*).

Weeds

The major weeds and their ranks of importance are reported in Table 10. The occurrence of weeds was a regular phenomenon in all chili-growing countries, although its intensity varied. It caused relatively more, and overtime increasing yield-losses in the tropics (Indonesia and Thailand) compared in the dry and sub-temperate climates of India and China (Table 10).

[6] We asked farmers to provide a ranking for insects and diseases based on the average annual losses, however the climate conditions during the survey year influenced these rankings. This implies that changing environmental conditions can alter these ranking. For example, in India, relatively dry and hot climate during the last 2-3 years have contributed to the deviation from ranking anthracnose and phytophthora blight as the top diseases.

Table 10. Major chili weeds as perceived by farmers in selected chili-producing countries of Asia, 2002

Country	Rank*					Occurrence		Average loss (%)	
	1	2	3	4	5	1993-97	1998-2002	1993-97	1998-2002
China	EC	PO	DI	EL	CY	5	5	2	2
India	CD	PA	CR	PH	CO	5	5	3	2
Indonesia	TK	PO	UG	AC	-	5	5	11	15
Thailand	DA	PE	CR	AM	-	3	5	7	11

**EC=Echinochloa crusgalli; PO=Portulaca oleracea L.; DI=Digitaria sanguinalis; CY=Cyperus difformis; EL=Eleusine indica; CD=Cynodon dactylon; PH=Phalaris minor; PA=Parthenium hysterophorus; CO=Commelina sp; CR=Cyperus rotundus; DA=Dactyloctenium aegyptium; AM=Amaranthus gracilis; PE=Pennisetum polystachyon; TK=Cyperus sp.; AC=Ageratum conyzoides; UG=Unidentified grasses.*

Farm Management Practices

Farm management practices greatly varied across major chili-producing countries in Asia (Table 11). These variations are explained in the following section.

Table 11. Advance management practices on hot chili in selected chili-growing countries of Asia, 2002

Farm management practices	China	India	Indonesia	Thailand	Overall[1]
Purchased seed (overall) (% of chili farmers)	90	54	51	9	59
Purchased seed for hybrid (% of hybrid farmers)	100	92	66	100	91
Purchased seed for open pollinated (% of OP farmers)	3	69	44	5	49
Purchased seed for local variety (% of local farmers)	-	24	20	0	22
Soil treatment in field (% of chili farmers)	36	23	8	6	23.3
Seed treatment (% of chili farmers)[2]	23	17	45	18	21.6
Plowing with tractor (% of parcels)[3]	4	73	14	70	50.9
Raised bed or furrow (% of parcels)	100	47	96	66	65.2
Straw and sawdust mulching (% of parcels)	14	7	22	32	11.4
Plastic mulching (% of parcels)	19*	1	42	0	9.6
Sprinkle irrigation (% of parcels)	1	2	1	6	1.9
Use of organic manure (% of parcels)	98	82	76	28	82.3
Use of inorganic fertilizer (% of parcels)	100	94	100	93	96.0
Irrigated parcels (% of parcels)	84	64	79	41	69
Advance method of inorganic fertilizer application (% of parcels)	63	-[4]	85	67	70.1
Use of herbicide (% of parcels)[5]	100	0.3	24	50	27.3
Use of insecticide (% of parcels)	100	75	100	75	83.4
Use of fungicide (% of parcels)	98	70	94	41	77.2
Number of harvesting	18	3	9	5	7.1
Percentage of hired labor in harvesting[6]	0.4	91	36	31	61.8

[1]Estimated as weighted average of individual country data using their relative share in chili area of these four countries as weights; [2]Includes both soaking and dusting; [3]Includes tractor+hand and tractor+animal; [4]Not available; [5]Includes also chemical+manual weeding; [6]Include family+hired;
*This also includes straw+plastic mulching, sawdust+plastic mulching, and nylon net.

Purchase of Chili Seed

Overall, 59% of chili seeds were purchased--91% of the hybrid, 49% of open pollinated, and only 22% of the local chili-variety seed. The percentage of purchased seed was highest in China and lowest in Thailand. In Thailand, no farmer bought the seed of local chili variety. About nine percent farmers cultivating hybrid chili did not buy its seed, but used F2 seed from the previous crop to save cost. In Indonesia, the percentage of such farmers was quite large at 34% (Table 11).

Soil and Seed Treatment

About one-fourth of the soils of chili fields were treated for soil-borne diseases, and a similar percentage of farmers treated their seeds to protect against seed-borne diseases. The percentage of soil treatment was highest in China, while the percentage of farmers treating chili seeds was highest in Indonesia.

Land Preparation

About 70% chili fields in India and Thailand were plowed with tractor indicating high level of mechanization in chili cultivation in these countries. In China and Indonesia, such mechanization level was low. Almost all farmers in China and Indonesia, and two-thirds of farmers in Thailand made raised beds or furrows before planting chili in fields. These were less common in India (still about one-half had raised beds) because of relatively less risk of flooding in the dry region. On the whole, straw mulching and plastic mulching was practiced on about one-tenth of chili plots. Straw mulching was more common in Thailand, and the frequency of mulching with plastic sheets was relatively higher in Indonesia.

Seedling Nursery

All farmers in the survey countries prepared seedling nurseries, except in India where about one-fourth of the farmers practiced direct seeding.

Irrigation and Fertilizer Application

Most of the chili area was irrigated, except in Thailand. Most of the time, the traditional method of gravitational flow of water in furrows was used to irrigate chili fields. Sprinkle irrigation was used only on less than 2% fields, and that was also mainly concentrated in Thailand.

Most chili fields in Asia received organic and inorganic fertilizer. However, the application of manure was less spread on 28% fields in Thailand. All manure was applied by broadcast; 70% fields received inorganic fertilizer through advanced methods such as placement.

Chemical Application

Almost all chili fields received manual weeding in all countries. Herbicide was also used on all fields in China, while only one-half and one-fourth of chili fields were applied with herbicides in Thailand and Indonesia, respectively. No herbicide was applied in India. On the whole, 27% of chili fields in Asia received herbicides treatment during the survey year.

Almost all chili fields in China and Indonesia received insecticide treatment to control insects, while about three-fourths of fields in India and Thailand also received this treatment. On the whole, over 83% of chili parcels in Asia were treated with insecticides during the survey year.

Similarly, almost all chili fields in China and Indonesia were treated with fungicides to control diseases; while over two-thirds of fields in India and two-fifths in Thailand also received this treatment. On the whole over three-fourths of chili fields received fungicide treatment.

Crop Duration

Chili crop duration was highest in China, and lowest in Indonesia. The crop was grown and harvested at different times of the year in different countries (Figure 8). These variations in harvesting schedule provide an important opportunity for trade across Asian countries. For example, in India the crop was harvested in the early part of the year, in Thailand during the later part of the year, and in China it was harvested during June-October. In Indonesia, the harvesting of the wet season crop starts in May when nowhere in the sample countries the fresh harvest was available.

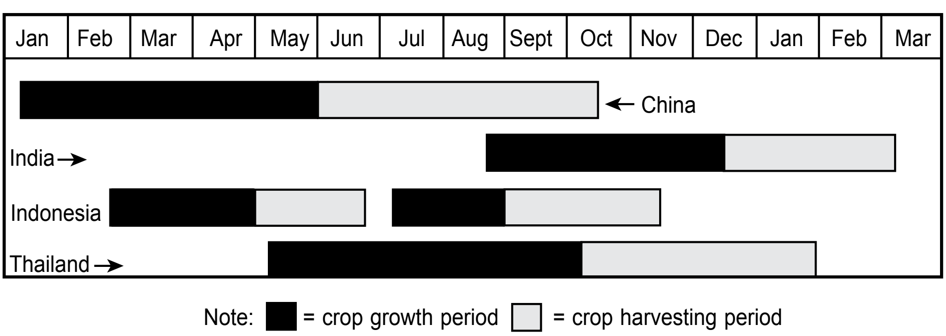


Figure 8. Chili crop schedule in major chili-growing countries of Asia

The individual country analysis suggests that introduction of modern chili varieties had also spread the crop cultivation and harvesting period. This was expected to reduce seasonality of chili output. Appropriate trade links across countries will also help reduce such seasonality.

Harvesting

The number of times the chili fields were harvested varied from three in India to 18 in China with an average of seven harvestings. The longer crop duration and higher yield in China compared to other countries partly explain this. Other factors responsible for more frequent harvesting in China and Indonesia was the green nature of chili fruit harvested there, while in India and Thailand relatively mature fruit was harvested. The higher number of harvesting might also explain low disease and insect incidence in China. Harvesting was mainly a family activity in China, Indonesia and Thailand, while it was mainly performed by hired labor in India.

Input Use

Input use on chili crop varied across countries (Table 12). In the following subsections, these variations are discussed for hot-chili across the four countries where the farm surveys were conducted.

Table 12. Input use (unit/ha) on chili in selected chili-growing countries of Asia, 2002

Input use	China	India	Indonesia	Thailand	Overall[1]
Seed rate (kg)	0.4	2.4	1.1	2.6	1.8
Total fertilizer nutrient (kg)	914	385	239	119	472
Manure (t)	23.8	7.0	8.7	2.5	11
Chemical spray (number)	14	17	53	12	21
Insecticide	7	10	21	5	10
Fungicide	5	7	29	5	9
Herbicide	2	-	3	2	2
Manual weeding (number)	2	4	4	4	4
Irrigation (number)	3	11	75	41	18
Labor (days)	482	294	345	265	340
Land preparation (%)	11.8	14.0	12.9	12.4	13
Management (%)	47.2	50.6	55.5	55.1	51
Harvesting (%)	22.5	25.2	25.4	24.7	25
Post-harvesting (%)	18.4	10.2	6.2	7.8	11
Full time labor force engaged (000 number)[2]	739	1,264	276	87	3,797

[1]This was estimated as weighted average of individual country input use with the relative share of each country in the total chili area of the four countries as weights.

[2]This was estimated by multiplying the per ha labor use with chili area in the respective country and then dividing it by 220. The overall figure in the last column of this row is for the whole of Asia, not just for the four countries.

Seed Rate

Overall, 1.8 kg of seeds were used to cultivate one ha of chili field in Asia. The highest amount was used in Thailand and India. In both countries, high impurity in home-produced open pollinated seeds may have created low-germination risk and forced farmers to use high seed rate to cover the risk. In Thailand the rainfed situation may also have created the low-germination risk. The lowest amount of seed was used in China because of the high cost of hybrid seed.

Inorganic Fertilizer

An average of 472 kg of nutrients of inorganic fertilizer were applied to chili in Asia, with the highest amount in China and the lowest in Thailand.

Chemical to Control Pests

Overall, 21 chemical sprays were applied to chili crop in Asia per season; about one-half were insecticides and another half were fungicides. The highest number of sprays of insecticide and fungicide were applied in Indonesia suggesting high insect and disease infestation in the country.

Irrigation

About one-third of chili area was rainfed. The proportion of irrigated area was highest in China and lowest in Thailand. The number of irrigations varied from three in China to75 in Indonesia. In Thailand and Indonesia, irrigation was done manually daily or every other day.

Labor

On average, 340 labor days per ha were needed in chili cultivation from seed to market operations. This implies that chili cultivation provided full-time year-round jobs to 3.8 million people in Asia. The use of labor per ha was highest in China, and lowest in Thailand. Manual land preparation, intensive input application especially of manure, and frequent harvesting contributed the highest labor use in China, while low input intensity under mainly rainfed situation resulted to lowest labor use in Thailand.

About one-half of the total labor went to crop management operations like manuring, planting, weeding, fertilizer and chemical application, irrigation, etc. Twelve to 14% of labor went to land preparation. About one-third of the total labor was used in the harvesting and post-harvest operations.

Per Hectare Yield

The per-ha yield of chili in fresh weight in Asia, estimated in this study, was 15.9 t. This is higher than what was estimated in the Food and Agricultural Statistics (FAO) at about 9.1 t (Table 3). In case of China, the FAO multiplied the total chili area with two to count for the area in winter and summer seasons, even if the same chili crop continued in both seasons (personal communication with Dr. Liu Yong). While this doubled the area, it reduced the yield for China in FAO statistics. In the other three countries, the higher yield estimated in this study could be because of the concentration of this study on commercial farms in main chili-growing areas.

Table 13. Yield (t/ha) of chili in selected chili-growing countries of Asia, 2002

Chili type/environment/cropping pattern	China	India	Indonesia	Thailand	Overall[1]
Overall	36.5	10.0	12.6	5.8	15.9
By chili type					
Hybrid	37.0[a]	16.6[a]	13.9[a]	19.1[a]	20.9
Open pollinated	31.0[b]	13.7[b]	11.0[b]	5.3[b]	16.8
Local	-	4.1[c]	10.0[b]	4.6[b]	5.0
By irrigation type					
Irrigated	36.9[a]	14.3[a]	15.6[a]	10.4[a]	19.2
Rainfed	34.3[b]	3.2[b]	7.3[b]	2.9[b]	10.5
By cropping pattern type					
Sole	36.6[a]	12.4[a]	15.6[a]	10.4[a]	18.0
Mix cropping (relay and intercropping)	26.8[b]	1.0[b]	10.3[b]	5.4[b]	8.0

[*]Different superscript on figures under a main category implies that they are statistically different across sub-categories.
[1]This was estimated as weighted average of individual country input use with the relative share of each country in the total chili area of the four countries as weights.

Per hectare yield of chili was highest in China at 36.5 t, and lowest in Thailand at 5.8 t (Table 13). Some of this difference may be due to output quality. For example, Chinese hybrid varieties are large and succulent with high water content while popular varieties in other countries are often higher in solids or dry products. Some of the variation in yield, however, was due to production efficiency, illustrating the potential in chili production once appropriate management practices were adopted and favorable environments were provided. The use of high-yielding varieties, high input intensity, appropriate management practices, and favorable climatic conditions with regular water supply explained the high yield in China, while low input intensity with relatively unfavorable rainfed climatic situation explained the low yield in Thailand.

One way to improve the chili yield is to replace the local chili area with modern varieties, both hybrids and open pollinated types. However, the open pollinated yields were significantly higher than local types only in India. In Thailand and Indonesia, the difference in the yield of open pollinated and local types was not significant. The economics of different chili types will be discussed in a later section to see the economically viable options available to small farmers for improving chili productivity and profitability.

As transient drought can greatly damage crops, better access to irrigation water can help not only in improving yields but also reducing risks. However, except in Thailand, most chili areas were cultivated under irrigated conditions; therefore this option may not help enhance overall chili productivity in Asia.

Chili yield was also reduced when it was grown as relay or intercrop. The reduction in chili yield was more than 34% in Indonesia, although some of it was compensated, may be partly, by the productivity of the other crops. As a significant proportion of chili area was intercropped in Asia, converting it into a sole crop will significantly improve its productivity.

Output Prices and Chili Grades

Except removing infected and damaged output, grading by quality was not done at the farm level. However, a large percentage of chili output was of one or another grade according to the criteria set by the market agents, except in China where all chilies were of mix grade. In other countries, about 40-50% chili output was sold as mix grade. In India, grade1 and mix grade had the highest and about equal percentage of output, while in Indonesia grade 2 had the highest proportion. In all major chili producing countries of Asia, better grade output fetches significantly higher prices (Table 14).

Table 14. Chili production grades and prices in selected chili-growing countries of Asia, 2002

Country	Percentage				Price of fresh chili (US$/100kg)				
	Grade1	Grade2	Grade3	Grade mix	Grade1	Grade2	Grade3	Grade mix	Overall
China	-	-	-	100	-	-	-	-	13.4
India	40	14	7	40	20.0	15.5	8.9	17.8	17.3
Indonesia	6	42	9	43	71.3	50.3	21.7	36.7	43.2
Thailand	20	13	12	53	37.1	29.7	22.3	27.2	27.2

Overall, the farm gate prices ranged between US$13/100kg in China to US$43/100kg in Indonesia. Some of the differences were due to the variation in quality. Prices in India were slightly higher than in China. The highest prices in Indonesia may also be due to lack of competition, as it is difficult and costly to import from other countries fresh chili which was the major form consumed there. High chili price in Thailand compared to India and China was inducing imports from other countries.

Economics of Chili Production

Factor Share

The per ha cost of chili production was highest in China and lowest in India and Thailand. The structure of per ha varied from country to country. Labor claimed the major share in China and Thailand, contributing about one-half and two-thirds of the total cost, respectively, while the share was 26% and 18% in India and Indonesia. Pesticide was the major cost in Indonesia, and one of the major cost items in India. The fertilizer share ranged from three percent in Thailand and 17% in India. Irrigation cost claimed only a small share in China and India, while it contributed about 10% in Indonesia and Thailand. The fixed cost ranged from 30% in India and 15% in Thailand. The share of seed ranged from two percent in Indonesia and seven percent in China (Table 15).

Table 15. Total cost (US$/ha) and factor share (%) of chili cultivation in selected chili-producing countries of Asia, 2002

Country	Total cost	Factor share (%)					
	(US$/ha)	Labor	Seed	Fertilizer	Irrigation	Pesticide	Others[1]
China	2,730	49.4	6.8	12.4	0.2	8.4	22.8
India	1,110	26.0	5.0	17.0	2.0	20.0	30.0
Indonesia	1,974	18.0	2.0	14.0	10.0	37.0	19.0
Thailand	1,168	63.0	3.0	3.0	9.0	7.0	15.0

[1]This includes land rent, taxes, interest and structure costs.

Unit Output Cost

Overall, per unit production cost of chili was lowest in China, and highest in Thailand. By chili type, hybrids had the lowest unit output-cost. However, the unit output-cost of open pollinated in comparison with local type varied across countries. It was lower than local chili in India because of better performance of the former in terms of yield. However, in Indonesia and Thailand, the unit cost for open pollinated was higher compared to local type because of insignificant difference in yield between the two, and higher cost of the former (Table 16).

Table 16. Unit cost (US$/t) of chili cultivation in selected chili-producing countries of Asia, 2002

Chili type	China	India	Indonesia	Thailand
Hybrid	80.1	120.3	134.3	136.0
Open pollinated	84.2	168.4	203.1	212.7
Local	-	205.6	156.5	202.8
Overall	80.5	162.2	144.3	201.3

Benefit-Cost Ratio

The benefit-cost ratio in chili cultivation was highest in Indonesia and lowest in Thailand. The ratio for hybrid was higher than for local and open pollinated types in Indonesia and Thailand, while in India the open pollinated gave the highest benefit-cost ratio. No significant difference between open pollinated and hybrid in China was observed (Table 17).

Table 17. Benefit-cost ratio (%) for chili cultivation by chili type in major chili-producing countries of Asia, 2002

Chili type	China	India	Indonesia	Thailand
Hybrid	83	79	251	117
Open pollinated	73	111	116	42
Local	-	40	115	40
Overall	82	70	209	51

Resource Use Efficiency

Resource productivity for fertilizer and labor was generally higher when they were used in modern chili varieties compared to when they were applied in local type in all the survey countries. Among modern varieties, productivity was higher in hybrids compared to open pollinated types in all countries, except in India and fertilizer productivity in Indonesia where the reverse was true. It showed the success of open pollinated varieties in India, while in other countries the hybrid types provided more economically viable options. In fact, labor and fertilizer productivity in open pollinated chili type in Thailand and labor productivity in Indonesia was either lower or insignificantly different than in local chili type (Table 18).

Table 18. Partial resource productivity in chili cultivation by chili type in selected chili producing countries of Asia, 2002

Chili type	China		India		Indonesia		Thailand	
	Labor (US$/day)	Fertilizer (US$/kg)	Labor (US$/day)	Fertilizer (US$/kg)	Labor (US$/day)	Fertilizer (US$/kg)	Labor (US$/day)	Fertilizer (US$/kg)
Hybrid	8.2	10.1	6.9	6.5	19.0	21.9	16.7	37.9
Open pollinated	7.7	5.2	8.4	7.1	12.7	24.1	3.2	12.9
Local	-	-	5.6	4.1	11.1	16.1	3.2	13.6
Overall	8.1	9.6	6.7	5.7	16.6	20.9	3.6	17.2

Despite high return on open pollinated varieties in India, the seed of these varieties was not generally available, implying that success on the experiment fields in the public sector research institutes had not been transferred to the farmers, and a large group of chili farmers had to depend on the expensive and relatively less economically viable hybrid type.

Fertilizer productivity was highest in Indonesia and Thailand while labor productivity was lowest in Thailand, except in hybrid type. This may be explained in terms of low fertilizer per unit of output used in Indonesia and Thailand and high labor per unit of output applied in Thailand.

Farmers' Constraints

In all the surveyed countries, diseases and insects were ranked first or second constraint seriously limiting chili production. Even though the losses due to diseases and insects were low in China, farmers still considered this as the most important constraint. Low and variable price was ranked third in China and Thailand, while market problems and the environment (mainly drought) were the number three priority constraints in Indonesia and India, respectively. Low and variable prices in India, market problems in China, environmental problems (mainly floods) in Indonesia and Thailand were at the fourth priority constraints. Low yield variety in Thailand, poor quality seed in Indonesia, environmental problems in China, and weeds in India were also the cause of concerns of farmers (Table 19). It should be noted that high cash required for chili cultivation was not noted as a major constraint, at least for those farmers who were already cultivating chili. It is perhaps a great barrier for new entrants, especially small farmers.

Table 19. Rank of contraints faced by chili farmers in selected chili-growing countries of Asia, 2002

Constraint	China	India	Indonesia	Thailand
Diseases	1	1	2	1
Insects	2	2	1	2
Low price/variability in chili price	3	4	-	3
Market problems	4	-	3	-
Low yield/variety	-	-	-	5
Poor quality seed/high seed cost	-	-	5	-
Environment (drought/flooding)	5	3	4	4

Note: Highest rank = 1 and lowest rank = 5.

Attributes for Chili Selection

The producers' choices for different attributes in variety selection for two forms of chili output (i.e., green and red) are presented in Table 20. In general, high market price and yield were the two highest ranked criteria of farmers in variety selection, except for green in Indonesia and Thailand. Disease and insect resistance attributes were generally ranked third or fourth, or even sixth. This is despite the fact that farmers in all surveyed countries considered diseases and insects as major constraints. This clearly suggests that research on insect and disease resistance cannot be sold to farmers without enhancement of yield and incorporation of the attributes that consumers prefer in chili so that producers can have high prices for their outputs.

Table 20. Ranking of factors in the selection of chili seed by chili type in major chili-growing countries of Asia, 2002

Characteristic	China		India		Indonesia		Thailand	
	Green	Red (fresh)	Green	Powder	Green	Red (fresh)	Green	Powder
Market price	2	1	2	2	2	1	1	1
Yield	1	2	1	1	4	2	3	2
Disease free	3	4	3	4	1	-	-	6
Insect free	4	5	4	-	3	-	5	-
Chili color	-	-	5	3	-	4	4	3
Appearance	5	3	-	-	-	-	-	-
Thick flesh	-	-	-	-	-	5	-	-
Hotness	-	-	-	5	5	3	-	4
Pod numbers	-	-	-	-	-	-	2	-
Fragrance	-	-	-	-	-	-	-	5

Note: Highest rank = 1 and lowest rank = 5.

Marketing Aspects

Marketing Outlets

The detailed market structures for chili are discussed in each country report. It was noted that the major output goes through commission agents wholesalers in the main market in all major chili-producing countries of Asia. In China, a significant proportion of chili output also went to traders who pick the output from the farm. In Thailand and China, about one-fifth of output was sold in local markets. In other countries, the share of cooperatives or local market was insignificant (Table 21).

Table 21. Market outlets for chili in selected chili-growing countries of Asia, 2002

Country	Farmer selling to different agents (%)			
	Local market	Commission agent/ wholesaler in main market	Consumers/traders picked at farm	Others/ cooperatives
China	21	58	21	-
India	3	91	-	6
Indonesia	7	89	-	4
Thailand	22	72	-	6

In China, the chili market seemed to be less integrated with the main markets, as a large proportion of the output was channeled through local markets or through disposal at the farm to local traders/consumers.

Marketing Constraints of Farmers

Variable and uncertain chili prices were the major marketing constraints faced by the farmers in China and Indonesia, while in India high marketing cost was the major constraint. Farmers in Thailand expressed marketing constraints in terms of the lack of collective bargaining power of chili growing farmers. In Indonesia, lack of price information and exploitation of middlemen were also expressed as major constraints (Table 22).

Table 22. Marketing constraints faced by chili farmers in selected chili-growing countries of Asia, 2002

Constraint	Percentage of farmers			
	China	India	Indonesia	Thailand
Variable/uncertain price	72	18	30	10
Low demand and prices	22	-	6	-
Exploitation of the middlemen	-	17	12	-
High marketing cost	-	45	-	-
Lack of price information	-	-	19	-
Lack of collective bargaining	-	-	-	52
Lack of government participation	-	-	-	28
Others	6	20	18	10
No marketing problem	-	-	15	-

Constraints of Marketing Agents and Processors

Poor and un-graded chili products, irregular output supplies that cause fluctuating prices, and lack of credit for chili marketing were considered as major constraints in chili marketing and processing across all the four countries surveyed.

Preferences for Chili Attributes

Market Agents

In India and Thailand, the middlemen always bought dry chili from farmers, while in Indonesia fresh chili was purchased. In China green chili was purchased as fresh while red chili was purchased either as fresh or dry; the ranking of market agents for the selection criteria were similar for green and red. Low output price (in China and Thailand) and color (fresh in Indonesia and dry in India) were the first ranking criteria of marketing agents in the selection of chili. In India, the red color was associated with hotness, although the association may be false. Appearance in China, hotness in India, prices in Indonesia, and fragrance in Thailand were second ranking criteria (Table 23).

Table 23. Ranking of chili attributes preferred by market agents (middlemen) in selected chilling-growing countries of Asia, 2002

Characteristics	China		India	Indonesia	Thailand
	Green	Red	-	-	-
Low output price	1	1	4	2	1
Disease/insect free	-	-	4	3	5
Appearance	2	2	3	-	-
Freshness	3	3	5	5	-
Chili color	-	5	1	1	-
Fruit surface	5	-	-	-	4
Fragrance	-	-	-	-	2
Hotness	-	-	2	4	3
Softness	3	4	-	-	-
Thick mesocarps	4	-	-	-	-

Note: Highest rank=1 and lowest rank=5.

Processors

Processors buy dried chili to process it into powder which is generally used in making hot food, or give red color to dishes. Processors looked for chili color or pungency as first ranking criterion. Low output price in China, pungency in India, less number of seed (to have attractive red color) in Thailand, and chili color in Indonesia were second ranking criteria. Chili color in China and Thailand, prices in Indonesia, and attractive appearance in India were third ranking criteria. Fragrance was ranked fourth in China, India, and Indonesia and while prices were fourth in Thailand (Table 24).

Table 24. Ranking of chili attributes preferred by processors in selected chili-growing countries in Asia, 2002

Characteristic	China	India	Indonesia	Thailand
Prices	2	-	3	4
Appearance	-	3	-	-
Softness	5	-	-	-
Freshness	-	5	5	-
Chili color	3	1	2	3
Fragrance	4	4	4	5
Pungency	1	2	1	1
Number of seed	-	-	-	2

Note: Highest rank=1 and lowest rank=5.

Consumers

In general, criteria used for red and green chili were similar. As attributes selected for one product can also be sold in other products, this made the researchers' job easier. In China, overall appearance and market prices were first and second most important criteria consumers look for in both red and green chili; in India, pungency and material without blemishes were most preferred; in Indonesia, consumers look for freshness and number of seeds in the pod (perhaps a measure for hotness); and in Thailand both hotness and freshness were top attributes in consumers selection of chili (Table 25).

Table 25. Ranking of chili attributes by consumers in selected chili-producing countries of Asia, by chili type, 2002

Selection criteria	China		India		Indonesia		Thailand	
	Green	Red	Green	Red	Green	Red	Green	Red
Hotness	4	4	1	1	4	5	1	1
Disease/insect free	-	-	2	2	3	4	5	4
Overall appearance	1	1	-	5	-	-	-	-
Number of seeds	-	-	-	-	2	2	-	-
Market price	2	2	4	3	-	-	-	-
Freshness	3	3	3	-	1	1	2	2
Color	-	5	5	4	5	3	3	3
Fragrance	-	-	-	-	-	-	4	-

Note: Highest rank=1 and lowest rank=5.

Consumption Aspects

Consumption Pattern

The average annual per capita consumption of chili in Asia, as estimated through this survey, was 11.8 kg of fresh weight (Table 26).[7] Consumption was highest in China, where it was consumed as a supplement vegetable and lowest in India and Indonesia.

In Asia, the average annual per capita expenditure on chili stood at about US$4.3 (Table 27).[8] The expenditure was highest in Indonesia where chili prices were relatively higher than in other Asian countries, while in China the high consumption level explained the high expenditure despite low unit prices. One-fifth of the total chili consumption was for green fresh, while another one-tenth for red fresh. The share of dried red chili (ungrounded) was 12%, while 36% was consumed as chili powder. About 16% of the fresh weight was consumed in the form of processed products.

[7] This estimate, however, is biased toward higher consumption level in the chili growing areas surveyed.

[8] Consumption in the survey areas may be high and expenditures may not be because chili prices in the non-survey areas may be higher than in the survey areas.

Table 26. Relative share (percentage) of different chili types (fresh form) in total chili consumption in selected chili-producing countries of Asia, 2002

Type of chili	China	India	Indonesia	Thailand	Overall[1]
Green fresh	35.1	26.9	33.6	14.2	28.9
Red fresh	25.5	0.3	39.3	14.7	11.0
Sweet fresh	0.5	2.7	-	0.5	1.88
Dry chili	5.6	19.3	-	3.7	13.3
Chili powder	9.3	46.5	-	39.4	32.3
Other chili products[2]	24.0	4.3	27.1	27.5	12.4
Overall (kg/annum)[3]	18.9	9.7	9.6	11.3	11.8

[1]This was estimated by weighing the shares of each country with its population share in the four project countries.
[2]Others include chili pickle, paste, curry, and other chili product.
[3]The figures in this row are average annual per capita chili consumption in kg.
Note: The dry chilies and chili powder were converted into fresh by multiplying the weight of the former with 4. Similarly, chili pickles, chili paste, chili curry and other chili products were converted into chili fresh weight by multiplying the later with 2.

Table 27. Relative share of expenditure (%) of different chili types in selected chili-growing countries in Asia, 2002

Type of chili	China	India	Indonesia	Thailand	Overall[1]
Green fresh	28.1	17.8	33.0	14.1	21.7
Red fresh	30.6	0.9	40.0	14.5	12.6
Sweet fresh	0.8	2.0	-	0.3	1.4
Dry chili	6.4	17.4	-	4.0	12.3
Chili powder	9.9	52.4	-	39.4	36.4
Other chili products[2]	24.2	9.5	27.0	27.7	15.6
Annual per capita expenditure (US$)	5.0	3.3	7.1	6.3	4.3
Retail to farmgate price ratio	1.99	1.99	1.71	2.04	1.96
Total retail value of chili (million US$)	2,712	1,727	1,157	276	9,453[3]

[1]This was estimated by weighing the shares of each country with its population share in the four project countries.
[2]Others include chili pickle, paste, curry and other products.
[3]This is the value for whole Asia

Chili consumption pattern varied across Asian countries. In Indonesia, chili was either consumed as fresh or processed (pickle, paste, curry, and other products); no powder or dry chili was consumed. In China, the share of fresh chili to total consumption was also quite high. On the other hand, more than one-half of total consumption in India and two-fifth in Thailand was consumed as chili powder. The share of chili processed items ranged from 9.5% in India to 27.7% in Thailand (Table 27).

Retail Value

The per capita expenditure and consumption allowed us to estimate the average prices of chili and its products at the retail level in the survey area. Using the farmgate prices reported in Table 14, the ratio of retail to farmgate prices was estimated. This ratio was used to estimate the retail value of chili in each survey country. The weighted average of these ratios (using production at each country as weight) was used to estimate the retail value for Asia from its farm value reported in Table 3. Our estimate suggests that total retail value of chili and its products in Asia stands at about US$9.5 billion. About 29% of this value was traded in China and another 18% in India (Table 27).

Demand Elasticity

Demand elasticity depicts the percentage change in the consumption of a commodity with a given percentage change in its prices. Consumers' perceived responses for chili with various percentage change in its prices (increase and decrease) are discussed in each country report. The change in consumption as a result of the various increasing price levels of green/red and dry/powder chili is discussed here.

The change in fresh chili (green/red) consumption ranged from 2.3% in Thailand to 17.1% in China, while demand elasticity for powder and dry chili ranged from 3.3% in Indonesia to 8.0% in China (Table 28). The elasticities were higher for green/red chili than for dry/powder chili except in Thailand. However, both were relatively low: about the same as that of cereals in case of green/red and even lower than cereals in case of dry/powder. This suggests that in general there is a little chance of improving the demand of chili by reducing its price through technological changes, although such potentials are higher for fresh chili. These chances are much higher in case of sweet pepper as indicated by high elasticity (up to 0.62 as shown in India report).

In Thailand, however, the demand elasticities for both fresh chili and dry/powder were low, perhaps because both were consumed as spices and green/red chilies were not cooked as supplement dish like in some other countries.

Table 28. Demand elasticity of chili by product type in selected chili-producing countries in Asia, 2000

Price increase (%)	China		India		Indonesia		Thailand	
	Green/ red (fresh)	Dry/ powder	Green/ red (fresh)	Dry/ powder	Green/red (fresh)	Product	Green/red (fresh)	Dry/ powder
110	-0.35	-0.20	-0.05	-0.50	-3.16	0	-0.42	-0.81
125	-2.45	-0.90	-0.50	-1.00	-4.65	-0.07	-0.65	-1.08
150	-7.30	-3.30	-2.25	-2.80	-5.69	-0.08	-0.73	-2.17
175	-12.45	-5.90	-6.20	-5.00	-8.13	-1.98	-1.85	-3.14
200	-17.10	-8.00	-15.90	-7.90	-13.33	-3.32	-2.31	-4.21

Development Aspects

Employment

The cultivation of chili increases the demand of labor, as labor requirements for chili cultivation are at least double compared to cereals (Table 29). On average, shifting one-hectare of rice to chili will generate additional employment of about 223 labor days (more than a fulltime year-round job) at the farm. The highest increase in labor demand with such shift will be in China, where input use on chili is more intensive and many chili operations, such as land preparation, are manually performed. Such a shift of all chili area from rice in Asia has provided jobs to about 2.49 million people at the farm level. A similar number to be engaged in its distribution and processing activities is expected.

Table 29. Labor use in chili and rice, and additional labor demand generated by shifting rice to chili in major chili-producing countries of Asia, 2002

Crop	China	India	Indonesia	Thailand	Overall
Chili	482	294	345	265	340[1]
Rice	112	117	132	98	117[1]
Additional demand by shifting chili from rice (000 number)[2]	567	761	171	55	2,493

[1] Estimated as weighted average of each country data using their relative share in chili area as weights.
[2] This was estimated by multiplying difference in labor requirement between chili and rice with total chili area and divided by 220 in the respective country and Asia.

Gender Impact

Chili is a female gender crop, as percentage of the female labor engaged in its cultivation is much higher than in cereal crops. For example, the female share in total labor used on chili in Asia was 58% compared to only 29% in rice. The female shares were highest in Thailand, and lowest in China (Table 30). From the country report analyses, it can be deduced that the contribution of female labor was higher for improved compared to local chili varieties. Therefore, research efforts to generate improved chili varieties will serve to benefit female labor.

Table 30. Labor distribution (percentage) in selected chili-growing countries of Asia, by gender and chili type, 2002

Chili type	China		India		Indonesia		Thailand		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Hybrid	40.2	59.8	61.8	38.2	64.7	35.3	75.5	24.5	57.3	42.7
Open pollinated	36.9	63.1	62.1	37.9	59.2	40.8	75.8	24.2	62.1	37.9
Local	-	-	58.9	41.1	57.4	42.6	67.5	32.5	56.0	44.0
Overall hot-chili	39.8	60.2	60.4	39.6	61.5	38.5	75.1	24.9	57.6	42.4
Rice	25.7	74.3	28.2	71.8	38.6	61.4	30.4	69.6	29.0	71.0

Agricultural Business Activities

Chili cultivation requires more purchased inputs, such as fertilizer, pesticide, and irrigation water compared to widely grown rice in the region (Table 31). For example, the current chili area in Asia created an additional demand of seed (US$150 million), fertilizer (511 thousand nutrient t), manure (19 million t), and pesticide (US$566 million).[9] Some of these inputs need more cash outlay, which generate demand for loans to finance chili production expenses, and more fertilizer and pesticide sales shops are needed. Moreover, increased input demands create employment opportunities in supply and services sectors.

On average net return per ha on chili cultivation in Asia stood at US$1,437, which was US$1,348 higher than in rice cultivation. Assuming that 2.45 million ha of chili area was shifted from rice, it would have generated an additional net income of US$3.31 billion to the chili farmers in Asia.

Table 31. Non-labor input use in chili and rice, and additional input demand generated by shifting rice to chili in major chili-producing countries of Asia, 2002

Input/crop	China	India	Indonesia	Thailand	Overall[1]
Seed (US$/ha)					
Chili	184.9*	54.2*	39.5*	35.0*	80
Rice	31.1	17.2	14.0	6.1	19
Additional demand by shifting rice to chili (million US$)[2]	51.9	35.0	4.5	2.1	150.0
Fertilizer (kg/ha)					
Chili	914*	402*	239*	119*	483
Rice	434	252	169	86	275
Additional demand by shifting rice to chili (000t)[2]	161.9	141.8	12.3	2.4	511.2
Manure (t/ha)					
Chili	23.8*	7.12*	8.7*	2.46*	11
Rice	0.8	4.33	2.0	0.96	3
Additional demand by shifting rice to chili (million t)[2]	7.8	2.6	1.2	0.1	18.8
Pesticide (US$/ha)					
Chili	229*	226*	730*	82*	278*
Rice	43	27	167	47	48
Additional demand by shifting rice to chili (million US$)[2]	62.7	188.2	99.2	2.5	566.1
Irrigation (no.)					
Chili	3.2*	11	75*	41*	18
Rice	7.8	12	18	18	12

[9] As sweet pepper cultivation is much more input intensive with higher economic returns, to the extent Asia data for green and fresh includes sweet pepper, these estimates are on the lower side.

Cont...,Table 31

Input/crop	China	India	Indonesia	Thailand	Overall[1]
Net income (US$/ha)					
Chili	2,064*	735*	4,351*	591*	1437
Rice	121	40	229	231	89
Additional income generated to chili farmers (million US$)	655.4	657.1	726.6	25.9	3314.7

[1] This was estimated as weighted average of individual country input use using the relative share of each country in the total chili area of the four countries as weights.

[2] This was estimated by multiplying the difference in chili and rice estimates in each country with the total chili area of the respective country.

Note: The * in the chili row suggests that that input use on chili is significantly different than in rice.

In addition, most of the chili output was commercially produced for the market, while a major portion of the cereal output was kept for home consumption in Asia. Therefore, chili cultivation generated additional demand for market activities. As fresh chili needs to be transported to the markets and processing locations as soon as possible, they will need sophisticated marketing infrastructure, such as better roads, storage, etc. Once such infrastructure is available, the efficiency of the whole marketing system will improve.

As the majority of chili was consumed in powder, dry, and processed forms in Asia, a large number of people were engaged in its post-harvest activities. Drying and removal of infected and damaged chilies were usually done on the farm. Doubling of the farm to retail prices (Table 27) in chili where post-harvest losses were not substantial indicated considerable post-harvest activities. Moreover, about 11% of the labor, ranging from 8-18%, used in chili production in Asia was in post-harvest activities (Table 12). In fact, substantial activities were performed on the farm for processing. This was reflected in the high proportion of processed chili items prepared within the farm households in every country surveyed.

The largely commercial nature of chili production increased income and employment of the people in peripheral communities not engaged directly in its production and marketing through a multiplier effect as it passes through more hands until it reaches to consumers.

Economic Efficiency

Economic efficiency of resources allocated in chili production, such as labor and fertilizer, was higher than those in rice production, a major cereal crop in these countries (Table 32). The benefit-cost ratio was also higher in chili production compared with rice except in Thailand. Despite these benefits, however, chili was not as extensively grown. The economic analysis pointed two major constraints:

1. Higher per ha production cost and more percentage of it was cash (except in China) compared to rice.
2. High variability in chili yield and therefore risk involved in its production compared to more stable yield of rice. The market variance in terms of fluctuating market

prices, compared to mostly stable rice prices managed through government supports further exaggerated the relative risk involved in chili production.

Table 32. Input use efficiency in chili and rice in selected chili-producing countries of Asia, 2002

Input/crop	China	India	Indonesia	Thailand
Total cost (US$/ha)				
Chili	2,731*	1,109*	1,974*	1,168*
Rice	665	364	438	306
Cash cost (percentage of total cost)				
Chili	37.9	74.7*	65.4	31.9
Rice	44.7	58.4	50.2	25.5
Labor (US$/labor day)				
Chili	8.1*	6.7*	16.6*	3.6*
Rice	4.8	3.2	4.0	3.0
Fertilizer (US$/kg nutrient)				
Chili	9.6*	5.7*	20.9*	17.2*
Rice	2.1	1.6	2.7	6.0
Benefit-cost ratio (%)				
Chili	82*	70*	209*	51*
Rice	23	11	52	76
Variance in yield				
Chili	0.25	0.81	0.91	1.19
Rice	0.17	0.29	0.37	0.06

Note: The * in chili row implies that the figure is different than the corresponding figure for rice at the 10% level.

Chili cultivation not only improved the efficiency of resources engaged in its production, but also enhanced the efficiency of resources engaged in the production of cereal crops. As chili is a commercial crop, farmers engaged in its production had better connection with the market (as reflected by their higher off-farm earning and loan-seeking behavior compared to non-chili farmers, Table 5). Therefore they can better understand the fluctuations in the market than farmers engaged in subsistence crops such as rice. They buy inputs on time and have to follow the stipulated timing in the contract for output delivery. Once they know the importance of timing of different production and marketing operations in chili production, they enforce the timeliness of operation in cereal crops as well. This improves the productivity and resource use efficiency of cereal crops cultivated by chili farmers compared to non-chili farmers.

This higher efficiency in cereal cultivation was achieved either through obtaining higher yield of cereals (except in case of Indonesia), or by saving costs as in case of China, or both. This improved net return, benefit-cost ratio, and labor and fertilizer productivity of rice cultivated by chili growing farms compared to the one grown by non-chili farmers (Table 33).

Table 33. Economics of rice cultivation of chili and non-chili farms in selected chili-producing countries of Asia, 2002

Parameter/type of farm	China	India	Indonesia	Thailand
Yield (t/ha)				
Chili farm	6.59	3.82	5.00	4.75
Non-chili farm	6.47	3.11	5.20	3.97
Total cost (US$/ha)				
Chili farm	658	374	402	327
Non-chili farm	734	361	445	266
Net return (US$/ha)				
Chili farm	130	46	264	244
Non-chili farm	30	31	247	191
Benefit-cost ratio (US$/100US$)				
Chili farm	24	12	66	75
Non-chili farm	10	8	56	72
Labor (US$/day)				
Chili farm	4.9	3.3	4.2	2.5
Non-chili farm	4.0	3.2	4.0	2.5
Fertilizer (US$/kg nutrient)				
Chili farm	2.1	1.7	3.0	5.8
Non-chili farm	1.5	1.5	2.8	5.3

Impact on Consumption

Chili cultivation improved the income of farmers, therefore, their ability to generally increase spending, especially to buy more and/or better foods, also improved. Except in Indonesia where non-chili farmers also planted other vegetables or cash crops, the total household incomes of chili farmers were statistically higher than non-chili farmers. The overall expenditure on food followed the same pattern. The total quantity of food was higher only in China and India, but the quality of food in terms of high value products such as fruits, vegetables, and/or livestock products was generally improved on chili farms in all the surveyed countries (Table 34).

Miracle of Modern Varities

The specifications in 3.1-3.3 were used to estimate the annual economic surplus generated due to modern varieties in 2003 in the survey countries and in Asia. The study estimated the surplus for hybrid varieties, as open pollinated (improved) varieties did not have clear advantage over traditional land races in terms of unit production cost (see Table 16). The data used in this estimation are reported in Table 35.

Table 34. Effect of chili cultivation on food consumption and expenditure by farmer group in major chili-producing countries of Asia, 2002

Item	China		India		Indonesia		Thailand	
	Chili	Non-chili	Chili	Non-chili	Chili	Non-chili	Chili	Non-chili
Family income (US$/month)	157.8[a]	137.5[b]	122.5[a]	72.3[b]	27.5[b]	39.7[a]	226.5[a]	176.3[b]
Family expenditure (US$/month)								
All expenditure	91.9[a]	85.6[b]	61.5[a]	57.0[b]	15.6[b]	22.2[a]	110.7[a]	91.8[b]
On food	53.3[a]	48.8[b]	42.2[a]	39.0[b]	10.4[b]	15.8[a]	48.0[a]	44.3[b]
Total Food (g/day)	968[a]	912[b]	920[a]	847[b]	995[b]	1,032[a]	1,147[a]	1,189[a]
Cereals	445[a]	416[b]	377[a]	360[a]	374[a]	362[a]	422[b]	532[a]
Vegetables	342[a]	329[b]	185[a]	151[b]	210[a]	195[b]	229[a]	188[b]
Fruits	49[a]	34[b]	40[b]	90[a]	91[a]	96[a]	146[a]	126[b]
Livestock products	71[a]	64[a]	242[a]	211[b]	116[a]	132[a]	126[a]	118[a]
Seafood	15[a]	17[a]	-	-	80[a]	93[a]	70[a]	58[b]
Others	47[a]	53[a]	76[a]	35[b]	134[a]	154[a]	156[b]	167[a]

Note: Different superscripts on figures in the chili and non-chili columns implies that the figures are statistically different across the two groups.

Table 35. Parameter values for producer and consumer surplus analysis for chili cultivation in selected countries in Asia

Parameter	China	India	Indonesia	Thailand	Overall
1. Production without innovation (000t)[1]	11,899	4,388	1,052	420	21,821
2. Farm price without innovation (US$/t)[1]	173	204	488	278	208
3. Demand elasticity[2]	0.15	0.08	0.11	0.03	0.13
4. Supply elasticity[3]	0.40	0.40	0.40	0.40	0.40
5. Probability of success (proportion)	1	1	1	1	1
6. Adoption rate (proportion)[4]	0.9	0.34	0.77	0.05	0.74
7. Reduction in cost (proportion)[5]	0.3	0.41	0.14	0.33	0.32
8. k (proportion of farm price decrease estimated as 6*7)	0.27	0.14	0.11	0.02	0.22

[1] These values were generated using equations 3.4-3.9, and the explanation after these specifications.
[2] Weighted average elasticities reported in each country chapters for different types of chili products.
[3] Estimated from the review of literature.
[4] Table 7.
[5] Percentage difference in unit cost of production between hybrid and local land races reported in Table 16.

Over US$ one billion per annum were being generated due to the use of hybrid varieties in chili production in Asia. However, about 75% of the benefits went to consumers and remaining 25% to producers. This is because of the low demand elasticity of chili, i.e., additional production generated by modern varieties dramatically reduced chili prices, which lowered the benefits of these varieties to farmers (Table 36).

Table 36. Producers and consumers surplus generated by modern technologies in chili production in 2003 in selected countries in Asia

Parameter	China	India	Indonesia	Thailand	Overall
Consumers surplus (Million US$)	411.28	105.46	44.13	1.79	776.92
Producers surplus (Million US$)	154.23	21.09	12.13	0.13	248.62
Total (Million US$)	565.50	126.55	56.26	1.92	1,025.54

More than one half of the surplus generated due to hybrid varieties was in China where adoption rate for these varieties was highest. This was remotely followed by India, where hybrids were adopted only on 34% of the area. The lowest surplus benefits of hybrid varieties were achieved in Thailand where only 5% farmers used these varieties.

Summary and Policy Implications

Chili is an important vegetable or spice in Asia in terms of production area, farm and retail value, and people engaged in its production, processing and marketing activities. In 2003, it was cultivated on a total area of 2.5 million ha which produced 22.4 million t of fresh weight output having a farm value of US$4.8 billion and a retail value of chili and its products at US$9.5 billion. It engaged about 4.2 million farm families in Asia. The value of its international trade (both import and export) reached US$5.6 billion, and US$664 million of it was for Asia. It provided full time yearly jobs to 3.8 million people at the farm level, and a similar number was engaged in its marketing and processing activities.

With the rising importance of chili in Asia both in terms of domestic production and trade, this study provided a timely analysis of the chili sector in selected countries as well as worldwide, explaining various issues in the food chain as the commodity passes from the producers to the consumers through various intermediaries. It is hoped that the information generated will be used in research prioritization to improve the efficiency of the whole chili sector. Comprehensive surveys and discussions were conducted with different stakeholders along the food chain in selected major chili-producing countries of Asia, including China, India, Indonesia, and Thailand. The surveys were conducted among farmers, marketing agents, processors, and consumers in these countries covering a total of 2,750 respondents. The data collected from these surveys and from secondary sources provided a comprehensive analytical look of the sector. Constraints were analyzed, and policy measures to improve its efficiency at the country levels were forwarded. Moreover, across-country comparisons provided a unique comparative picture of the sector operating under various ecoregions and socioeconomic setups and how various stakeholders interact with each other under these environments. It is expected that the analyses will be used as an example to analyze the food chain of other agricultural commodities, especially vegetables.

During the 1990s and early part of the first decade of the 21st century, chili production and per capita availability increased in Asia as well as in the world through expansion in area as well as improvement in yields. Most of this increase was in the chili consumed as fresh, rather than in its dry or powdered form. This is in line with the demand elasticity analysis, which suggested relatively high elasticity for chili consumed as fresh, and a very inelastic demand for dry and powdered chili. The research implications are that resources allocated to enhance production for dry powdered chili will mainly benefit consumers in terms of low prices, while most of the benefits of enhanced production in fresh chili will stay at the farm level. Moreover, with increased supply, the chance of expanding fresh chili consumption is higher, which will help mitigating the micronutrient deficiency.

The international trade of chili in Asia is on the rise as well, but it still constituted a small part of the total trade on chili. There were signs that relative competitiveness of chili trade in Asia was improving, especially in fresh chili, suggesting improvements in its production and marketing systems. However, with the opening up of markets and increasing free trade regime, trade competition is stiffening. Therefore, smaller countries need to improve their production and marketing systems to keep their competitiveness in the international market. These countries should focus on fresh chili types as both its prices and demand have been increasing at a much faster rate than pimento chili. However, the four Asian countries included in the survey are not currently realizing this potential since they would rather expand their trade in pimento. To make this shift, these countries have to make changes in their production systems and improve their marketing infrastructure.

Estimates suggest that about one-third of chili produced in Asia was consumed as dried and ground mainly for spice, and the remaining two-thirds was consumed as fresh. However, these shares varied across countries. South Asia was the main consumer of red, dry and ground chili, where their share in the total consumption goes as high as two-thirds. In Southeast Asia, except in Thailand, chili was mainly consumed as fresh.

Recent developments in chili production practices have transformed it from subsistence to a commercially and economically viable crop. The transformation started with the adoption of improved chili varieties in the forms of hybrids and open pollinated. In 2002, more than one-half of the chili area was planted to modern varieties. Except in Thailand, the share of hybrids in the modern variety area dominated.

Along with the modern varieties came the intensive and improved crop management practices including higher use of irrigation, fertilizer and pesticide. In addition, higher percentage of seed of these varieties was purchased, making it more likely to meet commercial quality and sanitation standards. Chili now receives a treatment befitting a commercial crop. For example, most chili fields received fertilizer, manure, and chemical treatments against insects and pests, one-fourth were treated against soil-and seed-borne diseases, one-half were plowed with tractor, 65% had raised beds or furrow, 11% were using straw and another 10% were using plastic sheet mulching. In addition, input use such as fertilizer and pesticide was comparable to any commercial crop, and the majority of chili parcels, even in the dry regions of India, were irrigated.

These technological innovations in chili production have generated enormous welfare to farmers and consumers. Estimates suggest that spread of hybrid chili varieties and associated improved management practices in chili cultivation have generated over US$ 1 billion worth of surplus to consumers and producers. Three-forth of this surplus went to consumers as they enjoyed the lower price of chili and another one-forth to producers as modern varieties had reduced production cost for expanded production.

The variation in these management practices across countries and chili types provide ample opportunities to transfer successful experience in one country to another, and study their impact on production. For example, a study on the factors behind a wider scale adoption of seed treatment and plastic mulching in Indonesia and soil treatment in China can help to promote these practices in other countries. More importantly, chili cultivation in different countries at different times of the year can provide an excellent opportunity for regional trade, which is currently at low level within Asia.

By using the photos of insects and diseases during the surveys, the study prioritized farmers' perceptions on major insects, diseases, and weeds in chili crop in each country. Tobacco budworm in China, mites in India, thrips in Indonesia, and caterpillar in Thailand were the most devastating insects in chili fields; Phytophthora blight, viruses, and anthracnose were considered high-ranking diseases by chili farmers. From the analysis of the disease-infected chili material collected from all over Asia, the virology department of AVRDC found that cucumber mosaic virus and chili veinal mottle virus were the most common in the continent. This survey noticed other important diseases previously considered unimportant, such as powdery mildew in India, and fusarium wilt in Thailand. The weeds in chili fields were less common across countries. The locally important insects and diseases should be given priorities in setting the research and development agenda for chili in each region. Not every country has to work on the theoretical aspect of each disease and insect. Each country should focus on its major disease, and can benefit from other countries' work for their major insects and diseases. The AVRDC should focus on adopting and promoting the integrated management diseases approaches, and pyramiding the resistance for multiple pests through breeding.

The use of chemicals on chili crop was quite high. On average, 21 sprays were made by chili-growing countries in Asia, with the highest of 53 in Indonesia. Despite an increasing use of chemicals on chili, the yield losses due to insects and diseases as perceived by farmers did not decrease; rather indications were that such losses in fact increased overtime. For 1998-2002, average losses due to insects and diseases stood at 24% each, the highest in India and lowest in China. The losses were generally higher in open pollinated improved varieties. This has raised a serious challenge for the researchers and policy makers especially in the wake of increased adoption of modern varieties. The need to develop integrated pest management strategies to minimize the use of pesticide, or improve the efficacy of the pesticide use has never been this important. Identification of appropriate pesticide and fungicide to control major insects and diseases, optimize application rate and schedule, and development of alternative pest management approaches can reduce pesticide use, and at the same time help reduce yield losses due to insects and diseases. Such identification is urgently needed in Indonesia and India, where the misguided use of same chemical as fungicide and insecticide was very common.

Despite the fact that insects and diseases are serious constraints in chili production, pest resistance was not the top criterion for farmers in selecting chili varieties. Instead, high yield and output prices were the two most important criteria for the farmers in making this selection. This implies that research on insect and disease resistance cannot be sold to farmers without enhancement in yield and incorporation of attributes consumers prefer in chili so that producers can have high prices for their outputs. Effective pest and disease resistance varieties will serve to increase the percentage of the total harvested crop that is marketable, improving net yields and productivity.

The first and second ranking constraints identified by chili farmers in Asia were insects and diseases. Other high-ranking constraints were low and variable prices (variable prices were also partly related with insect and diseases infestation), market problems (like high market and transportation costs) and environment (mainly drought in India and flooding in Thailand and Indonesia). The market agents considered irregular output supplies and lack of capital as major marketing constraints. Economic analysis pointed out high cash costs and high risk involved in chili cultivation as major constraints. Not many chili-growing farmers, however, mentioned cash requirement as a constraint; perhaps they were able to overcome this through borrowing or other income sources. Reduction in chili cash costs, such as for fertilizer and pesticide may however help small farmers to enter in this high-value cultivation. In addition, improved access to credit will not only expand chili production on more efficient farmers, it will bring investment to modernize its marketing and processing chains.

The economic analyses across varieties performed in this study suggested that local varieties were economically less viable than modern varieties in terms of net return, benefit-cost ratio, and per-unit output cost in all the survey countries. Among modern varieties, the choice between open pollinated and hybrids was less clear. In India, open pollinated was economically a better option, while in Thailand and Indonesia hybrids produced greater returns and lower per-unit output costs. The success of releasing low-cost economically-competitive open pollinated improved varieties in India was not widely transferred to small farmers. On the other hand, not very successful open pollinated improved varieties were available in Thailand and Indonesia (as benefit-cost ratio and per-unit production cost of these varieties were not significantly different than the local races), hence farmers resorted to expensive hybrids chili seed. The diffusion of open pollinated (improved) varieties in India need to be enhanced, while in Indonesia and Thailand, the efficiency of research institutes should be improved to enable them to develop economically-competitive open pollinated varieties.

We conclude that expansion of chili cultivation on a large number of farms will have positive impact on overall rural development through enhanced employment and income effect, improved resource use efficiency, spill-over effect to other crops, induced agricultural business activities in rural areas, and improved diet. Moreover, the development benefit will trickle down to socially disadvantaged groups, such as women. However, expansion of chili cultivation has limitations because of its low elasticity. This suggests that strategies to increase the volume of production should be carefully implemented, as this will dramatically decrease its prices therefore affecting the profitability of chili farmers. However, research and policy should continue focusing on reducing the production cost and variability in chili yield and prices. The accompanying increase in production will be adjusted with the adjustment in area under chili cultivation in a few years time. The strategies such as appropriately tailoring its production characteristics to meet consumers taste within the county, and by exploring foreign markets can also improve farmers' income. Grading of the product to improve its uniformity and quality can expand international demand and increase market value of the output as culls may find its use in processed products.

Appendix 1. Photos of Pest and Diseases

Bacteria

Bacterial Spot

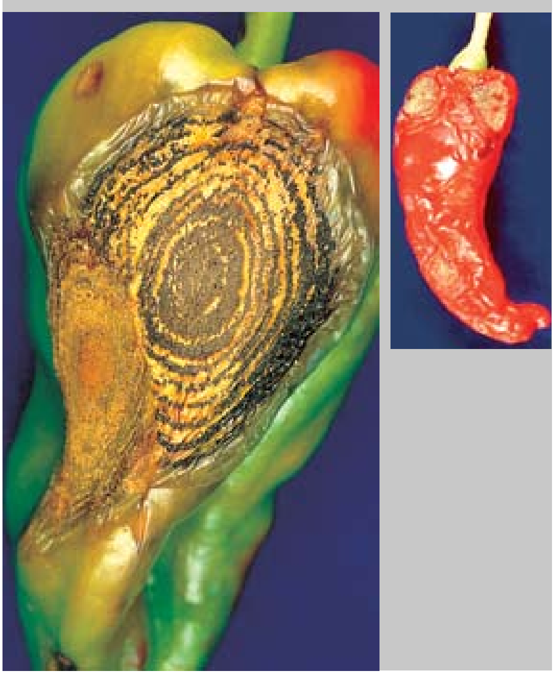
Jaw-fen Wang (AVRDC)

Bacterial Wilt

Jaw-fen Wang (AVRDC)

Fungus

Anthracnose



Tien-chen Wang (AVRDC)

Phytopthora blight

Tien-chen Wang (AVRDC)

Virus

Cucumber Mosaic Virus

Sylvia Green (AVRDC)

Chili Veinal Mottle Virus

Sylvia Green (AVRDC)

Tobamo Virus

Sylvia Green (AVRDC)

Potato Virus Y

Sylvia Green (AVRDC)

Leafcurl Virus

J.K. Brown (University of Arizona)

Tomato Spotted Wilt Virus

John Cho (University of Hawaii)

Insect

Aphids

Lowel Black (AVRDC)

Thrips

Lowel Black (AVRDC)

Mites

Lowel Black (AVRDC)

People's Republic of China

People's Republic of China

Yong Liu, Zhanhong Zhang, Xinqiu Tan, Mei-huey Wu, and Mubarik Ali

Introduction

Chili (*Capsicum annum*) was introduced in China by Spanish and Portuguese traders more than 400 years ago (Chen 2000). Since then, it has become a popular vegetable crop throughout the country. In 2003, chili (green and pimento) was cultivated on 337 thousand ha, with a total production of 12.4 million t (FAOSTAT 2004). The total trade of chili to and from China reached US$128 million. A recent boost in chili production and trade has placed China at the top position in the list of chili-producing and trading countries of the world. Chili is now becoming one of the most economically viable crops in some provinces of China. With its increasing importance in the production system of some provinces, a study to capture the farm, market, and household perspectives is needed. This study was conducted to provide a comprehensive picture of the issues as chili moves from the farm to the household table. The data from secondary sources as well as through surveys from various stakeholders along the chili food chain were used in the analysis.

Along with the expansion in chili production in China, a major shift is occurring across chili producing areas. Until 1995, Hunan province was the main chili production area with 70,000 ha, accounting for almost 80% of the total chili production of China. Since then, the production of chili has spread throughout the country. In 2003, Hainan became the top chili-producing province (Table 1). One of the reasons for this shift was the higher yield obtained in Hainan because of its tropical climate that allows growing two chili crops per year. Generally, yield is higher in the Southern provinces than in the Northern provinces.

Table 1. Regional shares in area, production, and per ha yield of chili in China, 2003

Province	Share in area (%)	Share in production (%)	Fresh yield (t/ha)
Hainan	43.3	64.7	70.0
Hunan	20.0	12.8	30.0
Sichuan	12.0	7.4	29.0
Guangdong	10.0	5.8	27.0
Jiangxi	5.3	3.5	31.0
Jiangsu	3.3	2.0	28.0
Shanxi	3.3	2.1	29.0
Other provinces	2.7	1.8	31.0
Total*	150	7,034	46.9

Source: Official file data from Hunan Vegetable Institute.
*1000 ha unit in area and 1000 t unit in production.

Collection of Farm Data Results

The data for this study was gathered from various stakeholders involved in chili production and marketing. Respondents were chili and non-chili farmers, housewives of the farming households and city dwellers, chili processors, and marketing agents. These data were gathered from major chili producing provinces of China, i.e. Hunan, Sichuan and Guangdong.[1] Three hundred farmers equally distributed across the three provinces were proposed to be interviewed. To provide flexibility for outlier farmers, however, a total of 322 farmers, comprising of 293 (91%) of chili-growing and 29 (9%) of non-chili farmers were randomly selected and interviewed in a three-stage random sampling process explained in the Synthesis chapter (Table 2).

Three hundred and twenty-nine women of farming households and sixty city households were interviewed on chili consumption. Six chili processors and forty-five chili marketing agents were included in the survey.

Table 2. Distribution of sample size by province and type of respondents in China, 2002

Respondent	Hunan	Sichuan	Guangdong	Total
Farmers	105	107	110	322
Chili grower	96	97	100	293
Non-chili grower	9	10	10	29
Farm household wife	110	109	110	329
City household wife	20	20	20	60
Processor	2	2	2	6
Market agent	15	15	15	45

Macro Trends

Domestic Production

Chili production in China increased from 3.9 to 12.4 million t at the rate of 9.7% from 1991-2003. Most of this increase came from the expansion in area from 122 to 337 thousand ha during the same years at an average annual rate of 8.9% (Table 3). The per-ha yield remained almost stagnant. A corresponding increase in the value of chili production from US$359 to 1,365 million was observed, although the price remained fluctuating between US$92 and US$125 per t of fresh weight chili equivalent.

[1] Despite the recent increase in chili production in Hainan province, it was not included in the survey because of the logistic reasons as it lies far away from the collaborating partners based in Hunan.

Table 3. Area, production, and yield of chili in China, 1991-2003

Year	Area (ha)[1]	Production (t of fresh weight)[2]	Fresh yield (kg/ha)	Farm value (million US$)[3]
1991	121,936	3,880,656	31,825	358.80
1992	115,227	4,097,187	35,558	489.70
1993	153,672	5,013,744	32,626	481.07
1994	173,495	5,740,603	33,088	649.82
1995	181,216	6,192,178	34,170	772.59
1996	206,235	7,245,360	35,132	767.63
1997	224,582	7,833,114	34,879	739.28
1998	234,645	8,103,127	34,534	754.62
1999	255,869	8,701,175	34,006	881.08
2000	286,609	10,284,452	35,883	988.65
2001	301,544	10,743,584	35,629	1,084.59
2002	322,000	11,414,871	35,450	1,244.86
2003	337,297	12,448,723	36,907	1,364.83
Growth rate (%)	**8.9**	**9.7**	**0.8**	**9.6**

Source of basic data: FAOSTAT database, 2004.

http://faostat.fao.org/faostat/form?collection=Trade.CropsLivestockProducts&Domain=Trade&servlet=1&hasbulk=0 version=ext&language=E

[1] Area under fresh and green chili reported in FAO statistics was divided by two to represent the year-round area, rather than area under each season.

[2] Area and production include fresh chili and pimento. The production of the latter was reported in ground or dry form, and was converted into fresh weight by multiplying with four.

[3] Estimated using the producers' prices reported in FAO-Agricultural data (producers prices). Prices in local currency were converted into US$ by using the annual average exchange rates reported in www.fftc@agnet.org (various issues).

International Trade

The country's international trade in chili increased exponentially (Table 4). The total volume of trade increased from 134 to 547 thousand t from 1991 to 2003, with the rate of increase in export volume and value higher than that of imports, increasing China's trade surplus. In 2003, the country experienced the largest trade surplus at 524 thousand t earning US$121 million net of import cost. Despite all these positive trends in international trade, most of the chili produced in China was for local consumption, with less than five percent for export.

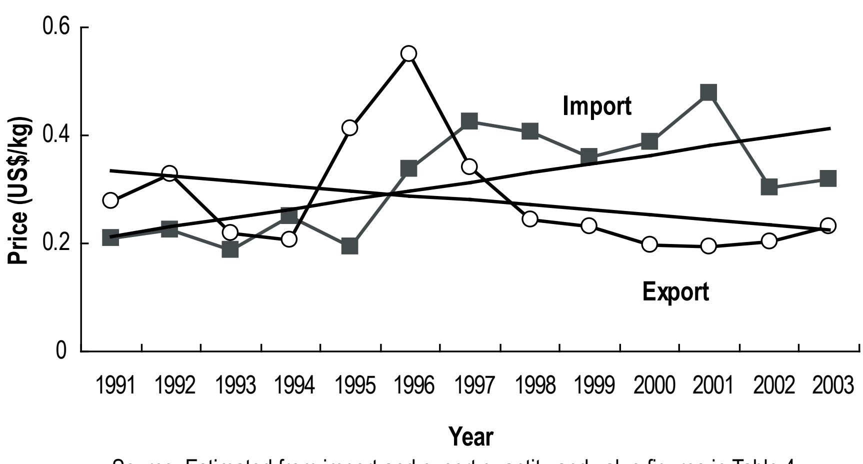
The trade surplus was the result of improved terms of trade for chili as reflected by the widening gap between import and export prices (Figure 1). In the early 1990s, export prices were higher than or equal to import prices. The former jumped to record level in 1996. Since then it continuously declined, finally reaching an even lower level than in 1990. On the other hand, import prices were generally rising. Consequently, export prices fell significantly lower than the import prices. The drop in export prices since 1996 may reflect improvements in chili production and marketing technologies, while increase in import prices may reflect shift in consumers' taste and preferences for better quality chili with improvement in their income. If these trends continue, China is expected to soon become a major player in international chili trade, especially with the trade liberalization regime.

Table 4. International trade in fresh chili, China, 1991-2003[1]

Year	Import		Export		Total trade		Trade surplus	
	Quantity (t)	Value (1000US$)	Quantity (t)	Value (1000US$)	Quantity (t)	Value (1000US$)	Quantity (t)	Value (1000US$)
1991	9,416	1,978	125,002	34,668	134,418	36,646	115,586	32,690
1992	48,021	10,767	138,386	45,405	186,407	56,172	90,365	34,638
1993	5,614	1,044	195,236	43,039	200,850	44,083	189,622	41,995
1994	8,540	2,142	243,210	50,160	251,750	52,302	234,670	48,018
1995	9,664	1,872	167,749	68,891	177,413	70,763	158,085	67,019
1996	12,929	4,341	138,064	76,010	150,993	80,351	125,135	71,669
1997	8,507	3,603	212,952	72,603	221,459	76,206	204,445	69,000
1998	7,117	2,899	237,736	57,886	244,853	60,785	230,619	54,987
1999	9,359	3,346	205,665	47,696	215,024	51,042	196,306	44,350
2000	9,713	3,764	259,982	51,366	269,695	55,130	250,269	47,602
2001	11,235	5,364	352,174	68,820	363,409	74,184	340,939	63,456
2002	10,873	3,280	389,980	78,671	400,853	81,951	379,107	75,391
2003	11,413	3,654	535,289	124,342	546,702	127,996	523,876	120,688
Growth rate (%)	**-2.1**	**3.7**	**9.6**	**6.2**	**8.6**	**5.8**	**10.9**	**6.7**

Source: FAOSTAT Agricultural data.
http://faostat.fao.org/faostat/form?collection=Trade.CropsLivestockProducts&Domain=Trade&servlet=1&hasbulk=0&version=ext&language=EN

[1] Includes fresh chili and pimento. The production of latter was reported in grounded form, which was converted into fresh weight by multiplying it by four.



Source: Estimated from import and export quantity and value figures in Table 4.

Figure 1. Trend in import and export prices of chili in China, 1991-2003

Climate of the Study Area

The climate in the study areas can be classified as sub-tropical in Guangdong province but sub-temperate in Hunan and Sichuan. The monthly average temperature in Hunan and Sichuan can go near freezing point during winter (although the daily temperature can be as low as 15 below freezing). Low temperatures below 10°C prevail for a long period, in November-March in Hunan and Sichuan making crop production activity, especially chili, difficult. In Guangdong, the temperature rarely falls below 15°C. In August, the maximum temperature reaches 25 °C in all the three provinces (Figure 2).

In Guangdong, the rainy season is long and precipitation rate is high. The rainy season in Sichuan is short and comes late in July and August, while precipitation rate in Hunan and Guangdong comes early in May and June. Very little precipitation (including snow) is experienced in Sichuan province in November-March. This precipitation gradually increases and reaches 240-250 mm in July-August. In Hunan and Guangdong, some precipitation or snow starts in February and reaches maximum in May-June. In Guangdong, the high rainfall continues in July-August (Figure 2). This broader rainfall pattern can help spread chili cultivation over time and reduce seasonality in chili supply.

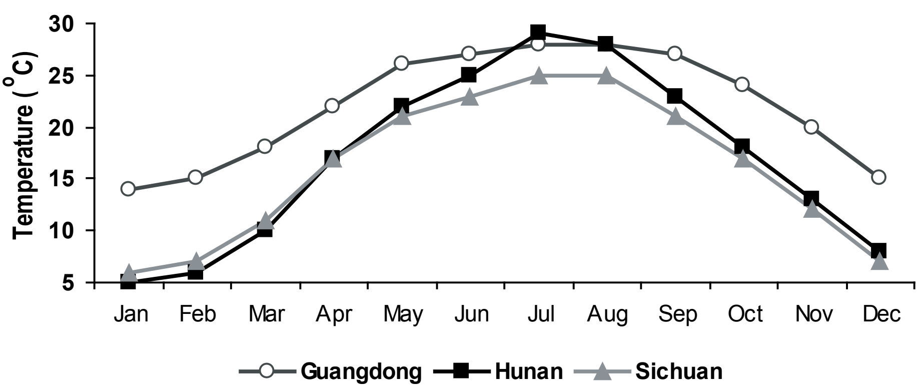


Figure 2a. Mean temperature in the study areas in China

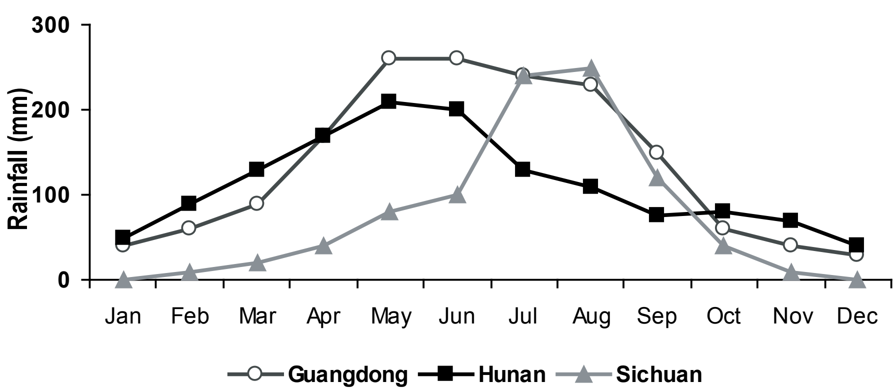


Figure 2b. Mean rainfall in the study areas in China

Source: Downloaded from "http://www.weatherbase.com/weather/city.php3?c=ID&refer=" and then city name

Farm and Farmer Characteristics

Socioeconomics Characteristics

On average, chili farmers had slightly bigger farm size (although the difference is not significant) as they own slightly more land but had lower percentage of cultivable area and land use intensity. Thus, cropping intensity was the same on both farms. Land fragmentation was higher on chili-growing farms. Surprisingly, the education of the chili household head was slightly lower compared to their counterparts in non-chili-growing families. The chili and non-chili farmers were similar with respect to family size, age of farmer, length of farming experience, and distance of their farms to paved road (Table 5).

Table 5. Characteristics of farmers in the sample areas, by farmer type, China, 2002

Characteristic	Chili farmer	Non-chili farmer
Farm size (ha)	0.39	0.30
Owned area (ha)	0.39	0.30
Cultivated area (% of farm size)	87	97
Chili area (ha)	0.10	-
Land use intensity (%)	87.7*	97.3
Cropping intensity (%)	101	102
Land fragmentation (no.)	2.0*	1.8
Farmers have some tenanted land (%)	5.1	6.7
Age of the farmer (year)	40.6	41.2
Education of family (year)	6.8	7.3
Education of household head (year)	7.6*	8.5
Family size (no.)	4.0	3.6
Family labor availability (number)	1.80	1.61
Farmer experience in agriculture (year)	21.3	20.6
Farmer experience in chili production (year)	12.6	0.0
Distance from paved road (km)	0.6	0.5
Distance from vegetable market (km)	3.5	2.9
Off-farm income (Yuan/year)	9,487*	5,986

* implies that the values across the two groups of farmers are significantly different at 10% level.

In terms of living conditions, both chili and non-chili farm households were quite similar in terms of the general condition of the home, construction materials used, house area and area covered, source of drinking water, and means of transportation owned (Table 6). Similar proportion of farmers owned household appliances like television and refrigerator. This indicated that both chili and non-chili farmers in the sample had similar living standards.

Table 6. Household living conditions and possession of appliances of farmers in the sample areas, by farmer type, China, 2002

Assets/appliances	Chili farmer	Non-chili farmer
House condition (% of farmers)		
Below average	7	7
Average	64	69
Above average	30	24
House construction (% of farmers)		
Mud, local stone	7	0
Bricked, cemented	93	100
House area (m^2)	237	204
Covered area (m^2)	136	132
Source of drinking water (% of farmers)		
Government water supply	25	31
Private pump	12	7
Open well/artesian well/others	63	62
Transportation (% of farmers own)		
Motor vehicles	54	62
Bicycle	97	100
Home appliance (% of farmers own)		
TV	97	100
Refrigerator	30	24
Radio/cassette player	44	34

Assets and Farm Machineries

The most commonly available machinery in the area was sprayer followed by tillage machine and water pump (Table 7). In general, both groups possessed similar number of farm machinery, but chili farmers kept more animals, especially pigs, than non-chili farmers.

Table 7. Ownership of farm machinery and livestock inventory of farmers in the sample areas, by farmer type, China, 2002

Farm machinery/livestock inventory	Chili farmer	Non-chili farmer
Farm machinery (number)		
Tractor	0.01	0.00
Water pump	0.26	0.21
Sprayer	1.09	1.07
Tillage machines	0.32	0.21
Livestock (number)		
Bullock and calf	0.29*	0.10
Hen and duck	14.13	15.59
Pigs	3.91*	2.34
Standard Animal Unit (SAU)**	7.50	6.48

* implies that the values across the two groups of farmers are significantly different at the 10% level.

** The SAU was estimated as: 0.93 buffalo + 1.08 cow + 0.5 pig + 0.19 goat + 0.4 young sock+ 0.75 donkey.

Land and Soil

The majority of the sample farms were in the plain fields, irrespective of farm types. They were located away from the river, although a significant proportion was also along the riverbank (Table 8). A relatively higher proportion of non-chili farms had fields away from the riverbank. Based on farmers' perception, most soils in the study area were medium in texture and were well-drained. The distribution of soil texture across the two groups did not vary significantly, although more non-chili farmers had better drained soils.

Table 8. Land form, drainage, and soil texture in the sample areas by farm type, China, 2002

Land and soil type	Chili farm	Non-chili farm
Land form (% of parcels)		
Slope with terrace	4.3	0
Slope without terrace	15.9	18.9
Plain on the river bank	37.8*	24.5
Plain away from the river bank	42.1*	56.6
Soil texture (% of parcels)		
Heavy	0.5	0
Medium	58.5	66.0
Light	41.0	34.0
Drainage (% of parcels)		
Well drained	66.0*	83.0
Medium drained	32.9*	17.0
Poor drained	1.1	0

* implies that the values across the two groups of farmers are significantly different at 10% level.

Varieties and Cropping Patterns

Chili Varieties

The sample farmers planted a number of varieties. Majority of the sample parcels (over 90%) were planted to hybrids (Table 9); Xiangyan19 was the major hybrid variety while Panjiadajiao and Qinyeguangpi were the dominant open pollinated varieties.

Table 9. Chili varieties grown in the sample areas, by chili type,China, 2002

Hybrid		Open pollinated	
Name of variety	Percentage of parcels	Name of variety	Percentage of parcels
Xiangyan19	40.5	Panjiadajiao	50.0
Xiangyan5	14.1	Qinyeguangpi	46.9
Xiangyan9	13.4	Suanjiaoguangpi	3.1
Xiangyan15	11.7	**Total**	**9.7**
Hangyou1	3.7		
Jianggan2	3.7		
Xiangyan21	3.7		
Ningjiao5	2.3		
Xiangyan10	1.7		
Xiangyan11	1.7		
Xiangyan1	1.3		
Xiangyan4	1.0		
Xiangyan2	1.0		
Xuefeng2	0.3		
Total	**90.3**		

Intercropping in Chili Fields

Almost all hybrid chili growers practiced single cropping, while open-pollinated growers practiced intercropping and relay cropping on a very limited scale only (less than one percent).

Cropping Pattern

Only one crop per year was planted in the chili fields. Farmers usually follow chili-chili rotation for many years (Table 10). Hybrids were planted and harvested earlier than the open pollinated varieties - cultivation period (from nursery to harvest) was last week of December to the second week of October in hybrids, compared to the third week of February to the fourth week of November in open-pollinated varieties.

Table 10. Chili-based crop rotations in the sample areas, by chili type, China, 2002

Chili farmer	Planting time (week and month)	Harvesting time (week and month)	
		Starting date	Ending date
Hybrid	4th December	4th May	2nd October
Open pollinated	3rd February	1st July	4th November
Overall	2nd January	1st June	2nd October

Chili was one of the major crops grown on chili farms, occupying about one-third of the farm area, which reduces the area allocated for other crops on these farms. Hence, the shares of cereals, other economic crops, and vegetables were significantly lower on chili-growing farms compared to the non-chili farms (Table 11).

Table 11. Cropping pattern in the sample areas, by farmer type, China, 2002

Crop	Chili farmer		Non-chili farmer	
	Area (ha)	Share (%)	Area (ha)	Share (%)
Chili	0.10	30.0	0.00	0.0
Cereals	0.14	41.0	0.16	53.0
Commercial crop	0.01	4.3	0.04	12.2
Other vegetables	0.05	16.5	0.07	25.2
Beans	0.00	0.0	0.00	0.8
Others	0.03	8.2	0.03	8.8
Total	0.34	100.0	0.30	100.0

Note: Cereals include rice, potato, corn, taro; Commercial crops comprise of cotton, and sugarcane; Beans include French bean; Other vegetables are brassica, watermelon, eggplant, lettuce, bitter gourd, pumpkin, fragrance melon, sponge gourd, cucumber, rape, and other unspecified vegetables; Others include fruit trees, and horticulture seedling.

Source of Information and Chili Variety Selection

Seed

The major source of information on new varieties of seeds was fellow farmers, extension agents and seed retailers (Table 12). There is a need to improve farmers' contact with extension agents so that the farmers can get unbiased information on varieties.

Table 12. Source of information on seed by farmers in the sample areas, by chili type, China, 2002

Source of information	Chili farmer (%)	
	Hybrid	Open pollinated
Extension agent	28	0
Farmer	31	0
Seed center	17	0
Seed retailer	24	0
Own farm	0	100

Selection of Chili Variety

Variety selection was affected by many factors. Farmers ranked five major factors according to degree of importance; market price and per ha yields were considered the most important irrespective of chili types (Table 13). In case of green and powder type chilies, per ha yield was given the highest priority, while in red and sweet chilies market price was the most important factor. Other factors having importance in variety selection were resistance to disease and insect attack, appearance, hardness and thickness of the flesh.

Table 13. Ranking of factors in the selection of chili variety in the sample areas, China, 2002

Characteristics	Overall rank			
	Green	Red	Sweet	Powder
Market price	2	1	1	2
Yield	1	2	2	1
Disease free	3	4	3	-
Insect free	4	5	4	-
Appearance	5	3	5	3
Thick flesh	-	-	-	5
Hardness	-	-	-	4

Note: Highest rank =1; lowest rank =5.

Chili Market Information

Farmers obtain information on chili output, such as price and technology, mainly from neighboring farmers and traders (Table 14). Government agencies were also important sources, particularly for open pollinated chili. Television and cooperatives were relatively less important information sources.

Table 14. Source of chili marketing information of farmers in the sample areas, by variety, China, 2002

Chili Variety	Source (% of farmers)						Rank					
	Neighbor farmer	News-paper	Trader	TV	Radio	Other	Neighbor farmer	News-paper	Trader	TV	Radio	Other
Hybrid	37	29	13	9	5	6	1	2	3	4	5	6
OP*	30	30	23	11	5	0	1	2	3	4	5	0
Overall	36	29	15	9	5	6	1	2	3	4	5	6

*OP= open pollinated.

Insect and Disease Problem

Insects

All farmers reported insects as a problem in both open pollinated and hybrid chili types. In terms of frequency of occurrence as well as farmers' perception, tobacco budworm was the most important insect in both farm types, followed by mites in hybrid and aphids in open pollinated varieties (Table 15). Other important insects on hybrid type chili were aphids and thrips, while mites were the third ranking insects in open pollinated type. Average losses due to insect attack were relatively low at 6.5% per crop season compared to that in other countries like India, Indonesia and Thailand. Although these losses had reduced from eight percent in the last five years, insect phenomenon remained a regular occurrence through out the period.

Table 15. Major insects in chili as perceived by farmers in the sample areas, by chili type, China, 2002

Chili variety	Farmers reporting insect attack (%)					Rank[1]				Occurrence (year out of 5)		Average losses (%)	
	Thrips	Aphid	Mites	Tobacco budworm	Other	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	6.4	18.9	23.8	50.5	0.5	C	M	A	T	5	5	8.2	6.5
Open pollinated	0.0	26.8	17.0	56.3	0.0	C	A	M	-	5	5	6.8	6.6
Overall	5.7	19.7	23.1	51.1	0.4	C	M	A	T	5	5	8.0	6.5

Note: A=Aphid (*Aphis gossypii* and *Myzus persicae*); C= Tobacco budworm (*Heliothis* sp.); M=Mites (*Polyphagotarsonemus latus*); T=Thrips (*Scirtothrips dorsalis*).

[1] The rank of 1 is the most devastating and 4 the least devastating insect.

Diseases

All farmers also reported disease epidemic on their chili fields. Most farmers identified the infestation of *Phytophthora* blight, anthracnose and viruses[2] in chili fields ranked in that order of importance both in open pollinated and hybrid varieties (Table 16). Similar with insect attack, average losses due to diseases also decreased from about eight percent in 1993-1997 to seven percent in 998-2002 mainly in hybrid type chili. However, these losses should be carefully extrapolated for whole China, as the sample did not include the main chili growing areas in the tropics like Hainan where losses may be higher. Occurrence of diseases remained a regular phenomenon every year.

[2] Farmers were not able to identify the specific virus or its principal vector attacking their chili crops.

Table 16. Major diseases in chili as perceived by farmers in the sample areas, by chili type, China, 2002

Chili variety	Farmers reporting diseases (%)					Rank[1]				Occurrence (years)		Average losses (%)	
	PH	AN	VR	BW	Other	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	30	26	20	13	12	PH	AN	VR	BW	5	5	8.3	6.9
Open pollinated	34	33	28	1	4	PH	AN	VR	-	5	5	6.5	6.9
Overall	30	26	21	12	11	PH	AN	VR	BW	5	5	8.1	6.9

Note: AN= Anthracnose (*Colletotrichum acutatum*, *C. capsici* and *C. gloeosporioides*); BW=Bacterial wilt (*Ralstonia solanacearum*); PH=Phytophthora blight (*Phytophthora capsici*); VR=Viruses.
[1] The rank of 1 is the most devastating, and 4 the least devastating disease.

Similar with insects and diseases, farmers also faced weed problems every year. The average loss due to weeds was about two percent, and remained the same over time (Table 17). The most common weed, both in hybrid and open pollinated types was *Echinochloa crusgalli*. This weed was also ranked first in terms of its devastating effect on chili, followed by *Portulaca oleracea* in hybrid, and *Cyperus difformis* in open pollinated chili type.

Table 17. Major weeds found in chili fields in the sample areas, by chili type, China, 2002

Chili variety	Farmers reporting (%)*						Rank[1]				Occurrence		Average loss (%)	
	EC	PO	DI	CY	SE	OT	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	20.3	17.6	16.0	11.7	11.7	22.6	EC	PO	DI	EL	5.0	5.0	2.2	2.1
Open pollinated	25.4	13.1	10.7	18.9	2.5	29.5	EC	CY	PO	EQ	5.0	5.0	2.7	2.4
Overall	20.8	17.1	15.4	12.5	10.8	23.3	EC	PO	DI	EL	5.0	5.0	2.3	2.2

Note: EC=*Echinochloa crusgalli;* PO=*Portulaca oleracea L.;* DI=*Digitaria sanguinalis;* CY=*Cyperus difformis;* EL=*Eleusine indica;* EQ=*Equisetum ramosissimum desf;* SE=*Setaria viridis*; OT=Other.
[1] The rank of 1 is the most devastating, and 4 the least devastating weed.

Farm Management Practices

Preparation of Seedling Nursery

All respondent farmers prepared nurseries or purchased seedlings and none used direct seeding method to grow chili. Nursery was started in winter in December and took until March to attain the required size due to low temperature. Nurseries were prepared in special houses with special heating facilities, tremendously increasing the cost of seedling in China.

Overall, 61% of farmers purchased seeds, 29% used purchased seedlings, and the remaining 10%, all open pollinated farmers, used home-produced seeds (Table 18). About one-third of farmers cultivating hybrid varieties purchased seedlings and the rest purchased seeds.

Table 18. Seed source of farmers in the sample areas, by chili variety, China, 2002.

Chili type	Percentage farmers using (percentage)		
	Purchased seed	Own-farm produced seed	Purchased seedling
Hybrid	69	0	31
Open pollinated	0	97	3
Overall	61	10	29

Soil Treatment

In the chili-growing areas of China, soil treatment at the nursery was more common than in the field. On average, a little over half of the nursery plots and one-third of the chili fields received soil treatment to control soil-borne diseases (Table 19). Soil treatment in the nursery and field was more common in hybrid varieties. The soils were treated mainly using broadcast method both in the nursery and field, although few hybrid-growing farmers adopted spray and other methods as well.

The most commonly used chemicals for soil treatment were Carbendazim and Quintozene (fungicides) and lime (to improve soil health). The quantity of chemicals applied per ha was many times more in the chili fields than in the chili nursery. Quantity of soil chemical treatment in nursery soils was more than three times higher in hybrids than on open pollinated varieties. In case of field treatment, the difference in quantity applied between the two varieties was significant but not great.

Table 19. Soil treatment (% of farmers) method and quantity of chemicals applied in the nursery and field in the sample areas, by chili variety, China, 2002

Treatment method	Hybrid		Open pollinated		Overall	
	Nursery	Field	Nursery	Field	Nursery	Field
Broadcast	38	35	38	24	38	33
Spray	9	1	0	0	8	1
Others	6	2	0	0	5	2
Total	53	38	38	24	51	36
Quantity of treatment (kg/ha)	157	1,100	44	858	146	1,080

Seed Treatment

Overall, less than one-fourth of farmers treated chili seeds (Table 20). The treatment was more common in open pollinated than in hybrid chili type. The seed was soaked for about five hours in hybrids and less than two hours in open pollinated varieties. A few farmers also dusted chili seed with fungicide or insecticide. The most commonly used chemical for dusting was Fludioxonil, a fungicide.

Table 20. Seed treatment (% of farmer) method in the sample areas, by chili variety, China

Chili variety	Soaking	Dusting	Overall
Hybrid	17	6	23
Open pollinated	29	3	32
Overall	18	5	23

Plowing

All chili farmers plowed their fields before cultivation (Table 21). Majority of the fields were plowed manually or by animals. The use of tractor was rare. The frequency of animal use for land preparation was highest for open-pollinated chili type. On average, only one plowing was done.

Table 21. Land preparation method practiced in the sample areas, by chili type, China, 2002

Chili type	Percentage of parcels									Number of operation	
	Plowing					Harrowing				Plowing	Harrowing
	Hand	Animal	Tractor	Others[1]	Total	Hand	Animal	Others[2]	Total		
Hybrid	52	43	5	*	100	66	6	1	73	1.0	0.8
OP[3]	23	74	0	3	100	74	13	0	87	1.1	0.9
Overall	49	46	4	1	100	67	6	1	75	1.0	0.8

* implies less than 0.5 percent.
[1]This includes hand+animal and hand+tractor; [2]This includes tractor and hand+animal; [3]Open pollinated.

Harrowing was done mainly by hand both in the open pollinated and hybrid chili types. The use of animals or other draft power for harrowing was very limited. On average, only one harrowing was done.

Bed Type

All sample farmers planted the crop in furrows or on raised beds. About one-half of the hybrid parcels had raised-beds and the remaining were of furrow type, while the majority of open pollinated fields had raised-beds. The plant-plant distance in open pollinated chili was also more than double that in the hybrid type possibly due to the bushy nature of open pollinated chili plants and straight and less vegetative nature of hybrid varieties. (Tale 22). The average height of raised-bed and furrows was estimated at 26 cm and width at 158 cm. There was no difference in the dimensions between raised-bed and furrows. Average inter-plant distance was estimated at 29 cm. The growers of open pollinated varieties make relatively bigger seedbed compared with those made for hybrid varieties.

Table 22. Bed type, dimensions, and inter-plant distance of chili plants in the sample areas, by chili variety, China, 2002

Chili variety	Bed type (% of farmer)		Height (cm)	Width (cm)	Plant to plant distance (cm)
	Furrow	Raised bed			
Hybrid	48	52	25	158	26
Open pollinated	10	90	32	165	54
Overall	43	57	26	158	29

Mulching, Staking, and Tunneling

About one-third of chili farmers practiced mulching, both in hybrid and open pollinated type of chilies (Table 23). In open pollinated chili type, simple straw was used as mulching material, while in hybrid different mulching materials were used. One-third of the mulching materials was nylon net or black poly-woven fabrics. Foil or plastic sheeting was also used in hybrid chili type either alone or in combination with straw or sawdust. A few hybrid parcels received only straw or sawdust mulch. The average life of foil and nylon net was about one year.

Table 23. Use of mulching material (% of farmer) in chili cultivation in the sample areas, by chili variety, China, 2002

Material type	Hybrid	Open pollinated	Overall
Farmer used mulching	33.5	30.0	33.2
Rice straw	3.6	30.0	6.8
Sawdust	8.6	0	7.6
Foil (plastic sheeting)	5.0	0	4.4
Nylon nets	11.3	0	10.0
Straw + foil	3.2	0	2.8
Sawdust + foil	1.8	0	1.6

Very few farmers (3 out of 322) used bamboo sticks or wooden stakes for the hybrid varieties (Table 24). These were nearly half meter long and pegged at a 38-cm distance, thus the number of sticks used per hectare was more than 52 thousand. The sticks lasted for only one year.

Plastic films and plastic nets were used for making tunnel in chili fields in the study areas. The use of plastic films was more common among hybrid chili growing farms while plastic nets were more commonly used for open pollinated variety fields. The size (height, width and length) of tunnels was bigger in hybrid than in open-pollinated chili fields. The average lifespan of the tunnels for hybrid and open pollinated variety was three years and one year, respectively.

Mulching and tunnel construction mostly went together. For example, only 10% of parcels had tunnels without mulch, while 37% of fields had tunnels with mulch. About 29% of the fields were mulched without tunnels, and 24% parcels had no tunnels and no mulching.

Table 24. Tunnel material type, life, and size used in the sample areas, by chili variety, China, 2002

Chili variety	Tunnel material type (% of parcels)		Tunnel life (year)	Tunnel size (m)		
	Plastic film	Plastic nets		Height	Width	Length
Hybrid	46.9	6.6	3.2	1.7	3.9	13.4
Open pollinated	10.0	36.7	1.0	0.4	1.7	4.8
Overall	42.6	10.2	3.0	1.6	3.6	12.5

Fertilizer Application

In China, almost all chili farmers applied both organic and inorganic fertilizers. Poultry manure followed by green manure were the most common applied organic fertilizers. (Table 25). Only a very small percentage of farmers in hybrid fields (less than one percent) used cattle manure. All farmers applied manure before transplanting of seedling.

Different methods of inorganic fertilizer application were used. In hybrid chili, half of the farmers used fertilizer placement method, while broadcast was the dominant method in open pollinated chili.

Table 25. Use of manure types and method of inorganic fertilizer application (% of farmer) in the sample areas, by chili variety, China, 2002

Chili variety	Organic fertilizer or manure (% of farmers)					Method of inorganic fertilizer application (% of farmers)			
	Cattle	Poultry	Green	Mixed	Total	Broadcast	Placement	Irrigation	Total
Hybrid	0.4	76.7	15.7	5.0	97.7	37	48	15	100
Open pollinated	0	93.6	3.2	3.2	100.0	44	27	29	100
Overall	0.3	78.5	14.3	4.8	98.0	37	46	17	100

Weeding

Weeds were removed manually from all open pollinated and 85% of hybrid chili fields (Table 26). On average, weeding in open-pollinated fields was done thrice, and twice in hybrid type fields. Most farmers (about two-thirds) believed that manual weeding is only partially effective, controlling 50% of weeds. Only three percent of farmers in hybrid and no one in open-pollinated fields believed that the weeding method they use was 100% effective.

Table 26. Extent, method, and perceived effectiveness of non-chemical weeding in the sample areas, by chili variety, China, 2002

Chili variety	Parcels received weeding (%)	Number of weeding	Method (% of farmers)		Effectiveness (% of farmers)		
			Manual weeding	Others	100%	75%	50%
Hybrid	85	2.1	98.7	1.3	2.9	26.3	69.8
Open pollinated	100	3.2	100.0	0	0	51.6	48.4
Overall	87	2.3	98.8	1.2	2.5	29.7	67.0

All farmers also used herbicide to control weeds. Over 90% of farmers applied herbicide (generally Glyphosate) using backpack sprayers (Table 27). Majority of farmers (97%) thought that the use of herbicide was only 75% effective.

Table 27. Method of herbicide application and its perceived effectiveness in the sample areas, by chili variety, China, 2002

Chili variety	Method of application (% of farmers)			Effectiveness (% of farmers)	
	Broadcast	Spray	Other	100%	75%
Hybrid	1.9	92.7	5.4	2.9	97.1
Open pollinated	9.7	90.3	0.0	3.2	96.8
Overall	2.7	92.5	4.8	2.9	97.1

Irrigation

In China, chilies were generally grown under good irrigated environment. However, more than one-fourth of open pollinated and 14% of hybrid chili parcels were rainfed (Table 28). The main sources of irrigation were natural flow mainly in mountainous areas and near the riverbanks and built canals. Open pollinated varieties were irrigated mainly through built canal systems, while both built and natural canal systems were used in hybrids. Around 60% of chili fields were irrigated by flooding method but without making ridges, and almost all the remaining parcels were irrigated by flooding with ridges. Only a few parcels in hybrid varieties received manual or sprinkle+trickle irrigation.

Table 28. Irrigation methods and sources in the sample areas, by chili variety, China, 2002

Chili variety	Method (% of parcels)				Source (% of parcels)				
	Flooding without ridges	Flooding with ridges	Others[1]	Rainfed	Natural canal	Built canal	Tube well	Tank	Others[2]
Hybrid	61	22	3	14	39	30	5	11	2
Open pollinated	58	13	0	29	3	48	13	0	6
Overall	61	21	2	16	35	32	5	10	2

[1]Others include manual and sprinkle+trickle.
[2]Others include combined source, such as built canal+natural canal+tube well.

Insect Control

All parcels were applied with insecticides using backpack sprayers, suggesting the seriousness of insect problem in chili production. On average, insecticide applications were found to be only 75% effective. The most commonly applied insecticides are shown in Table 29. The list of other types of insecticides, used by about one-third of sample chili growers, and their frequencies are reported in Appendix 1. On average, each farmer used three different types of pesticides, often a single product per spray, as mixing of insecticide is not common in China.

Table 29. Application of major insecticide in chili fields in the sample areas, by farmer type in China, 2002

Item	Farmer type		
	Hybrid	Open pollinated	Overall
Insecticide use (% of parcels)	100	100	100
Effectiveness (%)	75	75	75
Major insecticide (% of parcels)			
Methomyl	15	9	15
Dicofol	14	18	15
Chlorfluazuron	14	20	15
Chlorpyrifos+cypermethrin	12	12	12
Chlorfenapyr	12	16	13
Others	32	24	31

Disease Control

Overall, only two percent of chili parcels, or 13% of open pollinated chili type fields, did not receive fungicide application, again emphasizing the importance of diseases control in chili cultivation. Average number of sprays received by each parcel was around five.

In China, unlike in other countries, fungicides were distinctly different from insecticides. Five chemicals were the most commonly applied fungicides (Table 31). About one-third of sample chili growers applied other fungicides other than these five (Appendix 2).

On average, each farmer used three different fungicides. Mixing of fungicide in single spray was also not common in China. Again, farmers perceived that average effectiveness of fungicide application in controlling diseases was only 75% (Table 30).

Table 30. Extent of fungicide use and its perceived effectiveness on chili in the sample areas, by farmer type, China, 2002

Item	Farmer type		
	Hybrid	Open pollinated	Overall
Fungicide application (% of parcels)	100	87	98
Effectiveness (%)	75	75	75
Major fungicide (% of parcels)			
Carbendazim	17	10	16
Mancozeb	15	18	15
Thiophanate-methyl	13	12	13
Moroxydine hydrochloride+copper acetate	12	7	11
Metalaxyl	12	8	11

Traditional Method of Pest Control

More than one-half of farmers growing hybrids and three-fourths of farmers growing open pollinated varieties used traditional method of insect and disease control, the most common of which were more frequent picking and adjusting crop rotation, respectively (Table 31). More frequent picking in open pollinated-type chili and early sowing in hybrid chili were also popular. A combination of several management practices was adopted by a significant number of farmers.

Farmers' perceived 20-49% effectiveness of various traditional methods in controlling the insects and diseases. Overall, they perceived that it could control 36% of insects and diseases in hybrids and 26% in open pollinated varieties.

Table 31. Traditional farm management practices and their perceived effectiveness to control pests in the sample areas, by chili type, China, 2002

Management practice	Percentage of farmers			Effectiveness (% of farmers)		
	Hybrid	Open pollinated	Overall	Hybrid	Open pollinated	Overall
Often picking	29.0	22.6	28.3	38	25	36
Early sowing	8.4	0	7.5	49	-	49
Weed control	0.8	3.2	1.0	25	25	25
Increase irrigation	0.4	0	0.3	25	-	25
Decrease irrigation	3.8	0	3.4	20	-	20
Rotation	0.4	32.3	3.8	25	25	25
Others	0.4	6.5	1.0	25	25	25
Combine	9.2	12.9	9.6	32	31	32
Overall adoption	52.3	77.4	54.9	36	26	35

Havesting

On average chili were harvested 18 times in hybrid and about 16 times in open pollinated type chili. Almost 100% labor for harvesting was family labor (Table 32).

Table 32. Number of harvests and type of labor used in chili harvesting in the sample areas, by chili variety, China, 2002

Type of chili	Number of harvest	Labor type (% of parcels)		
		Family	Hired	Both
Hybrid	18.4	99.2	0.4	0.4
Open pollinated	16.2	100.0	0.0	0.0
Overall	18.1	99.4	0.3	0.3

Marketing

Farmers

About one-half of chili harvest of both open pollinated and hybrid types was sold directly to middlemen who collected these from farmers' fields (Table 33). A significant proportion of the output, particularly in open pollinated type, was also directly sold to consumers. About one-fourth of the hybrid and seven percent of open pollinated chili was sold in the local market. Only a small proportion of the output went directly to the main market. This suggested that chili farmers were poorly connected with the main markets of urban areas and relied mainly on middlemen.

Table 33. Market outlet for chili (% of farmer) in the sample areas, by chili variety, China, 2002

Chili type	Local market	Main market	Middlemen	Consumer picked at farm	Others
Hybrid	23	2	51	19	5
Open pollinated	7	4	51	38	0
Overall	21	2	51	21	5

Uncertain and low chili prices (and demand) were the major marketing constraints expressed by about 72% and 22% of farmers, respectively.

Market Agents and Processors

Market agents look at chili price as the first criterion, followed by appearance, and freshness, while processors who make chili powder use hotness as the first criterion, followed by price and color attributes, in that order (Table 34).

Table 34. Ranking of chili characteristics preferred by market agents and processors in the sample areas, China, 2002

Characteristics	Market agent		Processor (for chili powder)
	Green (for fresh)	Red (for powder)	
Price	1	1	2
Appearance	2	2	-
Freshness	3	3	-
Softness	3	4	5
Thick flesh	4	-	-
Fruit surface	5	-	-
Color	-	5	3
Fragrance	-	-	4
Hotness	-	-	1

Note: Highest rank =1; lowest rank =5.

Input Use

Seed Rate

Open pollinated chili farmers used about 1 kg/ha of seeds while hybrid farmers used only 300 grams per ha (Table 35). Similarly, for farmers using seedling, more were needed for open pollinated compared to hybrid chili. High cost and better germination rate of hybrid seed and difference in the nature of plant in each variety might have contributed to these.

Table 35. Seed rate and seedling number used in the sample areas, by chili variety, China, 2002

Chili variety	Seed rate (kg/ha)			Seedling (number of plants/ ha)
	Owned	Purchased	Average	
Hybrid	-	0.3	0.3	45,757
Open pollinated	1.0	-	1.0	54,000
Overall	1.0	0.3	0.4	45,855

Fertilizer Use

On average, 24 t/ha of farm manure was applied to chili, 23 t of which was poultry manure. Open pollinated chili varieties applied 73% more manure than hybrids (Table 36).

Overall, 914 kg/ha of inorganic fertilizer nutrients were applied on the sample chili farms. Open pollinated fields were applied with significantly higher amounts of phosphorus. However, the difference in the use of overall fertilizer nutrient across the two varieties was insignificant. As plant population in hybrid variety fields was lower that in open pollinated chili fields, the hybrid type may be receiving higher fertilizer nutrient quantities per plant.

Table 36. Organic and inorganic fertilizer types and quantity used in chili fields in the sample areas, by chili variety, China, 2002

Chili variety	Organic fertilizer or manure (kg/ha)					Inorganic fertilizer (kg/ha)			
	Cattle	Poultry	Green	Mixed	Total	N	P	K	Total
Hybrid	29	21,077*	131*	858	22,094*	455	282*	164	901
OP[1]	0	36,895	24	1,200	38,119	488	345	192	1025
Overall	26	22,751	119	894	23,790	458	289	167	914

The * on the figures in the hybrid row implies that these figures are significantly different than that of the corresponding figure in the OP row at 10 percent level.
[1]Open pollinated.

Use of Chemicals

Growers of open pollinated chili varieties applied nearly twice as much insecticide as the hybrid growers. The number of sprays was also significantly higher in open pollinated type chili (Table 37).

Table 37. Quantity of pesticides and number of sprays used in chili fields in the sample areas, by chili variety, China, 2002

Chili variety	Insecticide		Fungicide		Herbicide	
	Quantity (kg/ha)	Spray (no.)	Quantity (kg/ha)	Spray (no.)	Quantity (kg/ha)	Spray (no.)
Hybrid	21.6	6.5	17.3	5.2	19.1	2.09
OP[1]	42.2*	7.5*	25.3*	4.7^{ns}	17.5^{ns}	1.68*
Overall	23.8	6.8	18.2	5.1	19.0	2.05

* implies the number is significantly different across the two varieties, and ^{ns} implies the values are similar at least at 10 percent level.
[1]Open pollinated.

The average quantity of fungicide applied to chili was also significantly higher in open pollinated than in hybrid chili. However, the difference in the number of sprays was not statistically significant at 5% level. Again, the difference in fungicide use for the two types of chili remained striking even when quantities were estimated on per plant basis. This means that the open pollinated chili varieties may also be more vulnerable to disease attack.

On average, 19 kg/ha of herbicide was used. No significant difference in the application of herbicide quantities on hybrid and open pollinated chili was observed. However, the number of herbicide sprays was significantly higher on hybrid than in open pollinated varieties.

Irrigation

On average, hybrid chili fields were irrigated three times and only twice in open pollinated fields for the whole duration of the chili-growing season

Labor

On average, 482 labor days/ha were required for chili cultivation (table 38). Hybrids required 15% more labor than the open pollinated type, mainly for harvest and post-harvest operations. Labor requirements in chili cultivation were four times more than that in rice, especially in harvest and post-harvest operations. In land preparation and crop management operations, the percentage shares of labor requirements were lower in chili than that in rice, but higher in terms of actual man-days.

In chili operations, about 50% of labor was devoted to management, 20% each for harvest and post-harvest, and 12-14% for land preparation.

Table 38. Distribution of labor among different activity groups in chili and rice production in the sample areas, China, 2002

Chili variety/ rice	Percentage distribution				Total labor (day/ha)
	Land preparation	Management	Harvesting	Post-harvesting	
Hybrid	11.6*	46.9	23.0*	18.6	489
Open pollinated	14.0	50.1	18.8	17.1	425
Overall	11.8*	47.2*	22.5*	18.4*	482*
Rice	20.4	58.3	9.3	12.0	112

The * in hybrid row implies that the value for hybrid is significantly different from that of open pollinated at 10% level. Similarly, the * in the overall row compares the values of chili and rice.
Note: For the definition of activities included in each group, please see the synthesis chapter.

Chili cultivation in China was mainly a family affair, hence, source of labor was mostly the family. In hybrids, about 15% of labor for land preparation and five percent for crop management was hired (Table 39). Surprisingly, the proportion of hired labor in chili was lower than in rice.

Table 39. Source of labor in the sample areas, by chili and operation type, China, 2002

Chili type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Hired	Family	Hired	Family	Hired	Family	Hired	Family	Hired	Family
Hybrid	15.5	84.5	4.9	95.1	0.5	99.5	0	100.0	4.2	95.8
Open pollinated	10.7	89.3	0.8	99.2	0	100.0	0	100.0	1.9	98.1
Overall	14.9	85.1	4.5	95.5	0.4	99.6	0	100.0	4.0	96.0
Rice	33.7	66.3	4.2	95.8	12.5	87.5	0.3	99.7	10.5	89.5

[1]The distribution between family and hired labor under each operation adds up to 100.

Production

Per Ha Yield

As already discussed, chili was planted mainly as a sole crop in China; intercropping and relay cropping were practiced at a very limited scale. However, for comparison purpose, the yields of chili as a sole crop, intercrop and relay crop are reported in Table 40.

The overall per-ha yield of chili in the sample area was 37 t, lower than the national average yield of 47 t. These estimates of yield, however, were higher than that reported in macro statistics for these provinces (Table 1). The yield of hybrid chili was significantly higher (about 20%) than that of open pollinated. Regardless of variety planted, yield from chili as an intercrop or relay crop was nearly 20% less than sole-crop chili (Table 40). However, it is not certain how the combined yield of chili and the crop with which it was intercropped was affected by intercropping.

Table 40. Chili yield (t/ha) in various production systems in the sample areas, by chili variety, China, 2002

Chili type	Sole	Intercrop	Relay	Overall
Hybrid	37.1 (0.30)	-	28.5	37.0* (0.30)
Open pollinated	31.6 (0.24)	26.3 (0.14)	-	31.0 (0.24)
Overall	36.6 (0.30)	26.3 (0.14)	28.5	36.5 (0.30)

The * in hybrid chili row implies that the difference in chili yield of hybrids is significantly different that of open pollinated yield at 10 % level. The figures in parenthesis are coefficient of variation in yield.

Grades of Chili and Prices

Chili prices varied depending on the production areas and market types, and fluctuated over seasons. In general, market price was higher in Southern China than in Northern China and for hot chili than for sweet pepper (Liu et al. nd). In the survey areas, chili prices averaged at Yuan 1,107/t, with open pollinated chili of Yuan 1,069/t lower than that of hybrid chili at Yuan 1,112/t, although the difference was insignificant. Grading was not practiced in China and almost all output was sold as mixed.

Economics of Chili Production

Cost and Factor Share

The per ha cost of production of hybrid chilies was 21% higher than the open pollinated varieties (Table 41). Labor accounts for major share in total production cost in both varieties. The share of seed cost was about eight percent for hybrids, while it was less than one percent for open pollinated chili, signifying the high cost of hybrid chili seed. On the other hand, the shares of fertilizer, pesticide, and manure in hybrids were less than that in open pollinated chili; this did not mean, however, that quantities of these inputs were lower in hybrids. The cost of production per kg of chili was about the same for both open pollinated and hybrid varieties.

Table 41. Cost of production and factor share of chili in the sample areas, by chili variety, China, 2002

Chili variety	Total cost (Yuan/ha)	Factor share (%)							Output cost (Yuan/kg)
		Labor	Seed	Fertilizer	Manure	Irrigation	Pesticides	Others	
Hybrid	23,024*	49.5	7.5*	9.6*	2.2*	0.2*	8.1*	22.9	0.66
Open pollinated	19,076	48.0	0.8	13.9	4.2	0.1	10.8	22.2	0.70
Overall	22,607	49.4	6.8	10.0	2.4	0.2	8.4	22.8	0.67

The * in the hybrid row implies that the figure is significantly different with the corresponding figure in the open pollinated row at 10% level.

Returns and Resource Use Efficiency

The per ha gross and net returns from hybrid chili production were 30% and 45% higher than that of open pollinated chili (Table 42). Fertilizer productivity was significantly higher, while the benefit-cost ratio was not significantly higher on hybrids compared to open pollinated type. This meant that fertilizer was more efficient when applied to hybrid varieties. However, additional investments on hybrid or open pollinated type provided almost equal returns.

Table 42. Economics of chili cultivation in the sample areas, by chili type, China, 2002

Chili type	Gross return (Yuan/ha)	Net return (Yuan/ha)	B-C ratio (%)	Labor productivity (Yuan/day)	Fertilizer productivity (Yuan/ kg)
Hybrid	40,687*	17,663*	83	68	84*
Open pollinated	31,222	12,147	73	64	43
Overall	39,686	17,079	82	67	80

The * in the hybrid row implies that the figures is significantly different with the corresponding figure in the open pollinated row at 10% level.

Attractions and Constraints in Chili Production

The major attractions in chili production as perceived by farmers were its profitability, adaptability to climate and soil, farmers' experience in chili growing, tradition in the locality, incentive from the government, and labor availability (Table 43). The ranking of these attractions by farmers revealed that overall profitability, adaptability to climate, and adaptability to soils were the top three reasons for chili cultivation in the study areas. The same was true for growing hybrid chilies. In the case of open pollinated varieties, profitability, followed by tradition and labor availability were the top three reasons for chili cultivation.

Table 43. Ranking of attraction for chili cultivation in the sample areas, by chili variety, China, 2002

Trait	Ranking		
	Hybrid	Open pollinated	Overall
Profitability	1	1	1
Adaptability to climate	2	-	2
Adaptability to soil	3	-	3
Farmers' experience	-	4	-
Tradition of the locality	4	2	4
Government incentive	-	5	-
Labor availability	5	3	5

Note: Highest rank = 1 and lowest rank = 5.

The major constraints to chili production reported by farmers were incidence of insects and diseases, low prices received, poor seed quality, environmental limitations, marketing problems, and inadequate guidance from the Department of Agricultural Extension (Table 44). The overall ranking of these constraints by farmers revealed that diseases, insects and low prices of the produce were the top three constraints. These were also the three major constraints in the production of hybrid chili type, while insects, diseases, and low prices were the three main constraints in open pollinated chili cultivation.

Table 44. Ranking of constraints to chili production faced by sample farmers in the sample areas, by chili variety, China, 2002

Constraint	Hybrid	Open pollinated	Overall
Diseases	1	2	1
Insects	2	1	2
Low price/variability in chili price	3	3	3
Poor quality seed	5	-	-
Environment	-	-	5
Market problem	4	5	4
Inadequate extension	-	4	-

Note: Highest rank = 1 and lowest rank = 5.

Chili Consumption

Per Capita Consumption and Expenditure

Overall per capita consumption of chili in the survey area stood at 363 g per week in fresh weight, or 52 g per day (Table 45). This amounted to more than three times of available amount from domestic production in whole China, implying that consumption in the survey area was significantly higher than in other places in China. This was because chili was consumed as a vegetable supplement dish in this part of the country. The consumption of chili among the chili-growing families was significantly higher than that of non-chili growing farm families and urban dwellers. No significant difference in chili consumption was observed between non-chili growing families and urban dwellers.

Table 45. Relative share of different chili forms and products to total consumption in the sample areas, by consumer type, China, 2002

Type of chili	Quantity share (%) as consumed				Quantity share (%) after converting into fresh weight[3]			
	Chili farmer	Non-chili farmer	Urban consumer	Overall[4]	Chili farmer	Non-chili farmer	Urban consumer	Overall[4]
Green fresh	56.7	46.9	43.5	45.7	46.1	36.7	32.5	35.1
Red fresh	30.1	33.7	32.6	33.2	24.5	26.3	24.4	25.5
Sweet fresh	0.0	0.0	1.7	0.7	0.0	0.0	1.3	0.5
Dry chili	2.6	1.7	2.1	1.8	8.3	5.2	6.2	5.6
Chili powder	2.4	2.6	3.7	3.0	7.8	8.0	11.2	9.3
Chili paste	1.1	3.9	2.9	3.4	1.7	6.0	4.3	5.3
Chili sauce	4.5	4.4	7.0	5.4	7.2	6.9	10.4	8.3
Chili dipping	0.5	0.4	1.4	0.8	0.7	0.7	2.1	1.3
Chili pickle	2.1	5.5	4.4	5.0	3.4	8.6	6.6	7.7

Cont...,Table 45

Type of chili	Quantity share (%) as consumed				Quantity share (%) after converting into fresh weight[3]			
	Chili farmer	Non-chili farmer	Urban consumer	Overall[4]	Chili farmer	Non-chili farmer	Urban consumer	Overall[4]
Other chili products[1]	0.1	1.0	0.7	0.9	0.2	1.6	1.0	1.4
Overall (kg/year)[2]	20.4[a]	14.2[b]	14.8[b]	14.5	25.1[a]	18.2[b]	19.8[b]	18.9

[1]Others include chili curry, chili oil, Sambal and others.
[2]Figures in this row are average per capita chili quantities consumed (kg) over one year. The different superscript in a row implies that the figures are significantly different across consumer types.
[3]Dry and powder chilies were converted into fresh by using the conversion factor of 4. Similarly, chili pickles and paste were converted into chili fresh weight by multiplying the latter with 2.
[4]Overall chili consumption in China was estimated assuming 1%, 60%, and 39% weights for the chili producer, non-chili producer, and urban consumer, respectively.

In the survey areas, about one-third of the fresh chili consumed was green fresh and 25% was red fresh. Chili powder, sauce, and pickles were the main processed chili products, contributing about eight to nine percent of the fresh weight consumption. Dry chili and chili paste contributed less than six percent of the fresh weight consumption. Surprisingly, the share of sweet fresh chili in total chili consumption was insignificant.

On average, Chinese consumers in the sample area spent about Yuan 41/year for chili. There was no significant difference in the expenditure on chili across the three consumer groups. However, chili-growers were making significantly higher expenditure on green fresh and dry chili and lower expenditure on chili paste than that of non-chili growers and urban dwellers. Again the combined expenditure for green fresh and red fresh chili accounted for more than 50% of the total budget for chili (Table 46).

Table 46. Relative share of expenditure (%) of different chili forms and products in the sample areas, by consumer type, China, 2002

Type of chili	Chili farmer	Non-chili farmer	Urban consumer	Overall[2]
Green fresh	37.5	29.2	26.5	28.1
Red fresh	28.5	30.7	30.5	30.6
Sweet fresh	0.0	0.0	2.0	0.8
Dry chili	11.2	6.0	6.8	6.4
Chili powder	9.8	8.5	11.7	9.9
Chili paste	2.6	11.7	4.8	8.7
Chili sauce	6.6	5.5	7.5	6.4
Chili dipping	1.2	1.6	5.1	3.0
Chili pickle	1.9	3.1	3.3	3.2
Other chili products[1]	0.8	3.8	1.8	2.9
Overall annual expenditure (Yuan/capita)	45.5[a]	39.0[a]	44.7[a]	41.3

[1]Others include chili curry, chili oil, Sambal and others.
[2]The overall chili consumption in China was estimated assuming 1%, 60%, and 39% weights for the chili producer, non-chili producer, and urban consumer, respectively.
Note: The different superscript in a row implies that the figures are significantly different across consumer types.

Retail Value of Chili and its Products

The average price per kg of fresh weight chili and its products was computed to be Yuan 2.2 (US$0.265). This was computed by dividing the expenditure on chili (Table 46) by the amount consumed (Table 45). This amount was about double the farm gate price of Yuan 1.1 estimated earlier. Using the ratio between retail and farmgate prices, the farm gate value of chili in the country at US$1.365 billion (Table 3) was converted into retail value of chili and its products at US$2.71 billion.

Response to Price Changes

Chili powder and chili products had relative low response to price changes compared to red and green chilies. Doubling the prices of chili powder and chili products will bring only eight percent decrease in the quantity consumed, while doubling the prices of green and red chili will bring 18 and 16% decrease in the quantity consumed, respectively (Table 47). Similarly, decreasing the prices of chili powder and product by 50% will increase consumption by only about three percent, while a similar decrease in the prices of green and red chili will increase consumption by eight and 12%, respectively. Consumer response to price changes in red and green chili was similar to cereal crops, while the response for chili powder and chili products was even lower than in cereals.

Table 47. Demand elasticity as perceived by respondent-consumers in the sample areas, by chili type and product, China, 2002

Change in price (%)	Green	Red	Powder	Products
Increase in price				
110	-0.4	-0.3	-0.2	-0.2
125	-2.7	-2.2	-0.9	-0.9
150	-7.8	-6.8	-3.3	-3.3
175	-13.4	-11.5	-5.9	-5.5
200	-18.2	-16.0	-8.0	-7.8
Decrease in price				
90	0.9	1.2	0.0	0.0
75	2.6	5.0	0.6	0.9
50	8.1	11.5	2.9	3.3

Source of Supply

For farmers, green, red, and sweet fresh chilies, dry chili, and other chili products were mainly home-produced or purchased from the local market; chili powder was purchased mainly from the local market, while chili sauce was mainly home-produced (Table 48). On the other hand, urban consumers source chili and its products mainly from local market. However, significant proportions of various chili products were also obtained from cooperative shops or supermarkets in urban areas. The source of a large proportion of processed chili was home, especially among farm families, indicating that there was a significant small-scale chili-based processing activities going in the rural areas of China.

Table 48. Chili buying place (% of total purchase) in the sample areas by consumer type, China, 2002

Chili type	Farmer				Urban consumer			
	Home produced	Local market	Supermarket	Others	Home made	Local market	Supermarket	Others
Green	39.9	54.6	0.2	5.3	0	89.2	10.0	0.8
Red	42.9	52.3	0.2	4.6	0	89.2	10.0	0.8
Sweet	62.5	37.5	0.0	0.0	0	66.7	33.3	0
Dry chili	55.4	41.7	0.0	2.9	0	87.5	10.4	2.1
Chili powder	6.4	90.1	0.5	3.0	0	88.0	12.0	0
Chili sauce	87.9	6.6	1.7	3.8	17.5	41.2	24.6	16.7
Other chili products	53.0	30.8	12.6	3.6	10.7	33.3	51.8	4.2
Overall	45.8	47.9	2.3	4.0	4.5	69.7	22.4	3.4

Chili Attractions in Consumption

Consumers consider good appearance and market price as the first and second criterion, respectively, in buying fresh green and red chili (Table 49). For sweet chili and other products, consumers look at market price first then good appearance second. Other criteria such as pungency, freshness and fragrance were also taken into account, but were ranked lower in selecting chili and its products.

Table 49. Ranking of chili characteristics preferred by consumers in the sample areas, by chili type, China, 2002

Selection criteria	Green chili	Red chili	Sweet pepper	Powder	Other product
Market price	2	2	1	1	1
Overall appearance	1	1	2		2
Hotness/pungency	4	4	3	2	3
Freshness	3	3		3	3
Fragrance			4	4	4

Note: Highest rank=1 and lowest rank=4.

Consumers' Preference for Packaging

Consumers prefer fresh chilies (like green, red) and powder unpacked (Table 50). The main reasons for this included retaining product freshness, visibility, and convenience. Plastic bag packaging was preferred for sweet chili mainly because of its convenience and product visibility. Majority of consumers preferred chili products in glass packaging because of better storability, handling convenience, and product visibility. About 10% of consumers also preferred plastic and tin packaging for various reasons.

Table 50. Consumer preferences for different types of chili packaging in the sample areas, by chili type, China, 2002

Chili type	Packing	Preference (%)	Reason (%)						
			Freshness	Best image	Convenience	Storability	Presentation	Visibility	Other
Green/red									
	Unpacked	89	34	1	26	1	0	37	1
	Paper	3	35	4	39	7	0	11	4
	Glass	0	13	25	13	0	25	25	0
	Plastic	8	20	1	39	4	0	35	2
	Tin	0	0	0	0	100	0	0	0
Sweet									
	Plastic	100	0	0	50	0	0	50	0
Powder									
	Unpacked	73	17	2	42	1	0	36	2
	Paper	5	0	0	50	6	0	44	0
	Glass	6	9	0	24	42	3	18	3
	Plastic	16	13	1	43	9	1	29	4
	Tin	1	0	0	0	60	20	0	20
Product									
	Unpacked	1	33	0	0	17	0	50	0
	Paper	1	25	0	25	25	0	25	0
	Glass	77	12	1	28	39	1	17	1
	Plastic	11	20	2	33	10	5	29	2
	Tin	10	20	1	29	37	8	3	2

Development Impact of Chili Cultivation

Input Demand

Chili cultivation increases demand for labor compared to other field crops like rice. A shift of one hectare of rice to chili cultivation will generate demand for 370 labor days, or an equivalent of 1.7 full-year job (Table 51). This is only for production and does not include the labor requirement for processing. The cost of chili seed was about six times higher than that on rice. Similarly, fertilizer and pesticide use was about double, and manure use was many times more on chili that on rice. However, rice used more than double number of irrigation than chili.

The use of fertilizer in rice by chili farmers was significantly lower than that by non-chili farmers. This partially helped chili farmers spare resources to meet high input demand in chili production. Generally, the use of all other inputs in rice was also low in chili-growing farms, although the difference in the use between the two groups was not statistically significant.

Table 51. Relative per ha input use and cost of chili and its competing crops, China, 2002

Crop	Labor (days)	Seed (Yuan)	Fertilizer (kg)	Manure (t)	Irrigation (number)	Pesticides spray (number)
Chili	482[a]	1,530[a]	914[a]	23.8[a]	3.2[a]	13.9[a]
Rice	112	257	434	0.8	7.8	8.1
Chili farmers	111	255	423*	0.7	7.8	8.1
Non-chili farmers	121	268	535	1.4	7.7	8.0

The superscript [a] in different columns of chili row implies that the mean value of the parameter for chili is significantly different than for rice at 10% level.
The superscript * in chili farmer row implies that the figure is significantly different from the corresponding figure for non-chili farmers at the 10% level.

Resource Use Efficiency

Compared to rice, chili cultivation entailed substantial higher input requirements, especially those purchased in the market. The higher production cost and more liquid demand for chili production than rice limited its cultivation to farmers who has the resources and will to take risks. Although production cost of chili was about four times higher than that of rice, gross revenue was also higher by more than six times, providing a better benefit-cost ratio for investments in chili than in rice (Table 52). Similarly, although individual input-use in chili production was higher than in rice, the efficiency of inputs such as labor and fertilizer was also higher.

Chili cultivation improved efficiency of resources allocated for production, as well as resource use efficiency in other major crops planted in chili farms. This was evidenced by higher efficiency of fertilizer and higher benefit-cost ratio in rice, compared with non-chili farms. Despite similar yields and gross revenues on chili and non-chili farms, low input cost especially due to judicious application of fertilizer by chili farmers explained the difference in resource use efficiency across the two groups.

Table 52. Resource use efficiency in chili and competing crops in the sample areas, by farmer type, China, 2002

Crop	Yield (kg/ha)	Total cost (Yuan/ ha)	Gross return (Yuan/ha)	Net return (Yuan/ha)	B-C ratio (%)	Labor productivity (Yuan/day)	Fertilizer productivity (Yuan/kg)
Chili	36,955[a]	22,607[a]	39,686[a]	17,079[a]	82[a]	67[a]	80[a]
Rice	6,576	5,505	6,505	1,000	23	40	17
Chili farmers	6,587	5,447*	6,525	1,077*	24*	40	18*
Non-chili farmers	6,467	6,072	6,318	246	10	33	12

The superscript [a] in different columns of chili row implies that the mean value of the parameter for chili is significantly different than for rice at the 10% level.
The superscript * in chili farmer row implies that the figure is significantly different than the corresponding figure for non-chili farmer at the 10% level.

Impact on Gender

Overall, about 40% of the labor used in chili production in China were female compared to only 26% in rice, with their contributions in land preparation, crop management, and harvest and post-harvest operations higher than those in rice (Table 53). The percentage of female labor in different operation was generally higher in hybrids than in open pollinated chili type.

Table 53. Labor distribution (percentage) by gender in the sample areas, by chili and operation type, China, 2002

Chili type	Land preparation		Management		Harvest		Post-harvest		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Overall chili	37.2	62.8	28.4	71.6	56.2	43.8	51.0	49.0	39.8	60.2
Hybrid	38.0	62.0	28.3	71.7	56.7	43.3	51.0	49.0	40.2	59.8
Open pollinated	31.9	68.1	28.7	71.3	50.3	49.7	50.3	49.7	36.9	63.1
Rice	24.1	75.9	22.2	77.8	50.9	49.1	47.4	52.6	25.7	74.3

The distribution between male and female under each operation adds up to 100.

Impact on Consumption

Higher income from chili production induced higher food and total expenditures by chili farmers than non-chili farmers, with the former spending nine percent more on food and seven percent on total expenditures than the latter (Table 54). However, the average monthly income, as well as food and overall expenditures of chili farmers were still way below the urban dwellers.

Table 54. Average monthly household income and expenditure in the sample areas, by consumer type, China, 2002

Consumer type	Expenditures (Yuan)		Average monthly income (Yuan)
	Food	Total	
Chili farmers	441[b]	761[b]	1,306[b]
Non-chili farmers	404[c]	709[c]	1,138[c]
Urban consumers	579[a]	1,258[a]	3,166[a]
Overall	461	834	1,581

The different superscripts in a column imply that the figures are significantly different across consumer groups at 10% significance level.

Chili farm families spent more on food compared to non-chili farm families (Table 55). This enabled chili farmers to improve their consumption patterns in the form of enhanced consumption of vegetables, cereals, and fruits, hence improving micronutrient availability for their families. The consumption of all other food items, however, was similar in the two groups.

Table 55. Average daily consumption of different food groups in the sample areas, by consumer type, China, 2002.

Food group	Quantity (g/capita)			
	Chili farmer	Non-chili farmer	Urban consumer	Overall[1]
Cereals	445[a]	416[b]	344[c]	388
Vegetables	342[a]	329[b]	331[b]	330
Fruits	49[b]	34[c]	72[a]	49
Livestock products	71[b]	64[b]	125[a]	88
Seafood	15[b]	17[ab]	24[a]	20
Others	47[b]	53[b]	72[a]	60
Total	968[a]	912[b]	969[ab]	935

Different superscripts in a row imply that the figures are significantly different across consumer groups at 10% level.
[1]The overall chili consumption in China was estimated by assuming 1, 60, and 39 percent weight for the chili producer, non-chili producer, and urban consumer, respectively.

Summary and Conclusion

About 12.4 million t of fresh weight chili was produced in China valued at US$1.4 billion at the farm level. Based on the consumption survey, the estimated chili sector output was worth US$2.7 billion at the retail level. The production of chili in the country increased rapidly in the 1990s' mainly because of expansion in area while yield remained almost stagnant. This expansion in domestic production boosted China's international trade in chili. In 2003, China traded (both import and export) US$128 million worth of chili, and earned US$121 million net of import. The opening up and reform of the Chinese economy and the improvement in the free international trade regime helped bring about this boost. In the wake of increasing importance of chili in several southern provinces of China, this study was conducted to provide a comprehensive look of the chili sector by conducting extensive farm, household, and market surveys in major chili growing areas.

Farmers in the traditional chili-growing areas had similar characteristics with those of non-chili farmers. Hybrid varieties of chili were mostly used, and single chili crop rotation completed in one year was practiced. Management practices adopted on chili cultivation were quite advanced. For example, unlike in other Asian chili-growing countries, all farmers properly prepared raised beds or furrows before transplanting; soil treatment was practiced on a large number of farms; almost all farmers used pesticide for insect and disease control as well as herbicide for weed control. Farmers also used traditional method of insect and disease control, such as crop rotation and frequent harvesting. Almost every farmer applied manure to chili crop in large quantities. Farmers mostly had access to irrigation and canals.

The use of hybrids transformed chili cultivation in China, inducing higher input use, and improving farm management practices. For instance, more hybrid fields had soil treatment, mulched with commercial materials, applied with green manure, and used improved methods of irrigation. These fields were more frequently harvested at shorter intervals between harvests. Although hybrids were treated with fewer chemicals per plant perhaps because they were less prone to insect and disease infestation, they had more irrigation and more labor requirement due to higher yield. Most of all, the cost of hybrid seed was significantly higher than that of open pollinated type chili varieties. Hence, cultivation of hybrids incurred higher costs, but produced higher returns as well. In fact, the resource use efficiency of investment (benefit-cost ratio), and labor and fertilizer productivity were all higher for hybrid chili compared to the open pollinated improved chili varieties.

Improved management practices, use of hybrid seeds, and relatively low temperature led to relatively low losses of yield as a result of insect and disease infestations in China. The cost of raising seedlings, however, increased dramatically under the cold temperature. Farmers rank diseases and insects as the top production constraints, with tobacco budworm, Phytophthora blight, and anthracnose as the major insect pests and virus as the main disease. Farmers perceived low and variable prices of chili as the third constraint. Thus, farmers' preferred new varieties that can give high yield and can fetch high prices.

Chili is mainly consumed as fresh in China. Consumers' response in terms of changing chili consumption with a hypothetical change in chili prices was low (even lower than the elasticity for cereal) implying that it is an integral part of their diet. Overall appearance of green and red chili was an important criterion of consumers in making its purchase. Thus, improving the appearance of chili will help farmers obtain higher prices and enhance profitability. Producers and marketing agencies enhanced their profits by tailoring the packaging of various chili products according to consumer preferences as enumerated in this study.

Chili cultivation can have important impact on the rural development in China. Based on the average farm size, it was estimated that about 1.7 million farm families were engaged in its production throughout the country. Chili production generated a significant demand for inputs, especially fertilizer, pesticide, seed, and irrigation water, thereby encouraging agricultural business activities in rural areas. The shift of farm resources from traditional crops such as cereals to chili cultivation significantly improved resource use efficiency. Farmers also benefited from chili cultivation through improved income and diet. Chili was considered to be a gender-friendly crop.

Despite these advantages, however, expansion of chili cultivation has limitations because of its low elasticity. Demand may be expanded to a certain level by appropriately tailoring its production characteristics to meet consumers taste within the county, and by exploring foreign markets. Grading of produce to improve uniformity and quality can increase international demand and market value as culls may be used in processed products.

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Appendix 1. Frequency of insecticides used on chili, China, 2002

Common name	Number of farmer	Percentage of occurrence
Chlorfluazuron	145	14.8
Dicofol	145	14.8
Methomyl	144	14.6
Chlorfenapyr	125	12.7
Chlorpyrifos+cypermethrin	121	12.3
Deltamethrin	113	11.5
Imidacloprid	73	7.4
Tebufenozide (Mimian)	26	2.6
(Qinchonlike)	19	1.9
(Bisultap)	14	1.4
(Difhlorvos)	13	1.3
(Sumieshading)	11	1.1
Methomyl (Kuailin)	10	1.0
Abamectin (A'weijunshu)	7	0.7
Indoxacarb	6	0.6
Methamidophos	5	0.5
(Yashijing)	2	0.2
(Shamiejuzhi)	2	0.2
(Suanlin)	1	0.1
Phoxim	1	0.1

Note: The names in brackets are brand or local names.

Appendix 2. Frequency of fungicides used on chili, China, 2002

Common name	Number of farmer	Percentage of occurrence
Carbendazim	139	16.5
Mancozeb	143	16.9
Thiophanate-methyl	108	12.8
Moroxydine hydrochloride+copper acetate	97	11.5
Metalaxyl	96	11.4
(Striadimefon)	63	7.5
Chlorothalonil	59	7.0
Copper hydroxide	53	6.3
Amicarthiazol+mancozeb	31	3.7
Fenaminosulf	16	1.9
Fludioxonil	10	1.2
Thiram+ziram	9	1.1
Trichloroisocyanuric acid	3	0.4
(Jingangmycin)	3	0.4
(Kangkuling)	3	0.4
(Likujin)	2	0.2
Quintozen	2	0.2
Difenoconazole	2	0.2
Pyridaben+clofentezine	2	0.2
Isoprothiolane	1	0.1
Carbendazim (Tankexiu)	1	0.1
(Guoqing1)	1	0.1

Note: The names in brackets are brand or local names.

India

India

Maravalalu Chandre Gowda, Mei-huey Wu, and Mubarik Ali

Introduction

Chili is grown all over India. In 2003, it was grown on an area of 945.5 thousand ha with an annual production of 4.5 million t in fresh weight (FAOSTAT-Agriculture). India is one of the largest producers of pimento chili in the world, accounting for over 46% and 44% of its total area and production, respectively. However, its per ha productivity is quite low at 4.7 t in fresh weight compared to China, Turkey, and Pakistan at 25.6 t/ha, 8.9 t/ha, and 7.9 t/ha, respectively. India exported 349 thousand t of fresh weight equivalent chili worth US$62 million. This leaves a net annual per capita availability from domestic sources at about 3.9 kg in fresh weight. Despite the importance of chili in the production system of certain states and Indian diet, no comprehensive study is available on the issues and constraints at its various food chain levels. This study aimed to fill this information gap by conducting interviews and surveys from different stakeholders involved in the food chain, and analyzing secondary data related to its production, consumption, and distribution.

In 1999, Andhra Pradesh, Karnataka, Maharastra, Orissa, Tamil Nadu, West Bengal, Madhya Pradesh, and Rajastan accounted for 90.8% of total area and 92.9% of the total production of pimento chili in the country (Table 1). Its yield in fresh weight ranged from 1.5 t/ha in Madhya Pradesh to 9.4 t/ha in Andhra Pradesh.

Table 1. Area, production and yield of pimento chili by region in India in 1998-1999

Region	Area (1000 ha)	Production (1000 ton)		Yield (kg/ha)	
		Dry	Fresh	Dry	Fresh
All India	891.2	1,043.2	4,172.8	1,171	4,682
Andhra Pradesh	222.5	525.0	2,100.0	2,360	9,438
Karnataka	170.3	146.6	586.4	861	3,443
Maharastra	101.1	57.7	230.8	571	2,283
Orissa	90.0	76.0	304.0	844	3,378
Tamil Nadu	77.2	43.0	172.0	557	2,228
West Bengal	64.4	51.3	205.2	797	3,186
Rajastan	33.9	49.9	199.6	1,472	5,888
Madhya Pradesh	50.0	19.3	77.2	386	1,544
Uttar Pradesh	19.6	15.5	62.0	791	3,163
Gujarat	18.1	18.2	72.8	1,006	4,022
Assam	14.7	9.7	38.8	660	2,639
Bihar	6.1	4.7	18.8	770	3,082
Punjab	4.7	8.0	32.0	1,702	6,809
Manipur	8.8	5.3	21.2	602	2,409
Others	10.4	9.7	38.8	933	3,730

Source: Ministry of Agriculture (2003).

Macro Trends

Domestic Production

Production of fresh weight chili increased from 2.5 million t in 1991 to 4.5 million t in 2003 at an average annual growth rate of 3.3% (Table 3). Most of the increase in production (82%) came from yield enhancement, from 3.0 t/ha to 4.7 t/ha at an average growth rate of 3.2% during the same years. The remaining increase (18%) was attributed to area expansion from 851 thousand ha to 946 thousand ha with an average annual growth rate of 0.5%. The farm value of chili output did not increase at the rate corresponding to production, suggesting some decrease in its nominal price.

Table 3. Trends in area, production, yield, and farm value of chili, India, 1991-2003

Year	Area harvested (ha)	Fresh production (t)[1]	Yield (kg/ha)		Farm value[2] (million US$)
			Fresh[1]	Dry	
1991	851,383	2,512,230	2,951	738	850.96
1992	966,900	3,491,400	3,611	903	873.05
1993	934,830	3,243,900	3,470	868	629.21
1994	834,000	3,222,800	3,864	966	742.36
1995	888,000	3,285,500	3,700	925	931.48
1996	949,200	4,311,000	4,542	1,135	1,331.30
1997	846,300	3,528,000	4,169	1,042	768.52
1998	896,400	4,221,000	4,709	1,177	1,028.03
1999	964,400	4,257,000	4,414	1,104	917.57
2000	913,500	3,930,000	4,302	1,076	847.89
2001	945,500	4,210,500	4,453	1,113	791.60
2002	945,500	4,450,500	4,707	1,177	794.49
2003	945,500	4,450,500	4,707	1,177	866.57

Note: Total area and production includes sweet pepper, which fluctuated between 4.7-5.5 thousand ha and 42-50 thousand t.

[1]This was estimated by multiplying the dry weight reported in the statistics by four.

[2]Estimated using the FAOSTAT-Agriculture (producers' price) data for pimento. The prices of green chili were taken from Sri Lanka prices reported in the same source, as data for India were missing. The prices in local currency were converted using the exchange rate reported in www.fftc.agnet.org (various issues).

Source: FAOSTAT-Agricultural Data (Crop Production).

Primary Data Collection

The survey was conducted in Karnataka and Andhra Pradesh, the two major chili-growing states in India, covering 160 farmers from each state. Five districts in Karnataka (Bellary, Haveri, Gadag, Dharwad, Belgaum) and three districts in Andhra Pradesh (Guntur, Warangal, Khammam) were selected since they had the highest chili growing acreage in each state. The total sample for each state was proportionately allocated to each district depending upon their total chili area. Three villages from each district in Karnataka and four villages in each district of Andhra Pradesh having the highest number of chili-growing farmers were selected in consultation with extension agents in the area. The allocated sample within each district was distributed to each village depending on the total number of chili-growing farmers in each village. Ten to twenty percent of the sample in each village was allocated for non-chili growing farmers depending on the relative share of chili and non-chili crops grown. The chili and non-chili growing sample farmers were randomly selected from each group. Input-output data for all crops grown during one year at the time of the interview were recorded based on farmers' memory. To understand the role of chili and its role in the overall food consumption pattern, farmers' housewives were also interviewed.

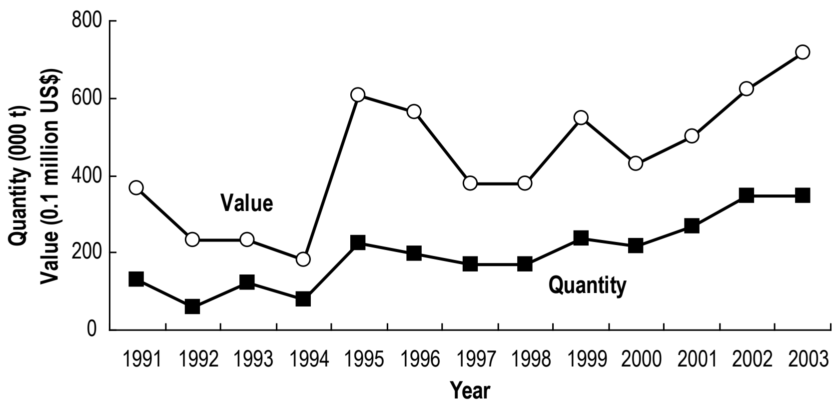
A total of 332 farmers were interviewed in the two states (Table 2). Over 90% of farmers' housewives were interviewed for family consumption pattern. Fifty urban housewives from Karnataka were interviewed to compare the consumption patterns and consumer preferences in rural and urban areas. Four processors and five market agents were also included in the survey.

Table 2. Sample size by type of respondents and province, India, 2002

Type of respondents	Karnataka	Andhra Pradesh	Total
Total farmers	169	163	332
Chili grower	154	137	291
Non-chili grower	15	26	41
Farmer's household wife	154	147	301
City household wife	50	-	50
Processor	2	2	4
Market agent	2	3	5

International Trade in Chili

The export of chili from India dramatically increased from 130 thousand t in fresh weight in 1991 to 348 thousand t in 2003. In terms of value, India earned about US$ 72 million in 2003, up from about US$37 million in 1991 (Figure 1). India imported very little quantities of chili worth less than US$3 million in 2003. Almost all exported chili were pimento, although the share of fresh chili in export earnings increased from 0.1% in 1991 to over 3% in 2003. Sri Lanka, Pakistan, Bangladesh, Malaysia, and United Arab Emirates were major importers of Indian chili, in that order.

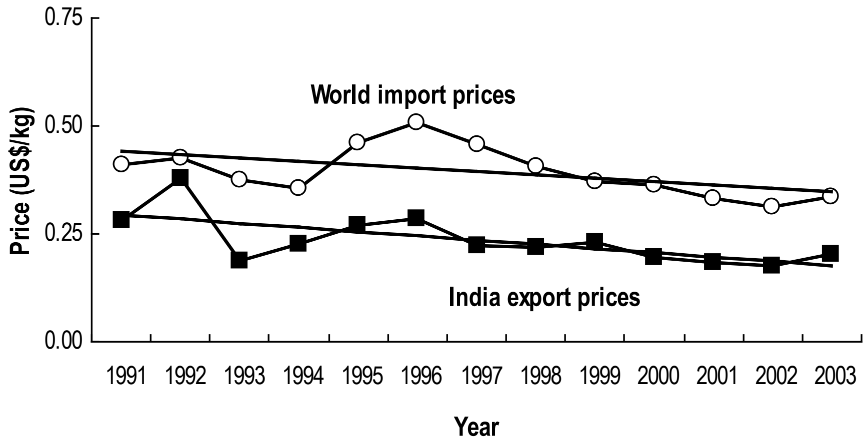


Source: FAOSTAT-Agricultural data (Agriculture and food trade).

Note: Pimento quantities were converted into fresh weight by multiplying it with 4.

Figure 1. Trends in export quantity and value of chili from India, 1991-2003

India remained competitive in the export of the pimento (ground) chili. Prices of these exports were about one-half of the international import prices, and the trend of Indian chili prices was parallel with the world prices (Figure 2). However, as the share of pimento chili in world trade was declining and it has a lower value compared to the fresh chili, the Indian chili sector has to think how to move from ground to fresh chili business.

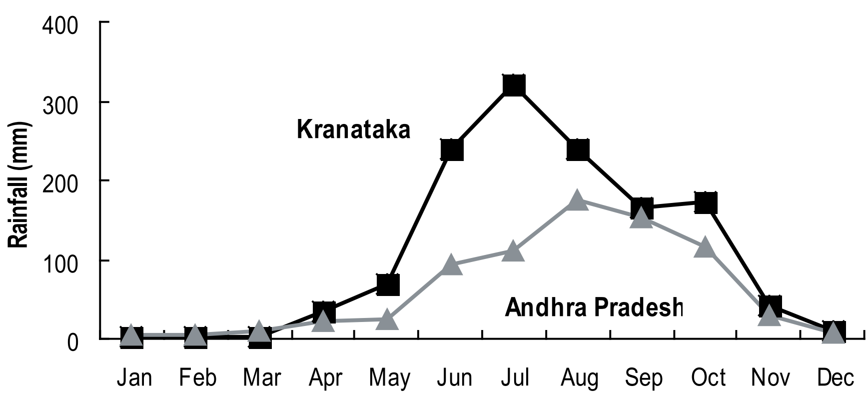


Source: Estimated from import quantities and values for India and World in FAOSTAT-Agricultural data (Agriculture and food trade). Both values are fresh weight form.

Figure 2. Trends in export and import prices of pimento chili in India , 1991-2003

Climatic Situation

The annual average rainfall in Karnataka and Andhra Pradesh is about 1330 and 750 mm, respectively. Most of the rains come in June-October, while remaining parts of the year is almost dry in both areas (Figure 3).

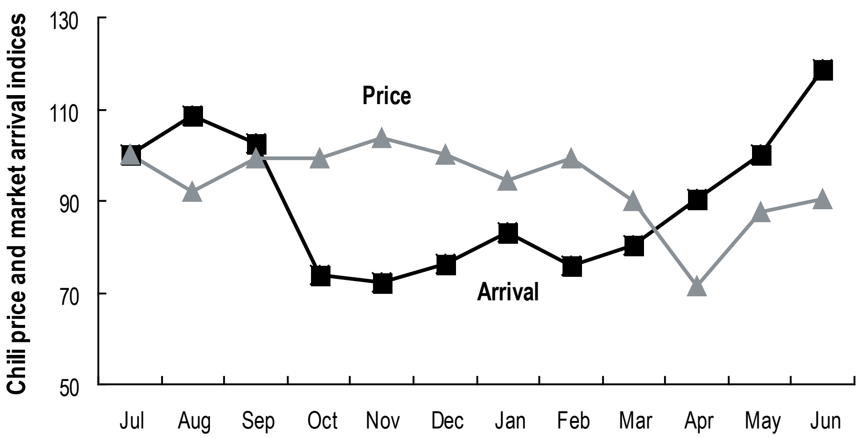


Source: Official file data from India Meteorological Department, Meteorological Centers of Bangalore and Hyderabad.

Figure 3. Monthly average rainfall in sample states

Seasonality in Chili Supply

Overall seasonality, defined as maximum minus minimum value divided by minimum and multiplied by one hundred, was over 64% and 45% in the market prices and market arrival of chili, respectively. The movement in seasonal prices was mirror image of market arrivals: the chili market arrival was highest in May-September and lowest in October-November. Conversely, the price of chili was highest in October-December, and lowest in April (Figure 4). These patterns matched with the harvesting pattern of the crop discussed in a later section.



Source: Subramanian, Varadarajan, and Asokan (2000).

Figure 4. Seasonality in chili prices and market arrivals in India

Farm and Farmers Characteristics

Socioeconomic Characteristics

Chili farmers had significantly bigger farm size than non-chili growers. One of the reasons for this was that the chili-growing farmers augmented their land holdings with rented land; chili farmers rented about 16% of the land compared to only six percent by non-chili farmers. One-fifth of the chili farmers had both owned and rented land, compared to only seven percent among the non-chili group. The land use intensity, number of fragments and cropping intensity were similar in both groups (Table 3).

Table 3. Characterization of farmers in the sample areas, by farmer type, India, 2002

Characteristic	Chili farmer	Non-chili farmer
Farm size (ha)	3.91*	2.87
Owned area (ha)	3.28	2.69
Rented area (ha)	0.63*	0.18
Cultivated area (ha)	3.83*	2.65
Chili area (ha)	1.96	0.00
Land use intensity (%)	98.71	96.32
Cropping intensity (%)	114.94	117.32
Land fragmentation (number)	2.18	2.22
Tenure status (% farmer)		
Owner	70.07	90.24
Tenant	9.51	2.44
Owner-cum-tenant	20.42	7.32
Age of the farmer (year)	43.84	41.73
Average education of the family (year)	5.57	5.49
Household head	6.42	6.49
Family size (no.)	5.11	5.49
Adult members	3.63	3.83
Children	1.48	1.66
Farmer experience (year) in agriculture	15.76	19.59
Farmer experience (year) chili production	15.19*	10.51
Distance from paved road (km)	0.58*	0.95
Distance from vegetable market (km)	14.96*	20.93
Family labor available for agriculture (number)	2.23	2.81

* implies that the value is significantly different across the two farmer groups at least at 10% level.

Family characteristics, such as family size composition, age, and education of household head, were similar for both groups. However, chili farmers had more experience in growing chili. Moreover, they were located nearer to agricultural market and paved road compared to the non-chili farms.

Average size of chili area, both single and intercropped, was about 1.96 ha per farm. Chili was the major crop on chili-growing farms, suggesting that chili farmers in the study area were more specialized in chili production than in any other crop.

Assets and Machinery

More farmers in chili-growing group had access to transportation and communication equipments. For example, more farmers own motor vehicle, and radio/cassette players (Table 4). However, more farmers in the non-chili growing group had private pumps for drinking water, while chili-growing farmers rely mainly on the government supply. Most farmers in both groups had their own houses; the house condition was average in case of chili-growing farmers, and above average in case of non-chili growing farmers.

Table 4. House-hold living conditions and home appliances owned by farmers in the sample areas, by farmer type, India, 2002

Assets/appliances	Chili farmer	Non-chili farmer
House area (m^2)		
Total area	185	236
Covered area	101*	149
House condition (% of farmers)		
Below average	16	21
Average	52*	34
Above average	33	45
House construction (% of farmers)		
Mud, local stone	58*	39
Bricked, cemented	42*	61
Source of light (% of farmers)		
Government electricity	96	100
Others	4	0
Source of drinking water (% of farmers)		
Government water supply	71*	37
Private pump	10*	41
Open well/artesian well/others	20	22
Transportation (% of farmers own)		
Motor vehicles	20*	7
Bicycle	66	71
Home appliance (% of farmers own)		
TV	56	59
Refrigerator	6	5
Radio/cassette player	38*	17

* implies that the value is significantly different across the two farmer groups at least at 10% level.

Chili-growing farmers owned more tractors and sprayers than non-chili growing farmers, while the latter group owned more water pumps and other small machineries (Table 5). The chili-growing farmers also owned more livestock. The numbers of calf, sheep and goat, and other animals owned by this group were all higher while the number of milking cows was lower compared to non-chili growing farmers. Number of hens and ducks were similar on each group of farms.

Table 5. Ownership of farm machinery and livestock inventory in the sample areas, by farm type, India, 2002

Farm machinery/livestock inventory	Chili farmer	Non-chili farmer
Farm machinery (number)		
Tractor	1.28*	0.12
Water pump	0.15*	0.37
Sprayer	0.78*	0.12
Mold board plow	0.25	0.29
Others	0.29*	0.59
Livestock (number)		
Milk cow	0.66*	1.05
Bullock and calf	1.82*	0.39
Sheep and goat	1.38*	0.51
Hen and duck	0.90	1.54
Others	2.29*	0.54
Standard animal unit (SAU)	2.77*	2.20

* implies that the value is significantly different across the two farmer groups at least at the 10% level.

Land and Soils

Chili farmers had slightly but insignificantly higher proportion of light soils compared to non-chili farmers (Table 6). However, chili-growing farmers had a higher proportion of land with slope/terraces and less proportion of plain lands away from the river bank. However, the soil drainage condition was not significantly different across the two groups.

Table 6. Land form, drainage, and soil texture in the sample areas, by farmer type, India, 2002

Characteristic	Chili farmer	Non-chili farmer
Soil texture (% of parcels)		
Heavy	34	38
Medium	51	55
Light	15	7
Land form (% of parcels)		
Slope with terrace	19*	11
Slope without terrace	30*	18
Plain near the river bank	14	14
Plain away from the river bank	36*	56

Cont...,Table 6

Characteristic	Chili farmer	Non-chili farmer
Drainage (% of parcels)		
Well drained	39	34
Medium drained	44	55
Poor drained	17	11

Credit Source

About two-thirds of farmers obtained loans from various sources, and there was little difference between the access to credit between chili and non-chili farmers (Table 7). Average loan size was about INR 43,000 for chili farmers and INR 21,000 for non-chili farmers. The higher loan size that chili farmers needed was perhaps due to the higher production cost involved in chili cultivation. Among chili farmers, hybrid farmers had their own resources to finance chili production, hence the amount of loans availed was only half that of the other chili farmers. Most of the farmers obtained loan from the government banks, with an interest rate ranging from 1.0-1.3% per month and most were used to buy agricultural inputs.

Table 7. Source, duration, interest rate, and purpose of loans of farmers in the sample areas, by farmer type, India, 2002

Type of grower	Loan (% farmer)	Average loan (INR*)	Source (% of farmers)				Duration (years)	Interest rate (%/month)	Purpose		
			Govt. Bank	Co-op	Mer-chants	Others			Inputs	Tractor	Others
Hybrid	52	21,309	38	57	2	2	9	1.2	100	0	0
Open pollinated	67	41,250	79	21	0	0	14	1.1	90	0	0
Local	75	46,822	48	43	4	6	15	1.3	86	6	8
Overall	67	42,954	52	38	4	6	13	1.3	92	3	5
Non-chili farmers	68	21,118	48	45	6	0	11	1.2	93	0	7

* One US$ = 45 INR (Indian Rupee).

Varieties and Cropping Pattern

Chili Varieties

About one half of chili farmers grew local varieties, and another one-third grew hybrid types; the remaining 14% used improved open pollinated varieties (Table 8). The major local varieties grown were Byadagi Kaddi and Sankeshwara, while the major hybrid varieties were Tejaswini and Namdhari. The major open pollinated variety in the sample area was Guntur (G-4). The other varieties grown in the sample area are reported in Table 8.

Table 8. Chili variety grown in the sample areas, by chili type, India, 2002

Local		Hybrid		Open pollinated	
Name of variety	% of parcels[1]	Name of variety	% of parcels[1]	Name of variety	% of parcels[1]
Byadagi Kaddi	34.1	Tejaswini	30.0	Guntur (G-4)	43.7
Sankeshwara local	12.8	Namdhari	25.4	LCA 334	30.9
Warangal Paprika	11.9	Wonder Hot	17.7	LCA 960	10.9
Dyavanur	9.4	Roshini	5.4	LCA 206	7.2
Nagaram	8.4	Festival	5.4	Chilli-275	5.5
Byadagi Dabbi	5.9	INDAM – 5	4.6	LR-1	1.8
Dyavanur Kaddi	4.0	Alankar	4.6	Overall	14.2
Nerli local	3.0	Dilli Hot	3.1		
Nulvi Dabbi	2.5	Madhubala	2.3		
Nulvi Kaddi	2.0	AgniRekha	1.5		
Annigeri	2.0	Overall	33.6		
Sweet / Bajji type	1.0				
Sada Dabbi	1.0				
Benthur deluxe	1.0				
Prakasham	0.5				
Bombay Dabbi	0.5				
Overall	52.2				

[1]Total number of parcels is 399.

Cropping Pattern

Over 80% of chili fields were grown as single crop, and 18% were intercropped with one crop mainly cotton (Table 9). Very few parcels were intercropped with two crops, like onion and cotton. Intercropping was more common in local chili.

Table 9. Intercropping in the sample areas, by chili type, India, 2002

Intercrop	% of parcels			
	Hybrid	Open pollinated	Local	Overall[1]
Chili alone	43	16	41	80
Chili with one other crop	-	6	94	18
Cotton	-	5	95	79
Onion	-	-	100	5
Tobacco	-	-	100	10
Maize	-	-	100	3
Groundnut or cowpeas	-	50	50	3
Chili with two other crops	-	-	100	2
Onion and cotton	-	-	100	38
Cotton and other crop	-	-	100	50
Onion and sorghum	-	-	100	12

[1]Total number of parcels is 399.

When chili crop was cultivated alone, more than half of the total area under all crops (cropped area) was devoted to chili (Table 10). This implied that the sample farmers were professional chili growers who plant chili on a commercial scale. Most chili area came from cereals as its area was reduced to half when compared with non-chili farmers. Some area also came from beans and pulses. However, chili-growing farmers had to reduce some area under other vegetables. The proportion of area under commercial crop on chili farms and non-chili farms was similar.

Table 10. Cropping pattern in the sample areas, by farmer type, India, 2002

Crop group	Chili farmers				Non-chili farmers	
	Without intercropping		With intercropping[1]		Area (ha)	Share (%)
	Area (ha)	Share (%)	Area (ha)	Share (%)		
Chili	1.65	52.2	2.87	32.5	0.00	0.0
Cereals	0.73	23.2	1.28	14.5	1.27	49.8
Commercial crops	0.40	12.6	2.89	32.7	0.32	12.5
Other vegetables	0.03	1.0	0.26	3.0	0.16	6.4
Beans and pulses	0.28	8.8	1.52	17.2	0.66	25.6
Others	0.07	2.3	0.01	0.1	0.15	5.7
Total	3.16	100	8.84	100	2.56	100

[1]When crop A is intercropped with crop B, the given area was counted for each A and B, separately.

Note: Cereals include maize, sorghum, rice, and wheat; Commercial crops include cotton, sugarcane, tobacco, and sunflower; Beans and pulses comprises of groundnut, soybean, red gram, Bengal gram, cowpea, greengram, and horsegram; Other vegetables are onion, watermelon, tomato, cauliflower, garlic; and other crops are Jute, crotalaria, pomegranate, banana, jasmine, crossandra, and marigold.

Cultivation Time

In the sample area, hybrid and open pollinated chilies were cultivated as soon as monsoon starts to recede from middle to end of September, while local chili was grown more than a month earlier, mostly in the middle of the rainy season in early July (Table 11).

The start of harvesting of local varieties was a little early in middle of December, while hybrids and open pollinated varieties were started in the late December and early January, respectively. The last harvesting of modern varieties of chilies (hybrid and open pollinated) was completed in the third and fourth week of March, while the harvesting of local type was finished in February. There was not much difference in the total duration of the crop across different chili varieties. Harvesting in March causes a significant drop in prices in March and April (Figure 4).

Usually, chili-chili-chili rotation was followed for many years. The ground was left fallow for a few dry months, from the end of harvest until the cultivation of the next chili crop.

Table 11. Cultivation and harvesting time of chili in the sample areas, by chili type, India, 2002

Chili farmer	Planting time (week and month)	Harvesting time (week and month)	
		Start	End
Hybrid	4th September	3rd December	4th March
Open pollinated	2nd September	1st January	3rd March
Local	1st August	2nd December	1st February
Overall	4th August	3rd December	1st March

Information Source and Chili Variety Selection

Seed

The dominant information source on seed for all chili types was the seed dealer (Table 12). Village shops and neighbor-farmers were also significant sources of seed information for open pollinated and local types of chili. Sivanarayana and Bhupal Reddy (2002) also revealed the same pattern of information-seeking behavior of the chili farmers wherein the input dealers were the major sources of information in Warangal district of Andhra Pradesh.

Table 12. Seed information source by chili type, India, 2002

Item	Hybrid	Open Pollinated	Local	Overall
Source of information (%)				
Village shop	22	24	19	22
Neighbor farmer	17	22	23	19
Seed dealer	50	38	40	46
Govt. department	5	8	2	5
Other	4	5	9	5

Note: The figures in a column do not add up to one hundred because some farmers did not use any seed information source.

Selection of Chili Variety

Farmers considered per ha yield to be the top criterion in the selection of varieties, followed by high market prices, which was a composite measure of all good appearance characteristics. Disease and insect resistance was ranked third or fourth in green chili, while chili color was ranked third in red chili (Table 13).

Table 13. Ranking of factors in the selection of chili seed in the sample areas, by chili type, India, 2002

Characteristics	Overall rank	
	Green (for fresh)	Red (for powder)
Market price	2	2
Yield	1	1
Disease free	3	4
Insect free	4	
Chili color	5	3
Hotness		5

Note: highest rank=1; lowest rank=5.

Overall Chili Market

Farmers got information on chili market (prices, demand, etc.) from neighboring farmers, newspapers, and traders (Table 14). Hybrid chili-growing farmers considered traders to be the most important source of information. All the other chili growers ranked neighboring farmers as number one important information source on chili marketing. It is important to note that television and radio were ranked relatively low, despite farmers' ownership of these electric devices. This suggested that not much information regarding chili prices was relayed through media, or the information relayed was not specific to the varieties and the quality of produce grown by chili farmers in the sample area. These results were consistent with the survey findings of Sivanarayana and Bhupal Reddy (2002) where the T.V. and radio were the last ranked sources of information of chili farmers.

Table 14. Source of chili marketing information and their rank in the sample areas, by farmer type, India, 2002

Chili farmer	Source (% of farmer)						Rank					
	Neighbor farmer	News-paper	Trader	TV	Radio	Other	Neighbor farmer	News-paper	Trader	TV	Radio	Other
Hybrid	22	22	22	13	3	18	2	3	1	4	-	5
Open pollinated	25	23	20	6	11	15	1	3	2	4	5	-
Local	25	24	20	4	12	15	1	2	3	-	4	5
Mixed	23	21	21	13	5	17	1	3	2	4	-	5
Overall	24	23	21	9	8	16	1	3	2	4	-	5

Note: highest rank=1; lowest rank=5.

Insect and Pest Problem

Insects

About 95% of the farmers reported insect problem in all types of chilies (Table 15). Majority reported thrips, mites, and borers in the chili fields. In terms of importance, majority of farmers ranked borer as the number one damaging insect in hybrid, thrips in open pollinated, and mites in local chili fields.

Table 15. Major insects found in chili in the sample areas, by farmer type, India, 2002

Farmer type	Farmers reporting (%)					Rank[1]				Occurrence (years out of 5)		Average losses (%)	
	T	A	M	C	Other	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	29.7	10.1	28.2	28.7	3.3	C	T	M	A	2	3	26	14
Open pollinated	36.1	2.8	33.3	27.8	0	T	M	C	A	4	4	58	67
Local	27.8	16.6	29.0	24.6	2.0	M	T	C	A	2	2	58	64
Mixed	30.6	7.7	31.1	27.6	3.0	T	M	C	A	4	3	39	41
Overall	29.3	12.3	29.5	26.4	2.5	M	T	C	A	3	3	48	56

A=Aphids *(Aphis gossypii and Myzus persicae)*; C=Caterpillar *(Helicoverpa armigera and Spodoptera litura)*; M=Mites *(Polyphagotarsonemus latus)*; T=Thrips *(Scirtothrips dorsalis)*.
[1]The rank of 1 is the most devastating, and 4 the least devastating insect.

On average, serious insect infestation occurred every three to five years. The highest losses due to insects in 1998-2002 were in open pollinated and local chili varieties where up to two-thirds of the crop were lost. Average loss due to insect attack on all types of chili crop in 1998-2003 was 56% implying that if insects were properly controlled chili yields could easily be increased by 50%. Average losses due to insects increased from 48% in 1993-97. Increasing losses was observed in all chili types, except in hybrid probably because of short history of use of hybrid varieties. Moreover, hybrid farmers protected their crops from insects with more sprays. The decline in production of Bydagi (local) chili in Karnataka was attributed to high intensity of mosaic virus transmitted by thrips (Koshy 2000).

Diseases

Over 92% of farmers reported disease infections in their chili crops. Diseases were unidentified in most cases, except in local chili type where powdery mildew and anthracnose dominated. Overall, more farmers reported incidence of anthracnose and powdery mildew (Table 16). According to Hingole and Kurundkar (2004), powdery mildew was an important disease causing widespread loss in Maharashtra and other parts of India.

Table 16. Major chili diseases in the sample areas, by farmer type, India, 2002

Farmer type	Farmers reporting (%)					Rank[1]				Occurrence (years)		Average losses (%)	
	AN	LS	PM	VR	UI	1	2	3	4	1993-1997	1998-2002	1993-1997	1998-2002
Hybrid	23.2	12.6	17.4	8.7	38.2	AN	PM	DB	LS	3	3	21	12
Open pollinated	16.2	18.9	29.7	5.4	29.7	PM	AN	LS	DB	2	4	35	50
Local	23.5	13.8	25.8	19.4	17.6	PM	AN	VR	LS	2	3	40	49
Mixed	20.7	13.4	17.3	15.1	33.5	AN	PM	DB	VR	2	3	33	35
Overall	22.5	13.6	22.0	15.1	26.9	PM	AN	VR	LS	2	3	34	43

AN=Anthracnose *(Colletotrichum acutatum, C. capsici and C. gloeosporioides)*; LS=Cercospora leaf spot *(Cercospora capsici)*; PM=Powdery mildew *(Leveillula taurica, asexual stage: Oidiopsis sicula)*; DB=Die back *(Colletotrichum)* or yellowing due to unidentified disease factor; VR=Viruses; UI=Other unidentified.

[1]The rank of 1 is the most devastating, and 4 the least devastating disease.

Anthracnose was ranked as the number one disease in hybrid and mixed-type farm, and powdery mildew by open pollinated and local-type farm. Overall, powdery mildew was the number one disease in terms of yield loss. It should be noted, however, that unprecedented drought was experienced during the survey year and the year preceding it, which might have reduced the devastation caused by the tropical diseases.

The average losses due to diseases in 1998-2003 were 43% for all chili types. This implied that yield can be increased by 50% if diseases were effectively controlled. The losses during these years were highest in open pollinated and local chili types, and lowest in hybrid chili. The losses due to diseases were less than those due to insects, probably due to difficulties in accurately attributing the losses to diseases or insects. Serious disease occurrence in chili increased from two to three in every five years from 1993-1997 to 1998-2002. The average yield losses also increased from 34% to 43% during the same time.

Weeds

Almost all farmers reported weed problems, although these were generally unidentified (Table 17). The number one weed was *Cynodon dactylon* in hybrid and open pollinated, *Cyperus rotundus* in mixed chili, and *Parthenium hysterophorus* by local chili fields. The second ranking weeds were *Cynodon dactylon* in local chili, *Cyperus rotundus* in open pollinated, and *Parthenium* in hybrid and mixed chili fields. The other important weeds reported by farmers were *Phalaris minor, Commelina sp.*, *Amaranthus* and *Sonchus arvensis* and were ranked depending on the chili field type. Occurrence of weeds was a regular phenomenon, and average losses ranged from 2-3% per season.

Table 17. Major chili weeds in the sample areas, by farmer type, India, 2002

Farmer type	Farmers reporting (%)						Rank[1]				Occurrence (years)		Average losses (%)	
	CD	CR	PH	PA	CO	OT	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	17	13	13	15	13	29	CD	PA	CR	PH	5.0	5.0	2.2	2.1
Open pollinated	20	19	8	11	9	32	CD	CR	PA	SO	5.0	5.0	2.7	2.4
Local	18	16	11	19	8	28	PA	CD	CR	PH	5.0	5.0	2.3	2.2
Mixed	13	17	11	15	11	32	CR	PA	CD	PH	5.0	5.0	2.2	2.1
Overall	17	16	12	17	10	29	CD	PA	CR	PH	5.0	5.0	2.7	2.4

Note: CD=*Cynodon dactylon*; CR=*Cyperus rotundus*; PH=*Phalaris minor*; PA= *Parthenium hysterophorus*; CO=*Commelina* sp.; AM=*Amaranthus*; SO=*Sonchus arvensis*; OT=Other.

[1]The rank of 1 is the most devastating, and 4 the least devastating weed.

Farm Management Practices

Preparation of Seedling Nursery

About three-fourths of farmers prepared nurseries, while the rest practiced direct seeding. The percentage of direct seeding was lowest in hybrid chili (12%), highest in local type (23%) and in between the two in open pollinated improved varieties (23%).

In most cases, seedling nursery was in flat beds where seeds were broadcasted. Seedlings may be thinned if germination was good and plant population was heavy. One or two weedings may be done if weed infestation was heavy. Otherwise seedlings were not disturbed until they were ready for transplanting.

In very few exceptional cases, nurseries were established on raised seedbeds (about 10~15 cm height and 100 cm wide and of appropriate length) with seeds either broadcasted or line-sown at 10 cm apart. This was done only in hybrids.

Soil Treatment

A significant proportion of chili fields, especially those planted to hybrid, and three percent of nursery parcels, were treated for soil-borne diseases and pre-sowing insects (Table 18). Parcels under local chili had less soil treatments. Soil treatment was done by broadcasting. The quantity of materials used for field soil treatment, usually the insecticide Methomyl, ranged from 61 kg/ha in local to 101 kg/ha in open pollinated variety fields.

Table 18. Soil treatment method (% of farmers) and quantity in the sample areas, by chili type, India, 2002

Method	Hybrid		Open pollinated		Local		Overall	
	Nursery	Field	Nursery	Field	Nursery	Field	Nursery	Field
Broadcast	2	27	7	22	1	12	2	19
Placement	0	3	2	2	0	0	0	1
During land preparation	-	6	-	2	-	1	-	3
Others	2	-	0	-	0	-	1	-
Total	4	36	9	26	1	13	3	23
Quantity of treatment (kg/ha)	350	69	64	101	0	61	242	72

Seed Treatment

While 16% of farmers treated seeds by dusting, a few farmers also practiced soaking to control seed-borne diseases (Table 19). About one-fourth of farmers applied dusting to seed of hybrid chili, and only nine percent to local varieties. The major chemicals used for seed dusting were Carbendazim and Mancozeb.

Table 19. Farmers (percentage) reporting seed treatment in the sample areas, by chili type, India, 2002

Chili type	Percentage of farmers	
	Soaking	Dusting
Hybrid	1	27
Open pollinated	2	17
Local	1	9
Overall	1	16

Plowing

Almost every chili field was plowed before planting. On average, 42% of chili parcels were plowed by tractor; 20% by animals; and 29% combination of both (Table 20). Tractor alone was less frequently used in local chili. On average, three to four plowings were done on different types of chili fields before transplanting.

On the whole, harrowing was done in 61% of chili parcels. Local and open pollinated (improved varieties) chili types had the highest number of harrowing. The main source of power for harrowing in local chili parcels were animals, and tractor in hybrid and open pollinated fields.

Table 20. Land preparation method in the sample areas, by chili type, India, 2002

Chili type	Percentage of parcels										Number of operation	
	Plowing					Harrowing					Plowing	Harrowing
	Animal	Tractor	Combined	Others[1]	Total	Animal	Tractor	Hand	Others[2]	Total		
Hybrid	12	60	23	3	98	17	26	3	9	55	3.4	1.0
Open pollinated	21	50	21	5	98	16	27	9	16	68	2.8	1.4
Local	25	27	36	4	91	24	10	14	15	63	3.0	1.3
Overall	20	42	29	4	94	20	18	9	13	61	3.1	1.2

[1]This include hand, hand+animal, hand+tractor, and hand+animal+tractor.
[2]This include hand+animal, hand+tractor, animal+tractor, and hand+animal+tractor.

Bed Type

Chilies are either planted in furrows or on flat beds. Very few farmers used raised beds in the study area. Overall, about one-half of parcels were flat beds and the remaining were furrows (Table 21). Slight variation in bed types across chili type can be seen: for example, 70% hybrid was grown on flat beds compared to only 41% in local chili.

The average furrow size was estimated to be 12 cm tall and 20 cm wide. Average inter-plant distance was estimated at 41 cm. While the height of furrows does not vary across varieties, these were relatively narrower in open pollinated type.

The plant-plant distance was lowest in open pollinated at 32 cm and highest in local varieties at 43 cm. Farooqi et al. (2003) observed a spacing of 45 x 45 cm or even closer than this in Andhra Pradesh.

Table 21. Bed type, dimensions and inter-plant distance in the sample areas, by chili types, India, 2002

Chili type	Bed type (% of parcels)		Furrow		Plant to plant
	Furrow	Flat bed	Height (cm)	Width (cm)	distance (cm)
Hybrid	30	70	13	21	41
Open pollinated	47	53	11	14	32
Local	59	41	12	20	43
Overall	47	53	12	20	41

Mulching, Staking and Shading

Only seven percent farmers used mulch, and these were mainly in hybrid chili fields. Farmers used rice straw, while plastic sheeting was used only on two percent parcels of local varieties (Table 22). The life of foil was about one year. No field was staked in the study area and no shade or tunnel was used to protect chili crop.

Table 22. Mulching material type in the sample areas, by chili type, India, 2002

Material type	Chili type (% of parcels)			
	Hybrid	Open pollinated	Local	Overall
Rice straw	13.1	5.5	2.5	6.6
Reflective foil (plastic sheets)	0	0	1.5	0.8
Overall	13.1	5.5	4.0	7.4

Fertilizer Application

In India, about 80% of chili-growing farmers applied organic fertilizers, mostly farm manure. Most of these were not properly decomposed, with only 0.5% of farmers practicing proper composting (Table 23). A few farmers used red earth or soil from uncultivated fields which were assumed to be more fertile. All farmers broadcast manure before sowing of seeds or transplanting of seedlings in the field. Inorganic fertilizers were also applied using the broadcasting method.

Table 23. Organic fertilizer type used in the sample areas, by chili type, India, 2002

Chili farmer	Organic fertilizer type (% of farmer)				
	Farm manure	Poultry manure	Compost	Red earth	Total
Hybrid	75.9	-	0.7	-	76.6
Open pollinated	70.9	-	-	-	70.9
Local	87.9	0.5	0.5	0.5	89.4
Overall	81.3	0.3	0.5	0.3	82.4

Non-chemical Weeding

Almost all chili parcels were weeded either manually or combining manual weeding with harrowing. On average, weeding was done four times (Table 24). Farmers' perception about the effectiveness of their weeding methods was high, except in local chili where over one-fifth of farmers thought that the weeding operation controlled only 75% weeds.

Table 24. Non-chemical weeding and its perceived effectiveness by farmers in the sample areas, by chili type, India, 2002

Chili type	Parcels received weeding (%)	Number of weeding	Method (% of parcels)			Effectiveness		
			Manual weeding	Harrowing	Both	100%	75%	50%
Hybrid	99	4.4	49	4	47	97	2	1
Open pollinated	100	4.3	47	6	47	90	8	2
Local	98	4.0	40	17	43	78	22	1
Overall	99	4.2	44	11	45	87	12	1

Irrigation

Chili crop was cultivated under irrigated as well as rainfed conditions in the sample areas. Over one-third of chili fields, mainly local type, were rainfed (Table 25). Over half of the chili parcels were flooded, mainly through ridges. A small percentage was irrigated manually, and an even smaller percentage was irrigated using sprinkle and trickle methods. The open pollinated and local chili types were mainly irrigated through canals, and hybrid chili type was irrigated from other sources.

Table 25. Irrigation methods and source in the sample areas, by chili type, India, 2002

Chili type	Irrigation method (% of parcels)					Irrigation source (% of parcels)			
	Flooding		Manual	Sprinkle + trickle	Rainfed	Canal	Tube well	Tank	Others*
	Without ridges	With ridges							
Hybrid	20	61	15	4	0	34	19	9	38
Open pollinated	18	45	9	4	24	53	10	1	13
Local	5	31	1	1	63	16	5	5	12
Overall	12	43	7	2	36	28	10	5	21

*Others include open wells, shallow open wells, streams and farm ponds.

Insect Control

Overall, three-fourths of chili farmers used insecticides, suggesting the intensity of insect problem in chili cultivation (Table 26). Pesticide coverage was 50% in local chili, more than 80% in open pollinated, and almost 100% in hybrid chili. A large percentage of parcels was treated with cocktail, a mixture of two or more pesticides. In cocktail, more number of chemicals was used than when it was singly applied. On average, seven to nine different types of pesticides were applied. Over 98% of farmers sprayed the insecticides, and only less than 2% used other methods like dusting and mixing pesticide with irrigation water.

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Table 26. Extent of insecticide use and its perceived effectiveness by farmers in the sample areas, by farmer type, India, 2002

Chili type	Percentage of parcels			Number of chemicals			Effectiveness (%)
	Single	Cocktail	Overall	Single	Cocktail	Overall	
Hybrid	63	36	99	7.4	9.2	8.0	77
Open pollinated	32	51	83	7.4	9.4	8.6	69
Local	22	23	45	5.4	8.7	6.7	51
Overall	44	31	75	6.6	9.0	7.6	64

Disease Control

Overall, three-fourths of farmers used fungicide to control disease infestation in chili. The pattern of fungicide use among different types of farmers was similar to insecticide suggesting that the applications of both were linked. Similar with insect control, more number of chemicals was used in cocktail than in single application. On average, six to seven different types of fungicides were applied (Table 27). Over 93% of farmers sprayed the fungicide and less than seven percent used other methods like placement, broadcast, and others.

Perceived effectiveness of fungicide ranged from 64% in local chili to 81% in hybrid, or an average of 75%. Many types of fungicides were available in the market, Mancozeb and Bavistin being the more popular (Appendix 1).

Table 27. Extent of fungicide use and their effectiveness on chili in the sample areas, by farmer type, India, 2002

Chili type	Percentage of parcels			Number of chemicals			Effectiveness (%)
	Single	Cocktail	Overall	Single	Cocktail	Overall	
Hybrid	80	20	99	5.5	7.3	5.8	81
Open pollinated	35	46	81	5.5	6.6	6.1	79
Local	29	20	49	4.8	6.4	5.5	64
Overall	47	23	70	5.3	6.8	5.8	75

Non- chemical/Conventional Method of Pest Control

Only a few farmers (not more than three percent), mostly of local chili, indicated that they used non-chemical methods to control insects and diseases. These methods included early sowing and more frequent picking. These were linked with the availability of labor and land, which in many cases were limited.

Harvesting

On average, harvesting was done three times (Table 28). In hybrids and open pollinated, it was done more than three times and less than three times in local types. About one-third of local chili, and one half of other chili types were harvested using family labor only. Both family and hired labor were used to harvest a substantial proportion of chili parcels, especially in local chili, while very few parcels were harvested using hired labor only.

Table 28. Number of harvest and type of labor used in chili harvesting in the sample areas, by chili type, India, 2002

Chili type	Number of harvest	Percentage of parcels		
		Family	Hired	Both
Hybrid	3.6	48.9	0.7	50.4
Open pollinated	3.1	45.5	1.8	52.7
Local	2.3	31.2	2.2	66.7
Overall	2.9	39.6	1.6	58.8

Marketing

Farmers

Farmers sold chili mainly in powder or dry form. The chili was dried before brought to crushing machines within their own or nearby villages, or these were crushed at home. Overall, 15% of output, mostly of local variety, was sold in green form. With the introduction of modern varieties, the share of chili sold as green has increased (Table 29).

Table 29. Form of chili sold by farmers in the sample areas, by chili type, India, 2002

Variety	Green	Powder or dry
Hybrid	18.0	81.7
Open pollinated	6.0	93.1
Local	59.5	40.5
Overall	15.4	83.6

In most cases, farmers brought the output to the main market where it was sold to retailers through commission agents (Table 30). Eight percent of hybrid chili farmers sold to commission agents who directly picked up the products from farmers' field, and another eight percent sold to the local village market.

Producers and village merchants did not practice grading. They did, however, remove discolored, damaged, and rotten chilies during drying process. The wholesale merchants, however, generally sorted out damaged and discolored chili before the produce was sold or sent to the consuming markets. Chili was most commonly packed in gunny bags. 'Toddy mats' were used in Andhra Pradesh. Green chilies were sometimes brought to market in baskets made of split bamboos and wicker.

A large majority of farmers stated that high market cost, uncertainty of chili prices, and exploitation of the middlemen in terms of high commission were major marketing constraints.

Table 30. Market outlets for chili in the sample areas, by chili type, India, 2002

Chili type	Farmer selling (%)			
	Local market	Commission agent	Main market	Assembler in village
Hybrid	8	8	69	15
Open pollinated	0	0	95	5
Local	3	0	93	4
Overall	3	1	90	6

Marketing Agents and Processors

In general, traders classified chili into four grades using the following criteria: i) color (red was better), ii) size (big was better), iii) shape (long conical shape was preferred), iv) seed content (higher seed content was preferred), v) pungency (strong was better), vi) presence of dirt and other foreign matter (lower presence was given higher grade), vii) damaged by insects and diseases (less was preferred), and viii) moisture content (drier was better) (Table 31).

On the other hand, market agents for dry or powder chili ranked these characteristics in the following order: 1--color, 2--hotness, and 3--appearance. Disease and insect infection were not considered as well as purchase price since the agents can adjust their selling prices accordingly.

For processors, chili color was the number one criterion in selecting both processed chili as well as fresh red chili for processing. Pungency was second. Other criteria were number of seeds; diseases and insect infestation, and freshness ranked in that order.

Table 31. Ranking of chili characteristics preferred by market agents and processors in the sample areas by chili type, India, 2002

Characteristics	Market agent	Processor	
	Dry or powder	Red	Product
Prices	4		
Disease/insect free	4	4	
Appearance	3		3
Color	1	1	1
Fragrance			4
Pungency	2	2	2
Number of seeds		3	
Freshness	5	5	

Note: Highest rank=1, and lowest rank=5.

Marketing agents ranked the following marketing constraints in the order of importance: 1--poor quality produce, 2--inadequate storage facilities, and 3--no government support and incentive for setting up chili marketing structure. (Table 32).

Table 32. Major constraints faced by market agents in the sample areas, India, 2002

Constraints	Percent reporting	Rank
Poor quality produce	25	1
Inadequate storage facilities	25	2
No government incentive/support	25	3
Low price/variability in chili price	13	5
Other marketing problem	12	4

Note: Highest rank=1 and lowest rank=5.

Input Use

Seed Rate

The rate of seed used per ha ranged from 3.1 kg in local to 1.6 kg in hybrid chili, or an average of 2.4 kg (Table 33). The average seed rate used in hybrids was high because of F2 seeds. However, farmers who grew F1 seeds of the hybrids actually used only 0.3 kg/ha and paid Rs 25,054/kg. Almost all hybrid and two-thirds of the open pollinated seeds were purchased. Among the farmers who grew hybrids, 46 purchased and used F2 seeds at the rate of 2.5 kg/ha at Rs 409/kg. The percentage of seeds purchased was relatively low in local chili types. In open pollinated varieties, four farmers bought and used seedlings (not reported in the table) at an average of 107,878 seedlings/ha. The major source of seeds were seed dealers followed by neighboring farmers, except in local chili type where neighboring farmers was the major source.

Table 33. Seed rate and seed source of farmers in the sample areas by chili type, India, 2002

Chili type	Seed rate (kg/ha)			Parcels using purchased seed (%)[2]	Seed source (% parcels)			
	Own farm produced[1]	Purchased	Average		Own produced[1]	Seed dealer	Village shop	Others[3]
Hybrid	3.8	1.4	1.6	92	27	55	6	12
Open pollinated	2.4	2.1	2.2	69	33	47	3	17
Local	3.2	2.9	3.1	24	59	15	13	13
Overall	3.2	1.8	2.4	54	35	45	7	13

[1] Includes seed obtained from neighboring farmers.
[2] Includes purchased seedlings.
[3] Others include extension agents, government departments, etc.

Fertilizer Use

Almost all farmers used inorganic fertilizers in all chili types, with an overall nutrient application rate of 385 kg/ha (Table 34). Application was highest in hybrids, and lowest in local chili. The most economical NPK levels were 90:52:30 kg/ha under rainfed conditions (Singh and Singh 1996).

Local chili types were applied with the highest amounts of organic fertilizers. On average, use of manure ranged from 6.1 t/ha in local chili to 8.4 t/ha in hybrids of which only 0.07 t/ha and 0.12 t/ha were compost manure, respectively. Small quantities of red earth (soil from uncultivated land believed to be more fertile) were also used to enhance land productivity.

Table 34. Quantity of organic and inorganic fertilizer application in chili farm in the sample areas by chili type, India, 2002

Chili type	Nutrients from inorganic fertilizer (kg/ha)				Type of manure applied (t/ha)				
	N	P	K	Total	Farm	Poultry	Compost	Red earth	Total
Hybrid	263	187	82	532	8.27	-	0.12	-	8.39
Open pollinated	205	146	48	399	6.33	-	-	-	6.33
Local	134	101	45	280	6.00	0.06	0.07	0.01	6.15
Overall	190	137	58	385	6.84	0.03	0.08	0.01	6.96

Insecticide

On average, 11 kg or liters of insecticide were used in all chili types. The amount of insecticide use was highest in hybrids, and lowest in local chili. A total of 41 different chemicals were used as insecticide in the survey area; sometimes the same chemical was sold with different brand names. About 40% of these were also used as fungicide. The major insecticides used in the study area were Monocrotophos, Fipronil, Cypermethrin, Dicofol and Chlorpyrifos (Appendix 1).

A higher quantity of pesticide was used in cocktail compared to the one in single pesticide application, except in open pollinated fields. Total number of sprays ranged from seven in local chili to 15 in hybrids (Table 35). The high number of sprays also indicated the seriousness of insect infestation problem on chili.

Table 35. Quantity of insecticide used and number of sprays on chili farms in the sample areas by chili type, India, 2002

Chili type	Quantity (kg or liter/ha)			Total number of sprays
	Single	Cocktail	Overall	
Hybrid	17.1	20.8	18.2	15
Open pollinated	18.8	15.2	13.7	13
Local	8.3	12.4	5.6	7
Overall	13.7	16.4	11.0	10

Fungicide

On average, 9.3 kg or l/ha of fungicide was used on chili(Table 36). The highest use was on hybrid, while the lowest use was on local chili. A total of 36 chemicals were used as fungicide; sometimes the same chemical was sold with different brand names; two-thirds of these fungicides were also used as insecticides. The major fungicides used in the study area were Mancozeb and Carbendazim. Unlike insecticide, fungicide quantities were generally reduced when cocktail was made. The average number of fungicide spray was seven, the highest being applied to hybrids and lowest to local chili.

Table 36. Quantity of fungicide use and number of sprays in chili farms in the sample areas by chili type, India, 2002

Chili type	Quantity (kg or liter/ha)			Total number of sprays
	Single	Cocktail	Overall	
Hybrid	16.7	7.3	16.2	13
Open pollinated	14.3	6.6	9.9	6
Local	9.9	9.0	4.7	3
Overall	14.3	6.8	9.3	7

Irrigation

On average, chili fields were irrigated 11 times with hybrid chili fields having the highest number of irrigations at 21 and local chili fields receiving the lowest of only five; open pollinated chili fields were irrigated 12 times. Other studies estimated eight to nine number of irrigations which was close to the estimates in this study (Singh and Singh 1996).

Labor

On average, chili cultivation in India used 294 labor days/ha. The lowest number of labor was used in local type while the highest in hybrid followed by open pollinated types, implying that improved varieties were labor intensive, as they require 48-112% more labor compared to local chili (Table 37).

Excessive application of inputs like seeds, potash fertilizers and human labor in the chili-based mixed cropping systems had been previously documented (Korikanthimath et al. 2000).

Table 37. Distribution of labor among different activity groups in the sample areas by chili type, India, 2002

Chili type	Percentage distribution				Total labor (day/ha)
	Land preparation	Management	Harvesting	Post-harvesting	
Hybrid	11.9	53.1	26.4	8.6	426
Open pollinated	14.3	47.2	29.9	8.7	298
Local	15.4	49.9	23.0	11.7	201
Overall	14.0	50.6	25.2	10.2	294

Chili management accounts for nearly one-half of the total labor used. Harvesting used one-fourth of the total labor requirement, land preparation 12-16%, and post-harvesting 10%. The share of the post-harvest and land preparation to total labor was surprisingly highest in local chili type.

Similar to rice, about three-fourths of the labor used on chili was hired. The proportion of hired labor was highest in harvesting operation and lowest in crop management operations. Improved chili varieties did not have significant impact on hired labor utilization (Table 38).

Table 38. Source of labor in the sample areas by operation and chili type, India, 2002

Chili type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Hired	Family	Hired	Family	Hired	Family	Hired	Family	Hired	Family
Hybrid	84.3	15.7	61.9	38.1	92.4	7.6	84.7	15.3	74.6	25.4
Open pollinated	83.2	16.8	63.7	36.3	92.6	7.4	83.7	16.3	76.8	23.2
Local	75.4	24.6	72.9	27.1	89.1	10.9	72.9	27.1	77.0	23.0
Overall	79.2	20.8	67.6	32.4	90.9	9.1	77.8	22.2	76.1	23.9
Rice	-	-	-	-	-	-	-	-	79.8	20.2

[1]The distribution between family and hired labor under each operation adds up to 100.

Production

Per ha Yield

The overall per ha yield of chili in the study area was about 10 t/ha in fresh weight (Table 39). This estimate was higher than the national average as well as the estimate of Farooqi et al. (2003) at 7.5 t/ha. This may be due to the concentration of our survey in major chili growing areas.

Table 39. Chili yield (fresh weight in t per ha) in various intercrops in the sample areas, by chili type, India, 2002

Chili type	Chili (alone)	Chili (intercrops with other crop)		Relay with another crop	Overall
		One intercrop	Two intercrops		
Hybrid	16.6 (0.61)	-	-	-	16.6[a] (0.61)
Open pollinated	14.2 (0.76)	7.6 (1.51)	-	-	13.7[b] (0.79)
Local	6.4 (0.88)	0.6 (0.94)	0.7 (1.12)	0.7 (1.04)	4.1[c] (1.27)
Overall	12.4 (0.81)	1.2 (2.96)	0.7 (1.12)	0.7 (1.04)	10.0 (1.01)

Note: The figures in brackets are coefficients of variation (CV). In a column, chili yield followed by a different superscript are statistically different at 10% level across chili types.

Yield was highest in hybrid, and lowest in local chili types due to its stumpy potential, low intensity of inputs applied, and traditional management practices used in its cultivation. The two to three times difference in yield in local and improved (hybrid and open pollinated) chili varieties suggests that there is a big potential for the improvement of the farmers' yield by introducing improved varieties, improving farmers' access to the inputs required in these varieties, and providing them training for the management practices associated with these varieties.

The yield of chili as an intercrop was lower than its yield as a single crop. Sheshadri (2000) also found in that the intercropping of hybrid cotton significantly reduced the dry chili yield. Similarly, Manjunatha et al. (2001) found lower yield levels of intercropped chili than the sole crop of chili. However, it is not certain how the combined yield of chili and the crop with which it was intercropped was affected by intercropping.

Intercropping not only decreased yield but also increased risk as reflected by the higher coefficient of variation (CV) in the system compared to the one in sole crop.

The availability of water can dramatically increase chili yield, regardless of its type. The variation in chili yield was also lower in the irrigated system compared to the non-

Table 40. Chili yield in fresh weight of sole crop (t/ha) in the sample areas, by irrigation and chili types, India, 2002

Chili type	Irrigated	Un-irrigated
Hybrid	16.6 (0.61)	-
Open pollinated	16.5^{a} (0.59)	6.2^{b} (1.71)
Local	8.7^{a} (0.63)	2.3^{b} (1.26)
Overall	14.3^{a} (0.67)	3.2^{b} (1.81)

Note: The figures in brackets are coefficient of variation (CV). In a row, chili yields followed by different superscripts are statistically different at 10% level across irrigation types.

Grades of Chili and Prices

Although farmers do not practice grading using the quality criteria defined earlier, they classified about two-fifths of their output as high grade (grade1) and another two-fifths of mix grade (Table 41). There were only relatively few that were classified as grade2 and grade3, except in local chili where 23% of the product was of grade2. There was not much incentive for grading, as price differential between grade1 and mix grade was insignificant . This explained why a large percentage of farmers sold their output without grading.

Table 41. Chili grades and prices in the sample areas, by chili type, India, 2002

Chili type	Percentage				Price of fresh chili (INR/kg)				
	Grade1	Grade2	Grade3	Grade mix	Grade1	Grade2	Grade3	Grade mix	Overall
Hybrid	41	5	8	46	9	7	3	7	7.1
Open pollinated	42	13	5	40	8	8	4	8	7.4
Local	36	23	8	33	9	7	5	9	8.5
Overall	40	14	7	40	9	7	4	8	7.8

The overall price of local chili was higher than other improved varieties. Therefore, farmers attach special preferences to the attributes in local chili type. The open pollinated (improved) varieties also fetched significantly higher prices than hybrid varieties.

Economics of Chili Cultivation

Cost and Factor Share

Per ha cost of chili cultivation was highest in hybrid, yet cost per unit of output was lowest because of its high productivity (Table 42). On the other hand, the per ha cost of local chili was lowest, but its per kg cost highest among hot chili types because of its low productivity. This implies that modern chili varieties need high investment, but its high productivity reduces the per unit cost of output. Therefore, local chili cannot compete with hybrid and open pollinated crops, unless it has special attributes preferred by consumers to attract higher price. The per ha and per kg cost of open pollinated type was in between hybrid and local types. However, the difference in per unit cost of hybrid and open pollinated was not significant.

After fixed costs such as land rent and machinery cost, labor was the next major input in chili cultivation, accounting for at least one-fourth of the total cost followed by pesticide. The share of labor in total cost was lower in hybrid and open pollinated chili compared to local chili, suggesting that farmers applied traditional labor-intensive technologies in local chili. The share of pesticide ranged from 19% in local to about 21% in open pollinated and hybrid chili types, respectively. Fertilizer was also one of the major cost items in chili cultivation accounting for 11-13% of total cost in different chili types.

Table 42. Cost of production and factor share in the sample areas, by chili type, India, 2002

Chili type	Cost of production		Factor share (%)						
	Total (INR/ha)	Per unit output (INR/kg)[1]	Labor	Seed	Fertilizer	Manure	Irrigation	Pesticides	Others[2]
Hybrid	64,816[a]	5.4[b]	25	8	11	5	3	21	27
Open pollinated	45,229[b]	7.6[b]	25	2	13	4	2	21	33
Local	34,635[c]	9.3[a]	27	2	13	6	1	19	31
Overall	49,957	7.3	26	5	12	5	2	20	30

[1]Output cost is based on fresh form of chili.
[2]Others include land rent, machinery cost, and interest cost.
Note: The different superscript in a column indicates that the figures are statistically different across chili types.

Economics of Chili Cultivation

Total cost and net return seems to be positively related across chili types. In general, net return was high where total cost was high. Ironically, high cost was associated with modern varieties, although this was a worthy investment since it generated high rates of return (Table 43). This implied that high return in chili cultivation was obtained only by those making high investments, hence limiting its cultivation to the resource-rich farmers.

Reducing the cost of chili cultivation especially for improved varieties is a challenge for researchers, while increasing chili farmers' access to credit a challenge for policy makers. This will expand chili cultivation to resource-poor farmers.

Table 43. Economics of cultivation of chili in the sample areas, by chili type, India, 2002

Chili type	Gross return (INR/ha)	Net return (INR/ha)	B-C ratio (%)	Labor productivity (INR/day)	Fertilizer productivity (INR/kg)
Hybrid	103,038[a]	38,222[a]	79[b]	309[ab]	292[a]
Open pollinated	97,639[a]	52,410[a]	111[a]	380[a]	320[a]
Local	52,636[b]	18,001[b]	40[c]	253[b]	185[b]
Overall	83,054	33,097	70	300	256

Note: The different superscript in a column indicates that the figures are statistically different across chili types.

Modern varieties not only provided high rate of return on investment, they also improved resource productivity, such as labor and fertilizer. Among modern varieties, open pollinated chili gave lower per ha yield, but incurred lower production cost compared to hybrid varieties. In fact, open pollinated varieties in India was more competitive than hybrid types, as it produced output at lower cost, and had higher resource efficiency, such as fertilizer and labor (Table 43).

Attractions and Constraints in Chili Production

Farmers considered profitability as the main attraction in chili cultivation, except those growing open pollinated varieties who considered it a second consideration. Adaptability of chili cultivation to local climate was their main attraction. Other considerations for chili cultivation were adaptability to soils, experience in chili cultivation, and tradition of growing chili (Table 44).

Table 44. Ranking of attraction attributes in chili cultivation (%) in the sample areas, by chili type, India, 2002

Attraction attributes	Ranking*			
	Hybrid	Open pollinated	Local	Mixed
Profitability	1	2	1	1
Adaptability to climate	4	1	3	2
Adaptability to soil	2	3	4	4
Experience	3	5	5	3
Tradition	5	4	2	5

*Highest rank=1 and lowest rank=5.

Overall, farmers viewed disease infestation and insect attack as the most important constraints in chili cultivation (Table 45). In different chili farmer types, disease infestation or insect attack was ranked either the first or second major constraints. Except in local chili farmer type, the third major constraint faced by farmers was low and variable prices. Unpredictable environment was the third major constraint in local chili, while it had relatively low priority in other types. Surprisingly, low yield and weeds were considered to be relatively low ranking constraints.

Table 45. Ranking of constraints faced by chili farmers in the sample areas, by chili type, India, 2002

Constraints	Type of farmer				
	Hybrid	Open pollinated	Local	Mixed	Overall
Diseases	1	2	1	1	1
Insects	2	1	2	2	2
Low price/variability in chili price	3	3	4	3	4
Environment	4	5	3	5	3
Weeds	5			4	5
Low yield variety		4	5		

Note: Highest rank=1 and lowest rank=5.

Chili Consumption

Per Capita Consumption of Chili

Among the various spices produced in the country, per capita consumption was highest for chilies (Farooqi et al. 2003). It was consumed either in green or powder forms. Very little other form of processed chili products were used in India. When all consumed chili items were converted into fresh weight, about two-thirds of the consumption by chili farmers, one-half by non-chili farmers and one-third by urban consumers were in chili powder form. Chili farm families consumed about one-fifth of the fresh chili weight in green fresh form, while the ratio for the non-chili growing farm and urban families was about one fourth. The share in the consumption of other chili forms and products were relatively small (Table 46).

Table 46. Relative share of different chili types in total consumption in the sample areas, by consumer type, India, 2002

Type of chili	Quantity share (%) as consumed				Quantity share (%) after converting into fresh weight[3]			
	Chili farmer	Non-chili farmers	Urban consumer	Overall[4]	Chili farmer	Non-chili farmers	Urban consumer	Overall[4]
Green fresh	45.3	60.0	48.2	55.4	18.4	29.1	23.7	26.9
Red fresh	0.9	0.1	1.7	0.7	0.4	0.0	0.9	0.3
Sweet fresh	2.4	0.0	15.0	5.5	1.0	0.0	7.3	2.7
Dry chili	8.4	6.8	15.2	9.9	13.7	13.3	29.8	19.3
Chili powder	38.9	26.4	19.1	24.0	63.2	51.2	37.6	46.5
Other products[1]	4.1	6.6	0.8	4.4	3.4	6.4	0.8	4.3
Overall (g/week)[2]	182.4[a]	92.3[b]	85.3[b]	90.5	448.8[a]	190.5[b]	173.8[b]	186.6

[1]Others include chili pickle, paste, curry and other chili products mostly prepared at home by chili-growing families.

[2]The figures in this row are average per capita chili consumption. The different superscript on the figures across this row implies that they are significantly different at the 10% level.

[3]Dry chilies and powder chili were converted into fresh by multiplying their weight with 4. Similarly, chili pickles, paste, curry and other products were converted into chili fresh weight by multiplying with 2.

[4]Chili consumption in India was estimated assuming 1%, 60%, and 39% weights for the chili producer, non-chili producer, and urban consumer, respectively.

On average, per capita weekly consumption of chili in India was about 186.6 g or 27 g daily of fresh weight equivalent. This consumption was higher than the per capita availability figure estimated from production. The reasons may be due to inclusion of the fresh market and home garden-produced chili in this estimate which was excluded from the macro statistics for production. Results may also be biased because of the concentration of this survey in the main chili-producing areas.

The highest consumption of chili was by families engaged in its cultivation compared to those who were not engaged in its production or living in urban areas. The consumption of non-chili growing farmers was similar to urban consumers.

In India, about three rupees per week per person were spent on chili. More than 50% of this was spent on chili powder and 17% on dry chili. The green fresh constitute 18% of the total expenditure on chili (Table 47).

Table 47. Relative share of expenditure (%) of consumers on different chili types in the sample areas, India, 2002

Type of chili	Chili farmer	Non-chili farmer	Urban consumer	Overall[1]
Green fresh	14.8	18.2	17.3	17.8
Red fresh	0.7	0.1	2.1	0.9
Sweet fresh	1.7	0.0	4.8	2.0
Dry chili	8.1	12.2	25.1	17.4
Chili powder	70.1	54.2	48.8	52.4
Other chili products[2]	4.7	15.2	1.8	9.5
Overall weekly expenditure (INR)[3]	6.4[a]	2.7[b]	3.0[b]	2.9

[1]The chili consumption in overall India was estimated assuming 1%, 60%, and 39% weights for the chili producer, non-chili producer, and urban consumer, respectively.

[2]Others include chili pickle, paste, curry and other chili products mostly prepared at home by chili-growing families.

[3]The different superscript on the figures across this row implies that they are significantly different at the 10% level.

Retail Value of Chili and its Products

Using the per capita weekly expenditure in Table 46 and per capita weekly consumption in Table 45, the estimated average per kg price of chili and its products in fresh weight was INR15.5 (US$0.345) at the retail level. This price was about double the farm gate price in the survey area reported in Table 41. Applying this proportion, the farm value of chili in India at US$867 million was converted into the retail value of chili and its products at US$1.727 billion.

Response to Price Changes

Powder chili had the lowest response when prices were changed; doubling its prices will decrease consumption by only eight percent and decreasing the prices by 75% will increase consumption by only 10%. The responses for red and green fresh chilies were slightly higher than for powder chili. The highest response came from sweet chili – doubling the price will decrease consumption by 62% and decreasing the price by 75% will increase consumption by 63% (Table 48). Therefore, red, green, and processed chili is an essential ingredient of every meal, while sweet chili is considered a normal vegetable in India.

Table 48. Effect of price changes on chili consumption in the sample areas, by chili type and product, India, 2002

Change in price (%)	Hot chili				Sweet
	Green	Red	Powder	Product	
Increase in price	Change in demand (%)				
110	-0.1	0.0	-0.5	-1.0	-10.0
125	-0.3	-0.7	-1.0	-3.2	-15.3
150	-1.5	-3.0	-2.8	-6.0	-37.7
175	-7.4	-5.0	-5.0	-10.7	-50.2
200	-19.3	-12.5	-7.9	-17.8	-61.7
Decrease in price					
90	5.1	4.0	0.7	2.0	10.8
75	7.2	6.8	1.5	5.7	25.7
50	10.3	10.0	3.2	9.8	46.3
25	11.4	14.8	10.0	15.0	63.0

Source of Supply

Farmers mainly got fresh and dry chili from their own farm, although a significant portion of these also came from the local market. Chili powder and products, such as pickle and paste, were also homemade suggesting significant on-farm processing activities in rural areas (Table 49).

Urban consumers bought fresh chili paste mainly from local market, and sweet chili from local and cooperative/supermarkets. About one-half of dry chili came from the local market and the remaining half was distributed across various sources. The sources for chili product were the main markets and cooperative shops/supermarkets. A significant portion of red chili consumed as fresh came from home sources, suggesting production in home gardens in urban areas. Most urban consumers also made their own chili powder to ensure quality from purchased or home garden-produced chili.

Table 49. Chili purchasing place by type of farmer and consumer in the sample areas, by chili type, India, 2002

Chili type	Farmer				Urban consumer			
	Farm supply	Home-made	Local or main market	Others	Home-made	Local or main market	Co-op. shop or supermarket	Others
Hot chili								
Green	46	0	24	30	0	57	34	9
Red	63	0	14	23	10	74	0	16
Dry chili	70	16	4	10	3	50	0	47
Chili powder	0	78	6	16	91	0	5	4
Sweet chili	50	0	36	14	0	50	50	0
Chili products	4	61	16	19	0	60	40	0
Overall	31	34	13	22	29	38	16	17

Chili Attractions in Consumption

In fresh green and red chilies, hotness was the number one attribute the consumers looked for when buying. In chili powder and products, red color or the impression of the color that the product will give to their food was the main criterion the consumers look for. In sweet chili, appearance or freshness was the top ranking characteristics. As sweet chili was most responsive to prices (Table 48), it became the number 2 ranking criterion. Surprisingly, pest infestation (disease and insect) was the second ranking criterion in fresh hot chili (green and red) (Table 50). It means that pests not only reduce yield, they may also decrease prices of the output.

Table 50. Consumers' ranking for chili characteristics in the sample areas by chili type, India, 2002

Selection criteria	Hot chili				Sweet chili
	Green	Red	Powder	Product	
Market price	4	3	4	3	2
Disease free	2	2	5		4
Insect free		2			
Overall appearance		5	3		1
Color	5	4	1	1	
Pungency	1	1	2	2	3
Shape					3
Freshness	3				

Note: Highest rank=1 and lowest rank=5.

Consumers' Preference for Packaging

Green and red chilies were preferred unpacked and sweet chili was preferred in paper wrapping. Consumers thought that these products remained fresh in this way - the most preferred attribute in sweet chili. Chili powder was preferred unpacked, in paper and glass wrappings with almost equal proportion each for various reasons, while chili products were mainly preferred in plastic and glass packaging (Table 51). However, for tropical conditions, it is recommended that High Density Poly Ethylene (HDPE) films are suitable for packaging Guntur (OP) and Byadagi (local) whole chilies in unit packs of 250 grams (Pura Naik et al. 2001).

Table 51. Consumer preferences for chili packaging in the sample areas, by chili type, India, 2002

Chili type	Packing type	Preference (%)	Reason (%)						
			Freshness	Best image	Cheap	Providing variety	Ideal*	Visibility	Other
Green/red									
	Unpacked	65	69	5	1	3	4	16	2
	Paper	18	19	13	9	22	23	13	1
	Glass	8	19	8	2	66	4	2	0
	Plastic	6	20	10	7	50	10	3	0
	Tin	4	17	26	22	26	9	0	0
Sweet									
	Unpacked	18	64	9	0	0	0	27	-
	Paper	70	37	5	5	28	5	21	-
	Glass	10	25	13	13	13	13	25	-
	Plastic	2	100	0	0	0	0	0	-
Powder									
	Unpacked	33	38	16	5	4	13	23	0
	Paper	27	4	17	7	50	20	2	1
	Glass	23	6	14	23	23	13	20	1
	Plastic	11	10	13	8	40	15	15	0
	Tin	6	33	13	8	25	17	4	0
Product									
	Unpacked	12	0	22	22	0	22	33	-
	Glass	35	0	16	27	8	16	32	-
	Plastic	53	2	12	35	8	15	28	-

* Ideal means ideal for active and modern people.

Development Impact of Chili Cultivation

Input Demand

Chili cultivation increased the demand for almost all inputs compared with other field crops. For example, on average, 177 and 227 more labor days/ha were employed on chili compared to rice and maize, respectively (Table 52). This implied that, on average, one full year job was created when one hectare of cereal was converted into chili cultivation. With one million ha devoted for chili in the country, this implied that chili cultivation generates one million additional jobs in India when conversion is made. This does not include the additional labor needed for chili processing, packaging, and other activities.

Table 52. Relative per ha input use and cost of chili and its competing crops in the sample areas, India, 2002

Crop	Labor (days)	Seed (INR)	Fertilizer (kg)	Manure (t)	Irrigation (number)	Pesticides spray (number)
Chili	294[a]	2,444[a]	402[a]	7.12[a]	11[a]	18[a]
Rice	117[b]	774[b]	252[b]	4.33[b]	12[a]	3[b]
Chili farmer	120	819*	272*	4.34	13	3
Non-chili farmer	112	705	221	4.32	11	3
Maize	67[c]	710[b]	224[b]	1.18[c]	1[b]	2[c]
Chili farmer	62*	778*	230	0.98	1*	2*
Non-chili farmer	77	546	210	1.64	4	3

Note: The different superscript in a column for overall row of a crop implies that the mean value of that crop is different than the other crops. The * in chili farmer row implies that the figure is significantly different than the corresponding figure for non-chili farmer at 10% significance level.

Similarly, the amount of inorganic fertilizer and manure applied was also higher on chili compared with rice and maize. Using a conservative estimate, transferring one million ha from rice to chili cultivation will generate more than 150,000 t of additional demand for fertilizer in India.

Application of farm manure on chili was also much higher when compared with cereals. This generates additional demand for on-farm livestock to get manure supply. The additional income from chili cultivation can also provide the necessary resources to establish livestock on the farm, which then further generates income and employment.

The more number of sprays on chili compared to rice and maize emphasized the need for developing pest-resistant chili varieties. The average number of irrigations in chili cultivation as a sole crop was found to be little less than that of rice but more than that of maize, although the number of irrigations in chili planted with rice was similar but far more than in chili planted with maize. Chili may not require a lot of water, as irrigation on chili is relatively thinly distributed, however, addition of number of irrigation for chili means more labor requirement for its application when compared with the irrigation on maize.

The input use on rice by chili farmers was comparable or higher with non-chili farmers. However, for maize, chili farmers invested significantly higher amount on seed and less on manure and irrigation than their counterpart non-chili farmer.

Resource Use Efficiency

On average, chili production was more profitable than production of other field crops, such as rice and maize. However, to attain higher returns from chili, three to six times more costs were incurred (Table 53). The benefit-cost ratio was also significantly higher in chili production than in other field crops. This implied that shifting resources from field crops to chili production will improve the rate of return on the employed resources. However, the variability in return in chili cultivation was also higher (not reported in the table) implying that chili was a more risky crop. Chili production also improved the resource productivity of individual input, such as labor and fertilizer.

Table 53. Resource use efficiency in chili and competing crops in the sample areas, by farmer type, India, 2002

Crop	Yield (t/ha)	Total cost (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B-C ratio (%)	Labor productivity (INR/day)	Fertilizer productivity (INR/kg)
Chili	12,290[a]	49,957[a]	83,054[a]	33,097[a]	70[a]	300[a]	256[a]
Rice	3,539[b]	16,422[b]	18,235[b]	1,813[b]	11[b]	145[b]	73[b]
Chili farmer	3,818*	16,864	18,928*	2,064*	12*	147	76*
Non-chili farmer	3,113	16,273	17,651	1,378	8	143	67
Maize	2,299[c]	11,210[c]	11,119[c]	-90[c]	-1[c]	128[b]	38[c]
Chili farmer	2,290	10,906	11,190	274*	3*	139*	39
Non-chili farmer	2,318	12,831	10,948	-1,883	-15	102	36

Note: The different superscript in a column for overall row of a crop implies that the mean value of that crop is different than the other crops. The * in chili farmer row implies that the figure is significantly different than the corresponding figure for non-chili farmer at 10% significance level.

Chili cultivation, especially the improved type, was not only more economical to grow, it also improved the economic and managerial capabilities of farmers such that they were able to apply more inputs and/or use better management practices in field crops. This was reflected in either higher yield or better returns from field crops on the chili farms compared to non-chili farms. For example, benefit-cost ratio in rice was significantly higher on chili farms because they get higher yield, although production costs were the same. Similarly, net returns and fertilizer productivities were significantly higher on chili farms. Therefore, spread in chili production will have a positive impact on the productivity of other field crops. Similarly, labor productivity in maize on chili farms was higher than on non-chili farms.

Impact on Gender

A large proportion of labor in chili cultivation, especially in harvesting, was female. Overall, female labor contributed about 60% in chili cultivation compared to less than 30% in rice (Table 54). The contribution was relatively small in local chili type. This implied that chili is a female gender crop. Moreover, improved chili types helped increasing the contribution of female labor.

Table 54. Gender distribution of labor in the sample areas, by operation and chili type, India, 2002

Chili type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Hybrid	64.0	36.0	45.5	54.5	90.4	9.6	71.3	28.7	61.8	38.2
Open pollinated	59.4	40.6	44.2	55.8	87.9	12.1	74.7	25.3	62.1	37.9
Local	52.6	47.4	49.1	50.9	84.7	15.3	59.1	40.9	58.9	41.1
Overall	57.0	43.0	47.1	52.9	87.4	12.6	64.7	35.3	60.4	39.6
Rice	-	-	-	-	-	-	-	-	28.2	71.8

[1]The distribution between male and female under each operation adds up to 100. The proportion for rice was available only for overall labor use, not for individual activities.

Impact on Consumption

Vegetable cultivation improved overall family income, inducing food consumption and overall expenditures. However, income and food consumption of chili farmers was still way below than that of urban consumers (Table 55). Therefore, chili farmers need new income sources to bring them at par with the urban consumers. Introduction of improved production technologies to farmers may be an effective means to achieve this goal.

Table 55. Monthly household income and expenditures by consumer type in the sample areas, India, 2002

Consumer type	Expenditures (INR)		Average monthly income (INR)
	Food	Overall	
Chili farmer	1,902[b]	2,771[b]	5,517[b]
Non-chili farmer	1,759[c]	2,567[c]	3,256[c]
Urban consumer	2,840[a]	5,130[a]	11,340[a]
Overall	1,931	3,050	6,010

Note: The different superscript in a column implies that the figures are significantly different across consumer types.

The main improvement in consumption pattern on chili farmer came from an enhancement in vegetable consumption. The improved income from chili production significantly improved the consumption of vegetables, livestock products, and "other" foods among chili farm families than of non-chili farm families. The consumption of fruits was lower in the former group (Table 56). Increased vegetable consumption by chili farm families will have positive consequence on the availability of micronutrients for the family members.

Table 56. Average daily consumption of different food group by consumer type, India, 2002

Food group	Quantity (g/capita)[1]			
	Chili farmer	Non-chili farmer	Urban consumer	Overall
Cereals	377[a]	360[a]	317[b]	343
Livestock products	242[b]	211[c]	295[a]	244
Vegetables	185[a]	151[b]	134[b]	145
Fruits	40[b]	90[a]	80[a]	86
Others	76[a]	35[b]	71[a]	50
Overall	920[a]	847[b]	898[ab]	868

[1]The different superscript in a row implies that the figures are significantly different across consumer groups.

Summary and Conclusion

Chili production in India is expanding more rapidly than the growth in population, giving boost to both export and domestic consumption. An encouraging development is that most of the expansion is contributed by an improvement in per ha yield and relatively little from expansion in area. The farm value of chili production was estimated at US$867 million per annum, while retail value of chili and its products were estimated at US$1.7 billion. Despite the increasing importance of chili in the domestic and export markets, little is known about its production, consumption, and marketing. This study intends to fill this information gap through comprehensive surveys of various stakeholders involved at different levels of its food chain, and trend analysis of macro data.

The chili-growing farms in India were located near the paved road and market. The farmers augmented their land holding by renting land, as they see more opportunity of earning income from chili cultivation. They had higher probability of owning tractors, but less probability of owning tube wells as the water table in rainfed areas was very deep, and they had better access to the public canal water source in irrigated areas. They also owned more livestock, giving them access to more supply of farm manure and generating additional income.

Chili growers in India allocate the majority of their land to chili production. A large proportion of chili cultivation (20%) was intercropped, mainly with cotton. A large number of farmers grew local chili varieties, mainly under rainfed conditions. The management practices in chili cultivation were old, and need to be revitalized. For example, a great majority of chili seedlings were prepared without any protection against insects and diseases; very few treat seeds and fields against infection; majority of chili fields had flat fields without any shading, tunnel, or staking; few farmers did mulching; and fertilizer is mainly broadcasted. Despite high losses due to insects and diseases about one-fourth of farmers did not apply pesticide or any other control measures, and few harvestings were practiced.

Low-technology input in chili cultivation in India resulted to high losses in yield due to insect and disease infestation. Despite this, farmers gave low priority to the insect- and disease-resistant varieties in making variety selection. Clearly, farmers were dissatisfied with the yield potential of existing varieties, and gave top priority to the high-yielding varieties while making variety selection. They give second priority to the ability of variety to fetch high prices. The important conclusion is that despite high yield losses, farmers will not accept any disease- or insect-resistant material for its own sake unless it is associated with higher yield, and ability to fetch high prices by having attractive chili color, pungency, and other characteristics.

Introduction of hybrid chili and open pollinated improved varieties changed the situation to some extent. Since hybrid seed was expensive, farmers resorted to F_2 progeny seeds selected from their own crop or from the neighboring farmers' fields. The F_1-growing farmers tried to maximize the return on seed investment by adopting improved management practices. For example, less hybrid fields were intercropped, more seeds were treated with dust, more fields received soil treatment with higher quantities of chemical application and straw mulching, and higher proportion of fields were constructed with irrigation ridges and treated with pesticides. The input quantities for fertilizer, insecticide and fungicide, and the number of irrigation were higher for the hybrid and improved pollinated varieties. These pesticide sprays were injudicious and detrimental to the environment. Labor use for land preparation, crop management, and harvesting and post-harvesting operations also increased suggesting that farmers really took good care of these varieties. This had dramatically reduced the yield losses due to insect and pest infestation in hybrid type, but the losses were still substantial in open pollinated and local chili types.

Open pollinated varieties were economically more viable than hybrids. It incurred lower cost, and per unit output cost was not statistically significant across the two varieties. On the other hand, resources engaged in open pollinated varieties had higher economic efficiency than those in hybrid. Open pollinated modern varieties were distributed by the public sector institutes and covered a significant proportion of chili area. This attested to the success of the public sector institutes in distributing these varieties to chili farmers. However more needs to be done to reach out to a large segment of poor farmers who are still growing traditional varieties, and do not have resources to buy the expensive hybrid seed or access to public sector seed supply. Improving access to these institutes will help poor farmers get out of poverty and ultimately enhance the competitiveness of the chili sector.

Despite some improvements due to the introduction of hybrid and open pollinated chili varieties by the private sector, chili production in India still has a lot of room for improvements. Even in improved varieties, more fields need to be protected from insect attack and disease infestation, and management practices can still be improved; specifically, seedling management and irrigation methods have to be improved, crop protection practices have to be modernized, input use has to be optimized, and harvesting and post-harvesting systems have to be upgraded. Above all, the access of farmers to improved hybrid and open pollinated varieties has to be improved. Without these, more competitive players like China may threaten India in the international chili market. With the opening of markets under WTO, even local markets may be threatened with cheaper chili supply from the international market.

Chili is mainly consumed in powder form in India. About one-half of the total consumption (after converting all consumption in fresh) is in powder form. Except for sweet chili, the demand elasticity is low (even lower than the elasticity for cereal) implying that it is an integral part of the consumers' diet. Chili color in powder chili and pungency in green and red fresh chili were found to be important criteria of consumers in making chili purchase decisions. Therefore, improving these attributes in different chili types can help farmers get higher prices and enhance their profitability. Producers and marketing agents can also tailor the packaging of various chili products according to consumers preferences enumerated in this study.

Chili cultivation can have important impact on rural development. Chili production generates a significant demand for inputs, especially fertilizer, pesticide, seed, and irrigation water, which encourages agricultural business activities in rural areas. Moreover, shift of farm resources from traditional crops, such as cereals, to chili significantly improves their efficiency. Chili cultivation has positive spillover effects on the production efficiency of other crops. It is considered to be a gender friendly crop. Farmers also benefit from chili production through improved income and diet. Despite these benefits, however, expansion of chili cultivation has limitations because of its low demand elasticity. The strategies to improve chili product quality by tailoring the produce to the demand attributes and expansion of its international market will help to expand the chili sector and simultaneously increase farmers' income.

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Appendix 1. Frequency of use of different pesticide on chili in the sample areas, India, 2002

Common name	Percentage distribution	
	Insecticide	Fungicide
Monocrotophos	11.71	1.95
Acephate (Asataf)	9.97	0.57
Chlorpyrifos (Coroban/Sitara)	8.84	0.57
Cypermethrin (Magister)	7.93	-
Fipronil (Regent)	7.78	0.23
Dicofol (Kelthane)	6.57	0.23
Spinosad (Tracer)	5.59	0.11
Phosalone (Zolone)	4.98	0.34
Dimethoate (Rogor)	4.98	0.11
Endosulfan	3.85	-
Imidacloprid (Confidor)	3.70	0.23
Quinalphos	3.25	0.11
Indoxacarb (Avaunt)	2.87	0.11
Triazophos (Hostothion)	2.64	0.11
Lamda Cyhalothrin (Karate)	2.11	-
Methomyl (Larvin/ Thiodicarb/Lannate)	1.82	0.34
Sulphur (Sulfex)	1.66	7.90
Mancozeb (Dithane M-45)	1.21	18.67
Unnamed	1.06	1.49
Ethion (Phosmid)	0.98	-
Methyl parathion (Metacid)	0.76	-
Deltamethrin + Triazophos (Spark)	0.76	-
Malathion	0.60	-
Carbendazim (Bavistin)	0.60	16.95
Phosphamidon (Demecron)	0.45	-
Acetapride (Pride)	0.45	-
Novulorun (Remon)(Insect growth regulator)	0.38	-
Copper Oxychloride (Blitox/Fytolan)	0.38	13.41
Bacillus Thuringiensis (B.t)	0.38	-
Hexaconazole (Contaf)	0.30	6.41
Phorate (Thimet)	0.23	0.46
Oxydemeton-Methyl (Metasystox)	0.23	-
Carbofuran (Furadon)	0.23	-
Decamethrin (Diceys)	0.15	-
Azadirachtin (Neem oil)	0.15	-
Carbaryl (Sevin)	0.08	-
Ziram (Cuman L)	0.08	1.15
Triadimefon (Bayleton)	0.08	3.89
Penconazole (Topas)	0.08	2.18
Mexacarbate (Zetran)	0.08	0.11

Cont..., Appendix 1

Dinocap (Kerathane)	0.08	0.57
Streptocmcine (Spectramycin)	-	3.78
Metalaxyl + Mancozeb (Ridomil)	-	3.09
Captan (Captaf)	-	3.09
Chlorothalonil (Kavach)	-	2.75
Benomyl (Benlate)	-	2.63
Zineb (Dithane Z-78)	-	2.41
Carbendazim + Iprodione (Quinta)	-	1.95
Carbendazim + Mancozeb (Saaf)	-	1.37
Propiconazole (Tilt)	-	0.34
Fosetyl-Al (Aliette)	-	0.23
Bitertanol (Baycor)	-	0.11

Note: The names in brackets are brand or local names.

Indonesia

Indonesia

Usman Mustafa, Mubarik Ali, and Ir. Heny Kuswanti

Introduction

Chili is an important and essential component of the daily Indonesian diet. It is mainly consumed in fresh semi crushed form, locally known as "Sambals" (RIV 1996). It is also an important commercial crop grown year-round mainly by small farmers both in high and lowlands under rainfed as well as irrigated conditions. In 2003, it was cultivated on a total area of 176 thousand ha producing about 1.1 million t of fresh weight with an average yield of 6.1 t/ha. The importance of chili in the Indonesian diet and cropping systems in certain areas demands systematic efforts in understanding the production, consumption, and marketing aspects of the whole sector. Lack of information at the national level will hamper appropriate planning of the sector, and keep it far below its potential. This study was designed to fill the information gaps, and to provide an analytical look of various issues at different food chain levels in Indonesia. The data used in this analysis were collected from secondary sources as well as through surveys from various stakeholders along the chili food chain.

Indonesia is located at the crossroads of the ancient world, spanning the trade routes between the Middle East and Asia. The country is the largest archipelago in the world with 33 provinces and approximately 13,000 islands. It is not surprising that traders, immigrants, and even pirates were enticed by the riches of these "Spice Islands". During the 1st to 7th centuries AD, Indian traders not only introduced the Sankrit, Buddhism and Hinduism, they also brought with them cucumber, eggplant, and cowpeas and assimilated curries into the native cuisine. Europeans, including the Dutch, Portuguese, Spanish, and British, in their search for spices, began arriving in the early 16th century and introduced temperate vegetables like tomato, chili, pepper, squash and pumpkin. (Recipes4us 2003; Freeman 2005).

The territory of the Republic of Indonesia stretches from latitudes 6^{o}N to 11^{o}S and from longitudes 95^{o}W to 141^{o}E. Indonesia consists of five big islands: Java, Sumatra, Sulawesi, Kalimantan, and Irian Jaya. Chili is grown mainly in East Java, Central Java, West Java and North Sumatra. More than 23% of chili production was harvested from West Java followed by 19% and 12% from East and Central Java, respectively (Table 1).

Table 1. Chili area and production by province, Indonesia, 2003

Province	Harvested area		Production in fresh weight		Yield in fresh weight
	(ha)	(%)	(t)	(%)	(t/ha)
East Java	40,553	23.0	197,989	18.6	4.9
Central Java	26,900	15.3	127,149	11.9	4.7
West Java	20,304	11.5	247,300	23.2	12.2
North Sumarta	17,345	9.8	132,943	12.5	7.7
West Sumarta	8,260	4.7	49,073	4.6	5.9
Aceh	10,304	5.8	42,836	4.0	4.2
Bengkulu	8,782	5.0	32,639	3.1	3.7
South sulawesi	7,031	4.0	31,929	3.0	4.5
Other	36,785	20.9	204,864	19.2	5.6
Total	176,264	100.0	1,066,722	100.0	6.1

Source: Directorate General of Food Crops and Horticulture (2004).

Primary Data Collection

Primary data on various aspects related to production, consumption, marketing, and processing of chili and production aspects of competing crop were collected from three major chili-producing provinces of the country, namely West Java, Central Java and East Java (Table 2). In each province, three to four districts or sub-districts were chosen in consultation with the provincial Department of Agricultural Extension (DAE). These districts or sub-districts include Wanasari, Peservani, and Cikajaing from West Java; Brebes, Tanjung and Kersana from Central Java province; and Pelem, Singnalan, Kepuh, and Nagnanpal from East Java. One or two major chili-growing villages were selected from each district/sub-district, again in consultation with DAE. Depending upon the availability of farmers, 10 to 25 chili and two to five non-chili farmers and their wives were randomly selected from each village. The survey team visited 14 villages. The survey was conducted during the months of September and October 2002 and the production data covered the crop harvested in the same year.

Table 2. Frequency distribution of the sample respondents by region and province, Indonesia, 2002

Type of respondent	West Java	Central Java	East Java	Total
Chili farmers	86	84	86	256
Non-chili farmers	17	16	17	50
Chili farmer housewives (HW)	75	84	84	243
Non-chili farmer housewives	16	13	17	46
City housewives (Jakarta)				62
Market agents (Jakarta, Pedagang Pengumpul Desa, Karamat Jati)				16
Chili processors (Jakarta, Tanjung, Cirebon)				6

A total of 256 chili-growing farmers and 50 non-chili growing farmers were interviewed on management practices, input use, outputs and input-output prices, and marketing channels of chili, and one major competing crop of chili grown during the survey year. Sixteen market agents from Jakarta, Pedagang Pengumpul Desa, Karamat Jati and six chili processors from Jakarta, Tanjung, and Cirebon were also interviewed to understand the chili market systems and processing. In the production survey, the household member responsible for cooking for the family (for convenience they will be called housewives, regardless of their sex) were also interviewed on consumption patterns. Two hundred forty-three and 46 chili- and non-chili farmer-housewives and 62 urban housewives (mainly from Jakarta) were also interviewed to inquire about consumption of chili and other food items and preferred chili traits.

Macro Trends

Domestic Production

Chili production in Indonesia fluctuated from 581 to 1,102 thousand t, while area under chili varied from 143 to 183 thousand ha in 1991-2003 (Table 3). Chili production reached the record level of 1,067 thousand t in 2003 because of the increase in both area and yield. Sustaining such sudden jump in production may, however, be difficult.

The farm values of chili production were more variable than production, suggesting bigger fluctuation in farm prices. The maximum value reached US$929.4 million in 1999, more than double the value in the previous year. Similar fluctuations happened in the past such as in 1995 to 1996. These fluctuations are indications of unstable chili markets and lack of information by farmers about its potential demand.

Table 3. Area, production, and yield of chili in Indonesia, 1991-2003

Year	Area (ha)	Fresh production (000 t)	Yield (kg/ha)	Farm value (million US$)[1]
1991	168,061	984.2	5,856	482.4
1992	162,519	970.3	5,971	315.2
1993	157,499	946.2	6,007	374.7
1994	177,600	1,042.0	5,867	445.3
1995	182,263	1,102.3	6,048	469.1
1996	169,764	1,043.8	6,149	876.7
1997	161,602	801.8	4,962	820.2
1998	164,944	848.5	5,144	415.2
1999	183,347	1,007.7	5,496	929.4
2000	174,708	727.7	4,165	568.6
2001	142,556	580.5	4,072	428.1
2002	150,598	635.1	4,217	593.6
2003	176,264	1,066.7	6,052	676.3

Source: FAOSTAT database and official files of Agricultural Statistics Office, Jakarta.
[1]It was estimated using the FAOSTAT-Agriculture (producers' price) data. The prices in local currency were converted using the exchange rate reported in www.fftc.agnet.org (various issues).

International Trade

The total trade (import plus export) of Indonesia gradually increased from 5.9 thousand t (fresh weight chili) worth US$1.2 million in 1991 to a record of 32.5 thousand t worth over US$5.1 million in 2002, then experienced a decline in 2003 (Table 4). Throughout these years, however, the country generally remained in deficit in chili trade, as quantity and value of imports were higher than the corresponding values of export. The trade deficit reached its maximum in 2002 when the country had a net import of over 26,000 t of fresh weight costing US$3.3 million. The import of chili has risen from just 5 thousand to over 29 thousand t, while export increased from 0.8 thousand t to 3.3 thousand t in 1991-2002. Both import and export declined in 2003, although export value was higher than import.

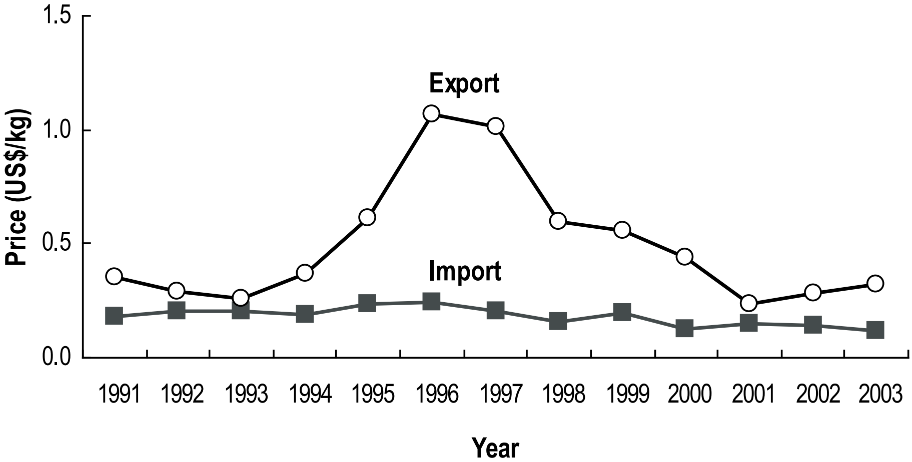
Indonesia is mainly an importer of pimento chili to be used for chili products, such as sauce and paste. Its share in the total imports (in terms of fresh weight and value) was over 87%. Indonesia also exports pimento chili, but its share in the total export ranged from around 54% to 98% in quantity and 36% to 96% in value from 1991-2003.

Indonesia exported high value chili and imported low-priced ones (Figure 1). The difference reached the highest level in 1996 when export prices reached its peak and then declined to its lowest level in 2001. Although there was declining trend in export prices since 1996, it remained higher than the import prices. Indonesia should try to bring its export prices significantly lower than its import prices to become competitive in the international market. To achieve this, the country needs to improve productivity in chili production and efficiency in its marketing system.

Table 4. International trade in chili from Indonesia, 1991-2003

Year	Import		Export		Total trade		Net trade balance	
	Quantity (t)	Value (1000$)	Quantity (t)	Value (1000$)	Quantity (t)	Value (1000$)	Quantity (t)	Value (1000$)
1991	5,188	936	753	264	5,941	1,200	-4,435	-672
1992	4,181	841	1,412	412	5,593	1,253	-2,769	-429
1993	11,430	2,309	1,438	368	12,868	2,677	-9,992	-1,941
1994	19,598	3,633	1,878	696	21,476	4,329	-17,720	-2,937
1995	6,382	1,519	2,862	1,742	9,244	3,261	-3,520	223
1996	7,826	1,914	2,834	3,037	10,660	4,951	-4,992	1,123
1997	16,695	3,374	1,607	1,631	18,302	5,005	-15,088	-1,743
1998	11,902	1,887	1,033	618	12,935	2,505	-10,869	-1,269
1999	13,290	2,620	2,506	1,392	15,796	4,012	-10,784	-1,228
2000	22,959	2,972	2,511	1,101	25,470	4,073	-20,448	-1,871
2001	26,241	3,970	4,190	1,000	30,431	4,970	-22,051	-2,970
2002	29,289	4,187	3,257	915	32,546	5,102	-26,032	-3,272
2003	26,418	3,031	2,890	924	29,308	3,955	-23,528	-2,107

Source: FAO-Agricultural data (Agriculture and Food Trade-Crop and Livestock Primary and Processed). The source reports the trade quantity of fresh chili and pimento as separate groups. The later was converted into fresh weight by multiplying it with a factor of four. The value of trade includes both for fresh and powder chili.

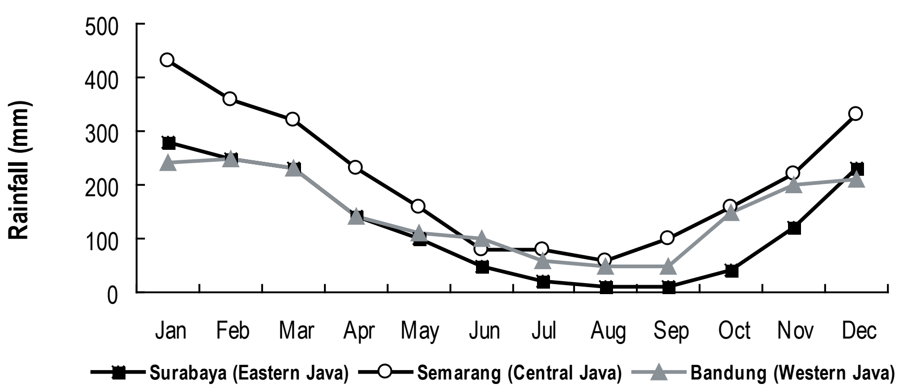


Source: Estimated from import and export quantity and value figures in Table 4.

Figure 1. Trend in import and export prices of chili in Indonesia, 1991-2003

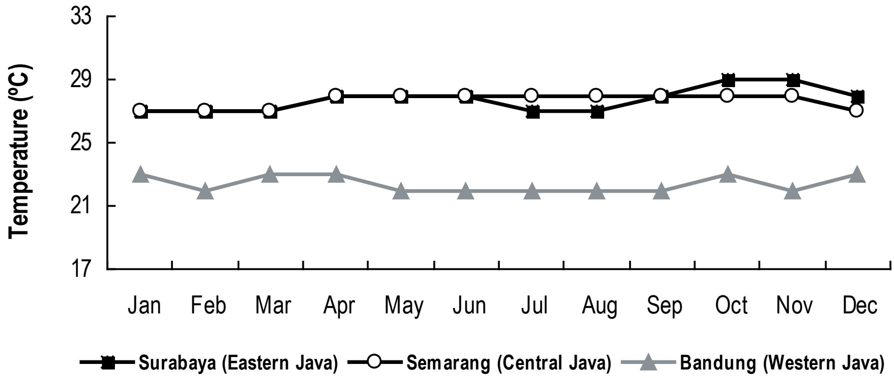
Climatic Situation

The climate of the study area is tropical with annual average rainfall ranges of 1480-1790 mm. Most of the rains come in November-March, while July-September is almost dry. The dry spell is longer and more severe in Surabaya of Eastern Java than in Central and Western Java. Central Java also experiences relatively higher rains during the rainy season compared to the other two sample regions (Figure 2a). In this study, November to April will be considered as wet season, and May-October as dry season for all sites.



Source: Downloaded from "http://www.weatherbase.com/weather/city.php3?c=ID&refer=" and then type city name

Figure 2a. Mean rainfall in the study areas in Indonesia



Source: Downloaded from "http://www.weatherbase.com/weather/city.php3?c=ID&refer=" and then type city name

Figure 2b. Mean temperature in the study areas in Indonesia

The temperature in Central and Eastern Java ranges between 27-29°C, while in Western Java it is much cooler, ranging between 20-23°C throughout the year (Figure 2b). The low temperature in Western Java is due to the high elevation of Bandung city (where temperatures are recorded) in Western Java. Therefore, upland chili production faces significantly low temperature compared to the production in lowland areas. Technology development for various ecoregion should take such differences in climatic situation into consideration.

Farmers Characterization

Socioeconomic Characteristics

While chili farmers were typically younger and had less farming experience than their counterpart non-chili farmers, they still averaged ten years experience of growing chili crop (Table 5). Interestingly, they have bigger family size, but no significant difference in the education level of the household heads of the two groups was observed. They had similar earnings from non-agricultural income as they spent almost the same time in agriculture as that of non-chili farmers. They also borrowed similar agricultural loans compared to non-chili farmers, as many of the non-chili farmers were vegetable or cash crop (such as cotton) farmers.

Table 5. Household characteristics of chili and non-chili farmers in the sample areas, Indonesia, 2002

Characteristics	Chili farmer	Non-chili farmer
Age of the farmer (years)	40[b]	45[a]
Agricultural experience (years)	15.1[b]	19.1[a]
Chili production experience (years)	10.3	-
Family size (no.)	4.54[a]	3.24[b]
Education (schooling years)	7.3[a]	8.8[a]
Farm size (ha)	0.56[b]	0.72[a]
Owned	0.36[b]	0.50[a]
Rented	0.20[a]	0.22[a]
Number of fragments (no.)	1.53[a]	1.35[b]
Off-farm income (000 IDR/year*)	2,717[a]	3,171[a]
Time spend in agriculture (%)	90.0[a]	89.1[a]
Cultivated area (ha)	0.49[b]	0.71[a]
Land use intensity (%)	94[b]	97[a]
Cropping intensity (%)	282[a]	177[b]
Chili area (ha)	0.38	-
Distance from paved road (km)	0.8[a]	0.7[a]
Distance from nearest vegetable market (km)	2.9[a]	3.2[a]
Agricultural loan (000 IDR/year)	1,568[a]	1751[a]
Farm equipments (average number)		
Small farm equipment	1.11[a]	1.37[a]
Water pump	0.2[a]	0.2[a]
Sprayer	1.3[a]	1.5[a]
Livestock (average number)		
Hen and duck	6.8[a]	6.7[a]
Cow	0	1.63
Animal (SAU**)	0.1[b]	2.0[a]

* One US$ = 9,012 IDR

** The standard animal units (SAU) was estimated as: SAU = 0.93 buffalo + 1.08 cow + 0.4 young stock.

Note: Different superscripts in a row imply that the values are different between chili and non-chili farmers at least at 10% significance level.

The farms of the chili farmers were smaller and more fragmented than that of the non-chili farmers. However, they allocated two-thirds of their farm area to chili. The typical field size allocated for chili production was 0.38 ha. No significant difference in the ownership of farm machinery was observed. The cropping intensity on chili farms was higher compared to non-chili farms, but land use intensity was almost similar. This was mainly because most chili farmers cultivated more crops at a time than the non-chili farmers implying that they were using shorter duration crops.

The farms of the chili farmers were smaller and more fragmented than that of the non-chili farmers. However, they allocated two-thirds of their farm area to chili. The typical field size allocated for chili production was 0.38 ha. No significant difference in the ownership of farm machinery was observed. The cropping intensity on chili farms was

House and Household Belongings

On average, three of every ten farmers keep one motorbike in their house, which was the main source of transportation between farms to their houses (Table 6). All non-chili farmer-respondents owned houses, while one percent of chili farmers were renting. A higher percentage of chili farmers had brick and cemented houses as compared to non-chili-farmers. Both groups had similar house covered area, although chili farmers had slightly larger total area of the house. The household belongings across the two groups were similar.

Table 6. Household living conditions and home appliances of respondents in the sample areas, by farmer type, Indonesia, 2002

Characteristic	Chili farmer	Non - chili farmer
House construction (%)		
Mud, local stone	11[b]	37[a]
Bricked, cemented	89[a]	63[b]
Source of drinking water (% of farmers)		
Government water supply	8[a]	8[a]
Private pump	37[a]	28[b]
Open well/artesian well/others	55[a]	64[a]
House covered area (m^2)	100[a]	87[a]
Total area of house (m^2)	192[a]	165[b]
Household belonging (% of farmers)		
Motor Bike	30[a]	40[a]
Car/pickup/jeep	5	-
Television	85[a]	94[a]
Radio and cassette player	100[a]	100[a]
Refrigerator	9[a]	2[a]
Stove	98[a]	88[a]

Note: Different superscripts in a row imply that the values are different between chili and non-chili farmers at least at 10% significance level.

Land Form, Drainage and Soil Texture

The soil texture reported by chili and non-chili farmers was almost similar (Table 7). On each farm type, the dominant soils were light. In the survey area, the majority of soils on chili and non-chili farms were well-drained, and the distribution with respect to drainage of land was not significantly different across the two groups. The majority of both chili and non-chili farmers were on flat land either on the riverbed or away from the riverbed side, and only a small percentage were on slope with and without terraces.

Table 7. Land form, drainage, and soil texture of farms in the sample areas, by farmer type. Indonesia, 2002

Character	Chili farmer	Non-chili farmer
Soil texture (%)		
Heavy	26	30
Medium	29	29
Light	45	41
Drainage (%)		
Well drained	45	38
Medium drained	34	35
Poorly drained	21	27
Land form (%)		
Slope with terrace	17	12
Slope without terrace	12	12
Plain on the river bed	36	28
Plain away from the river bank	35	48

Varieties and Cropping Pattern

Chili Varieties

In the sample area, three quarters of the chili parcels were planted with hybrid varieties, however, 34% of these were planted with the second year progeny of hybrid seed (F_2) (Table 8). The local and open pollinated (improved) varieties were grown only on 17% and 6% parcels, respectively, while only 3% parcels were found growing sweet pepper (hybrid). Similar distribution was observed based on area under different varieties. The hybrid chili was mainly concentrated in Central and West Java. The majority of the open pollinated and local chilies were grown in the Northern shore of Central Java. Sweet chilies were found only in West Java.

Among the hybrid chili-growing farmers the most popular variety reported was "TM999". The other common hybrid varieties were "Prabu", "Gada", and "Super". The most common local variety cultivated was "Segitiga" followed by "Helm" and "Titrandu". A substantial percentage of parcels (15%) were planted with unidentified "Local" varieties. In case of open pollinated, "Titsuper" was indicated as the most common variety followed by "Cakra", "Select Tam", and "Bendot". "Spartacus" (green-red) and "Gold Flame" (green-yellow) were the only two sweet pepper hybrid varieties reported by the farmers.

Table 8. Distribution of chili varieties grown in the sample areas, by region, Indonesia, 2002

Type	Name of variety	Percentage of parcels			
		West Java	Central Java	East Java	Overall (%)
Hybrid [+]		**38**	**52**	**10**	**75**
	TM999: Hung Nong/annum	80	20	-	43
	Prabu: East West/annum	-	100	-	22
	Gada:East West/annum	-	100	-	12
	Lado: East West/annum	-	100	-	4
	Taro:East West/annum	-	100	-	3
	CTH: Chis Tai/annum (wrinkle type)	100	-	-	2
	Super	-	-	100	8
	Others	50	21	29	6
Open pollinated (improved)		**11**	**67**	**22**	**5**
	Titsuper: East West/annum	-	-	100	52
	Cakra: Cakra Hijau	-	100	-	21
	Select Tam	67	33	-	21
	Bendot: annum	100	-	-	7
Local		**20**	**79**	**1**	**17**
	Segitiga	-	100	-	69
	Helm	-	100	-	10
	Titrandu	-	100	-	5
	Local (unidentified)	41	-	59	16
Sweet (hybrid)		**100**	**-**	**-**	**3**
	Spartacus: de Ruiter/green-red	100	-	-	75
	Gold Flame: de Ruiter/green-yellow	100	-	-	25

[+] = Thirty four percent hybrid chili growing farmer used his or her own produced seed.

Note: The percentages for different varieties within one chili type add up to 100. The percentage of the four chili types adds up to 100. The regional distribution of each variety adds up to 100. Total number of parcels was 387.

Intercropping

In Indonesia, the majority of chili parcels (58.4%) in the sample area were intercropped mostly with one crop. A higher percentage of hybrid chili parcels were grown as a single crop compared to local chili, while all the open pollinated and sweet chili fields were single cropped. The hybrid chili was intercropped with shallot, tomato, and cabbage, while local type chili was mainly intercropped with red shallot (Table 9). Adiyoga et al. (undated) also found a large proportion of chili fields intercropped with similar types of vegetables. The extent of intercropping in their study varied from 38% to 97% in various regions.

Table 9. Intercropping (percentage of parcels) in the sample areas, by chili type, Indonesia, 2002

Intercrop	Hybrid	Open pollinated	Local	Sweet	Overall
Chili alone	28.3	3.5	6.7	3.1	41.6
Chili with one other crop	29.1	-	24.1	-	53.2
Tomato	10.6	-	1.6	-	12.2
Maize	0.8	-	-	-	0.8
Red shallot (onion)	11.0	-	21.3	-	32.3
Coriander	1.6	-	-	-	1.6
Cabbage	2.8	-	-	-	2.8
Other	2.3	-	1.2	-	3.5
Chili with two other crops	4.8	-	-	-	4.8
Tomato and onion	1.6	-	-	-	1.6
Tomato and other	2.4	-	-	-	2.4
Others	0.8	-	-	-	0.8
Chili with three other crops	0.4	-	-	-	0.4
Tomato, onion, and cabbage	0.4	-	-	-	0.4

Note: Total number of parcels was 387.

Crop Rotation

About two-fifths of the chili-growing farmers in the sample area practiced chili-fallow-chili rotation, and the majority of them cultivated a single crop in one year leaving the land fallow during one crop season (Table 10). However, some planted two chili crops in a year. The rest of the chili fields come with different crops in the rotation. Tomato and shallot were the most common crops cultivated in rotation with chili.

Table 10. Chili-based crop rotation in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Crop rotation	Percentage of parcels
Hybrid	Shallot (RC*with chili) – Tomato – Shallot (RC* with chili)	3
	Tomato – Chili – Tomato	16
	Cabbage – Chili – Cabbage	5
	Corn – Chili – Corn	3
	Shallot – Chili – Shallot	7
	Chili – Fallow – Chili	46
	Other (RC* with chili) – Fallow – Other (RC* with chili)	9
	Chili – Other – Chili	11
Open pollinated	Shallot (RC* with chili) – Fallow – Shallot (RC* with chili)	51
	Onion – Onion (RC* with chili) – Onion	12
	Maize – Chili – Maize	12
	Paddy – Chili – Paddy	25

Cont...,Table 10

Local	Shallot (RC* with chili) – Paddy – Shallot (RC* with chili)	9
	Brassica – Chili – Brassica	11
	Cabbage – Chili – Cabbage	13
	Corn – Chili – Corn	14
	Paddy – Chili – Paddy	34
	Other crop– Chili – Other crop	9
	Chili – Fallow – Chili	10
Sweet (hybrid)	Chili – Fallow – Chili	100
Overall	Shallot – Chili – Shallot	6
	Chili – Fallow – Chili	40
	Other (RC* with chili) – Fallow – Other (RC* with chili)	15
	Tomato – Chili – Tomato	12
	Shallot (RC* with chili) – Other crop – Shallot (RC* with chili)	7
	Chili – Other crop – Chili	20

Note: Total number of parcels was 387.

* RC = Relay crop.

Cropping Pattern

About three-fourths of the area under all crops on chili-growing farms in the sample area went to vegetable cultivation including chili, while 28% of the area went to chili cultivation (Table 11). Percentage of the area under vegetables, including chili, was higher on chili farm than on non-chili farm. However, the latter group had higher proportion of area under other vegetables. The percentage of the area under cereals, beans and pulses, and commercial crops was higher among the non-chili farmers.

Table 11. Cropping pattern in the sample areas, by farmer type, Indonesia, 2002

Crop group	Chili farmer		Non-chili farmer	
	Area (ha)	Share (%)	Area (ha)	Share (%)
Chili	0.38	28	-	-
Other vegetables	0.61	44	0.69	55
Cereals	0.17	12	0.33	26
Beans and pulses	0.03	2	0.05	4
Commercial	0.11	8	0.18	14
Others	0.08	6	0.01	1
Total cropped area	1.38	100	1.26	100

Note: Cereals = paddy and corn; Beans and pulses = red bean, soybean, and peas; Other vegetables = shallot, tomato, cabbage, leaf onion, brassica, cauliflower, onion, egg plant, carrot, etc.; Commercial = potato, and groundnut; Others mainly are fruits such as papaya, banana, orange, mango, alpucat, jumbo, etc.

Cultivation Time

All sample chili farmers sow chili in nursery seedbeds, and later transplant the seedlings in the fields. Sample farmers reported variation in the sowing and harvesting time depending upon the mode of irrigation and type of chili. Chili is grown throughout the year in Indonesia (Table 12). The improved varieties of hot chili (hybrid and open pollinated) mature in shorter duration, especially because they have shorter harvesting span compared to local chili. In addition, these varieties had changed the cropping season of chili, which might enable the farmers to bring their outputs during the off-season and earn higher prices.

Table 12. Cultivation and harvesting time (week and month) by season and chili type, Indonesia, 2002

Chili farmer	Wet season			Dry season		
	Planting time	Start of harvesting	End of harvesting	Planting time	Start of harvesting	End of harvesting
Hybrid	1st Mar	1st May	3rd Jun	4th Jun	2nd Aug	3rd Oct
Open pollinated	-	-	-	1st Jul	3rd Aug	4th Oct
Local	3rd Jan	3rd Mar	2nd Jul	2nd Sep	4th Nov	4th Feb
Sweet	2nd Feb	2nd May	2nd Aug	3rd Oct	3rd Dec	4th Feb
Overall	4th Feb	1st May	3rd Jun	2nd Jul	1st Sep	2nd Nov

Information Source

Seed

The majority of farmers obtained seed-related information from neighboring farmers or friends followed by village retailers, extension workers and government seed centers (Table 13). The farmers growing sweet pepper got seed-related information from village cooperative and government centers. There was little connection between farmers and extension agents to supply independent information about seed quality.

Table 13. Source of information on seed and variety satisfaction of respondents in the sample areas by chili type, Indonesia, 2002

Chili farmer	Source of information about seed (%)[1]					Satisfaction (%)			
	Extension worker	Village retailer	Neighboring farmer	Gov. seed center	Others	High yield	Good price	Purity	All
Hybrid	2	14	57	8	7[+]	2	8	19	38
Open pollinated	-	-	22	11	-	-	-	-	44
Local	13	24	33	-	-	1	3	3	12
Sweet	-	-	-	38	62[**]	-	-	-	100
Overall	5	11	48	5	4	2	5	15	32

[1]The row sum of information source is not equal to 100 because some farmers do not use any information source.
[+] Mixed source; [**] Village co-operative

Overall, only a third of farmers were contented with their chili seed with respect to price, yield, and purity, while another 22% were satisfied with only one or another criterion. The remaining, about one-half of the farmers, were looking for better varieties. Users of local varieties were the least satisfied, while the growers of sweet pepper hybrids were completely contented. This analysis suggests that varieties with higher yield potential and better quality to fetch higher prices have high demand in chili-growing areas of Indonesia.

Market

Efficient marketing depends upon the access to accurate, appropriate, and timely information or intelligence. There was no formal source of market information for chili in the study area. Farmers obtained information mainly through private sources (Table 14). The major sources were traders and neighbor farmers ranked as the first and second most important information source, respectively. For the farmers using local varieties, neighboring farmers were the most important source.

Table 14. Market information sources and their rank by type of farmers in the sample areas, Indonesia, 2002

Chili farmer	Sources of market Information (%)						Rank					
	Trader	Neighbor farmer	Farmer asso-ciation	Govt. depart-ment	Radio	Other	Trader	Neighbor farmer	Farmer asso-ciation	Govt. depart-ment	Radio	News-paper
Hybrid	28	27	17	7	7	14	1	2	3	4	5	-
Open pollinated	45	35	15	10	10	0	1	2	4	3	-	-
Local	18	30	19	17	14	2	2	1	3	4	5	-
Sweet	29	33	19	9	0	11	1	2	3	4	-	5
Overall	32	30	14	6	4	14	1	2	3	4	5	-

Factors in Chili Variety Selection

The most important factor considered by farmers in the selection of red chili and sweet pepper varieties was the prices of the harvested fruit, while in green chili disease resistance was the main criterion. Market price in green, yield in red, and color in sweet pepper were the second most important criteria. Other less important factors in the selection of chili varieties are reported in Table 15.

Table 15. Relative ranking of factors considered in the selection of chili seed by farmers in the sample areas, by chili type, Indonesia, 2002

Factors	Green	Red	Sweet
Market price	2	1	1
Yield	4	2	4
Disease	1	-	5
Insect free	3	-	-
Appearance	-	-	3
Chili color	-	4	2
Flesh thickness	-	5	-
Pungency	5	3	-

Note: 1 = highest rank, and 5 = lowest rank.

Insects and Pests Problem

Insects

All the surveyed farmers reported insect as a problem in their fields. Overall, aphid, mites, and thrips were main insects reported by 26%, 23%, and 20% chili farmers, respectively (Table 16). Interestingly, the insects causing major problems varied across chili type. In hybrid cultivation, the highest ranking insects were thrips and mite, while mealy bug and aphid were major insects in local. Cultivation of sweet pepper under shades, houses/tunnels did not reduce the insect attack and all farmers reported the presence of all major insects, similar in other chili types, except mealy bugs.

Table 16. Major insects reported in chili fields in the sample areas, by chili type, Indonesia, 2002

Chili type	Farmers reporting insects as problem (%)						Rank[1]				Occurrence (years out of 5)		Average losses (%)	
	A	M	T	C	MB	Other	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	21	29	22	23	3	2	T	M	A	C	3.9	3.8	13	27
Open pollinated	36	11	16	5	31	1	T	A	M	C	4.4	4.0	9	34
Local	38	12	5	8	33	4	MB	A	M	T	3.8	4.7	8	17
Sweet	8	33	25	33	0	1	C	M	T	A	3.8	4.2	19	24
Overall	26	23	20	18	11	2	T	M	A	C	4.0	4.0	11	25

Note: A=Aphids (*Aphis gossypii* and *Myzus persicae*); C=Caterpillar (*Helicoverpa armigera* and *Spodoptera litura*); M=Mites (*Polyphagotarsonemus latus*); MB= Mealy bug (*Planococcus* sp. and/or *Pseudococcus* sp) or White fly (*Aleurodicus dispersus*); T=Thrips (*Scirtothrips dorsalis*).

[1]The rank of 1 is the most devastating, and 4 the least devastating insect.

On average, severe attack of insects occurred four out of every five years, and this frequency was similar across chili varieties and did not change overtime. The yearly yield loss due to insect was highest at 34% in open pollinated varieties from 1998-2002, followed by the losses in hybrid and sweet chili types. The estimates of average yield losses due to insect attack increased from 11% in 1993-97 to 25% in 1998-2002. The major increase happened in hybrid and open pollinated varieties.

Diseases

Almost all farmers reported the infestation of diseases on chili fields. Overall, viruses, anthracnose, and Phytophthora blight were the major diseases reported by 37%, 27%, and 21% farmers, respectively (Table 17). Viruses were problems in all chili types; anthracnose infested a large number of hybrid fields, while Pytophthora blight heavily infested open pollinated and local chili types.

Overall, viruses were ranked to be the most devastating disease, and anthracnose got the second highest rank followed by Phytophthora blight and bacterial wilt. Viruses got the highest rank by all chili types except hybrids where anthracnose was given the highest rank. Open pollinated and local chili-growing farmers ranked Phytophthora blight as the second important disease, while hybrid chili and sweet pepper farmers gave second rank to viruses and anthracnose, respectively. The third and fourth ranking diseases for different varieties can be seen in Table 17.

Table 17. Major chili diseases in the sample areas, by chili type, Indonesia, 2002

Chili type	Farmers reporting diseases (%)						Rank[1]				Occurrence (years)		Average losses (%)	
	VR	AN	PH	BW	BS	OT	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	29	36	14	11	3	7	AN	VR	PH	BW	4	3.4	21	20
Open pollinated	48	5	42	5	0	0	VR	PH	BW	AN	4.1	3.4	35	50
Local	50	9	38	2	1	0	VR	PH	AN	BW	3.6	3.8	41	49
Sweet	54	21	12	0	13	0	VR	AN	BS	PH	5	4	25	-
Overall	37	27	21	8	3	4	VR	AN	PH	BW	4	3.6	29	38

Note: VR=Viruses; AN=Anthracnose (*Colletotrichum acutatum*, *C. capsici* and *C. gloeosporioides*); PH=Phytophthora blight (*Phytophthora capsici*); BW=Bacterial wilt (*Ralstonia solanacearum*); BS=Bacterial spot (*Xanthomonas campestris pv. Vesicatoria)*; OT=Other.

[1]The rank of 1 is the most devastating, and 4 the least devastating disease.

The average annual losses due to diseases of 29% reported by chili farmers in 993-1997 had increased to 38% in 1998-2002. The losses had increased in open pollinated from 35% in 1993-1997 to 50% in 1998-2002; it stayed at about 21% in hybrid, and increased from 41% to 49% in local chili during these years.

Weeds

All the sample farmers reported weeds in chili fields. A large proportion of farmers could not identify the weed present in their fields. The most commonly identified weed was *Cyperus sp.* reported by 31% farmers; its infestation was lowest in open pollinated and highest in hybrid chili (Table 18). This was followed by *Portulaca oleraceae* reported by 24% of farmers. Its infestation was highest in local and lowest in hybrids. Weed infestation was a regular phenomenon, occurring almost every year. Depending upon the variety, 14-18% losses were estimated due to weed infestation. The yield losses due to weeds increased overtime.

Table 18. Major chili weeds in the sample areas, by chili type, Indonesia, 2002

Chili type	Farmers reporting weeds (%)						Rank[1]				Occurrence (years during every 5 yrs)		Average losses (%)	
	TK	PO	AC	CD	UG	OT	1	2	3	4	1993-97	1998-2002	1993-97	1998-2002
Hybrid	36	13	10	7	18	16	TK	UG	PO	AC	5	5	10	15
Open pollinated	17	39	-	-	39	6	PO	UG	TK	-	5	5	11	14
Local	21	44	1	-	26	7	PO	TK	UG	-	5	5	13	18
Sweet	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Overall	31	24	7	4	22	13	TK	PO	UG	AC	5	5	11	15

Note: TK = *Cyperus sp.*; PO = *Portulaca oleraceae*; AC = *Ageratum conyzoides*; CD = *Cynodon dactylon*; UG = Unidentified grasses; OT = Other.
[1]The rank of 1 is the most devastating, and 4 the least devastating disease.

Farm Management Practices

Preparation of Nursery Seedling

Most chili fields were transplanted. However, some farmers sow seed directly in the field especially when it was planted as relay crop with shallot or onion. The chili transplant bed size was about 1-1.2 m long and 0.3 m wide covered with straw-mulch. In general they grow the seedling nursery near or within the vicinity of their house for protection and better irrigation access. The seedlings were transplanted when they are about five to eight weeks old, with height of about 10 cm and with 2-4 leaves.

Seed Treatment

Seed soaking before sowing was not common; only three percent of farmers, mainly in local and open pollinated chili types, practiced seed soaking for an average of 1.2 hours. More common was dusting of seed with chemicals practiced by 44% farmers. All farmers of sweet pepper and the majority of open pollinated and local chili reported treating the seed with fungicide before sowing it in the nursery bed. The main purpose of this treatment was to control 'dampling off' (Pythium). Only one third of the hybrid-growing farmers treated seed with chemicals expecting that it was already treated by the seed company (Table 19). The main chemicals used for seed treatment were Carbosulfan (insecticide) and Dithane (a fungicide). Similar frequency of farmers giving seed treatment was found by Adiyoga et al. (undated).

Table 19. Seed treatment by farmers in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Farmer soaked the seed (%)	Duration of seed soaking (hrs)	Farmer applied chemicals to seed (%)	Chemicals applied (kg or l/ha)
Hybrid	2	1.1	33	0.01
Open pollinated	10	1	67	0.36
Local	8	1.5	74	0.35
Sweet	0	0	100	0.33
Overall	3	1.2	44	0.16

Nursery and Field Soil Treatment

A small percentage of farmers, only in hybrid and local chili types, applied soil treatment on chili nursery and main field to control the soil-borne diseases. In local chili, broadcast was the main method of soil treatment, while broadcast, placement and spray all were used for soil treatment in hybrid fields. Average per ha quantity of chemicals used in the field was 48 kg/l. The chemical used in nursery field was 2.4 kg-l/ha in case of hybrid and 17.5 kg-l/ha in case of local chili (Table 20). The main chemicals used for field soil treatment was Furadan (a fungicide) and for nursery Furadan and Sulfur (used to fumigate the soil to control insects and diseases).

Table 20. Nursery and field soil treatment in the sample areas by chili type, Indonesia, 2002

Chili type	Method of soil treatment (%)			Stage of treatment (%)		Quantity applied/ha (kg/lit)	
	Broadcast	Placement	Spray	Nursery	Field	Nursery	Field
Hybrid	11	5	7	14	9	2	48
Open pollinated	0	0	0	0	0	0	0
Local	7	1	5	5	8	18	51
Sweet	0	0	0	0	0	0	0
Overall	9	4	6	11	8	4	48

Land Preparation

The main means of land preparation was manual labor. Only 14% used power tiller or tractor. Adiyoga et al. (undated) found only three percent of the chili fields plowed by tractor. Farmers mostly applied single plowing including planking/leveling and seedbed preparation. Harrowing was done three to five times (four on average) during the season to control weeds. As sweet pepper was cultivated under hydroponics system, land was prepared and leveled only once without any plowing (Table 21).[1]

Table 21. Land preparation method in the sample areas, by chili type, Indonesia, 2002

Chili type	Percentage of parcels								Number of operation	
	Plowing				Harrowing				Plowing	Harrowing
	Hand	Animal	Power tiller[1]	Total	Hand	Animal	Power tiller[1]	Total		
Hybrid	78	9	13	100	96	1	3	100	1	4.7
Open pollinated	88	0	12	100	98	0	2	100	1	3.1
Local	80	0	20	100	98	0	2	100	1	3.6
Sweet[2]	-	-	-	-	-	-	-	-	-	-
Overall	79	7	14	100	96	1	3	100	1	4.4

[1] Including tractor.
[2] All sweet chilies in the sample were cultivated under hydroponics system.

Bed Types

A large majority of farmers grow chili on raised beds and only five percent used furrows; all sweet pepper fields were flat because they were in the hydroponics system. On average, furrows or raised beds were of 34 cm height and 118 cm wide (Table 22). The crop was planted in double rows with 59 cm average distance between rows and 43 cm average distance between plants within a row. The plant-to-plant distance was equal and highest in the case of hybrid and sweet chili types, but lowest and equal in local and open pollinated types. The sweet pepper farmers reported the largest row-to-row distance, while other varieties had almost similar distance.

Table 22. Bed types, height, width, plant-to-plant and row-to-row distance of chili in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Bed type (%)			Furrow or raised bed (cm)			
	Furrow	Raised	Flat	Height	Width	Plant-to-plant distance	Row-to-row distance
Hybrid	7	92	1	34	103	51	57
Open pollinated	11	89	0	43	133	27	53
Local	3	97	0	35	128	27	57
Sweet	0	0	100**	0	0	51	119
Overall	5	91	4	34	118	43	59

** Hydroponics system.

[1]Hydroponics system is probably the most intensive method of crop production. It adopts advanced technology, is highly productive, skilled, and is often capital-intensive. Since regulating the aerial and root environment is a major concern in such agricultural system, production takes place inside enclosures that give control of air and root temperature, light, water, plant nutrition, and protect against adverse climatic conditions (Jensen, 1991). Plants are grown in nutrient solutions (water and fertilizers) via drip irrigation in a plastic green house type structure with the not reusable artificial medium (such as burned rice peal).

Mulching, Staking, and Shading

Use of plastic sheet as mulching material was very common among sweet and hybrid chili farmers, but less common for growers of local varieties. All sweet pepper fields were covered with plastic sheets in the hydroponics system while 64% hybrid fields were covered with plastic sheets as mulching material (Table 23). Twenty five percent of the open pollinated chili and only four percent local chili farmers reported the use of plastic sheet for mulching purposes. Straw as mulching material was also commonly used in the production of open pollinated and local chili types.

The majority of the sample farmers used silver black plastic sheets as mulching material. The life of plastic sheet ranged from 15 to 36 months with an average of 24 months or two succeeding croppings.

Table 23. Mulching material type and life span, in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Type of material (% of farmer)		Type of foil (% of farmer)				Life of sheeting (month)	Staking (% of farmer)
	Plastic	Straw	Reflective	Silver black	Black	Other		
Hybrid	64	17	13	55	2	30	31	87
Open pollinated	25	66	50	-	-	50	36	25
Local	4	32	50	50	-	-	15	13
Overall	42	22	14	50	2	32	24	61
Sweet	100	-	-	100	-	-	24	100*

* String.

In the overall hot chili sample, 61% of farmers used staking to support the chili plant. This practice was more common in hybrids and sweet pepper than in other chili types. Only sweet pepper farmers used plastic shade houses made of bamboo to build the hydroponics system and used string while other chili farmers used bamboo as staking material.

Fertilizer Application

All the sample farmers applied inorganic fertilizer to their fields, and a great majority of them also used organic fertilizer (Table 24). However, none of the sweet pepper fields received manure because of their special production system. Poultry manure followed by mixed/compost and cattle manures were the main types used.

Generally, three applications of inorganic fertilizer split equally over the 3rd, 6th and 9th weeks after transplantation were applied to chili fields, regardless of variety. Some farmers also applied TSP (Triple Super Phosphate) with manure as basal application. A large proportion of the farmers also applied Zinc (Zn).

A great majority of chili fields were applied with fertilizer through placement method, and only a small proportion through broadcast or mixing fertilizer with irrigation. The sweet pepper farmers applied liquid fertilizer by mixing it with irrigation water in the hydroponics system.

Table 24. Organic fertilizer type and method of inorganic fertilizer application (% of parcels) in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Organic fertilizer type				Method of inorganic fertilizer application			Inorganic application (no.)
	Cattle	Poultry	Mixed	Total	Broadcast	Placement	Irrigation	
Hybrid	9	45	33	87	10	67	23	3.1
OP[a]	-	33	22	55	11	89	-	3.4
Local	33	33	8	74	27	73	-	3.5
Overall	9	42	25	76	15	69	16	3.3
Sweet	-	-	-	-	-	-	100*	*

[a] OP - Open pollinated.
* Hydroponics system.

Irrigation

Majority of the chili fields received irrigation, and only 21% were rainfed (Tale 25). The major irrigation source was canal covering more than one-half of the chili fields. Tube wells/pumps and tanks (ponds, reservoir, lake) covered only a small area. In case of sweet pepper, water was stored in water tanks and later pumped through pipes. Irrigation sources were almost similar across all other chili types except that no tank and mixed sources were used in open pollinated fields.

Flooding was the main method of irrigation. In local and open pollinated chili types, it was mainly done in ridges, while in hybrid it was applied with and without ridges.

Table 25. Method and sources of irrigation in the sample areas, by chili type, Indonesia, 2002

Chili type	Irrigation method (% of parcel)					Irrigation source (% of parcel)				
	Flooding		Manual	Sprinkle+ trickle	Rainfed	Canal	Tube well	Tank/ lake	Mixed	Rain
	Without ridge	With ridge								
Hybrid	35	30	12	2	21	55	9	7	8	21
Open pollinated	21	44	13	-	22	67	11	0	0	22
Local	35	43	3	-	19	61	16	4	0	19
Overall	34	33	10	2	21	57	10	6	6	21
Sweet	-	-	-	100	-	0	0	0	100**	-

** Implies a method where water is stored in a tank and later pumped through pipe for irrigation purposes.

Insect Control

All the sample farmers applied insecticide to control insects in the chili fields. More than 35 different brands of chemicals were used to control chili insects; among the most popular were Curacron, Agrimec and Decis (Appendix 1). Some of these chemicals were not registered in Ministry of Agriculture (National Commission of Pesticides). A large majority of farmers applied mixture (cocktail) of insecticides and it was more common in case of hybrid and sweet chili. On average about two chemicals were mixed to make a cocktail.

The use of insecticide, according to farmers' opinion, was less than a perfect method of insect control; more than one-fourth of insect losses, according to farmers' perception, were not controlled despite using insecticide regardless of varieties (Table 26).

Table 26. Extent of insecticide use and their perceived effectiveness on chili in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Farmer applying (%)		Number of chemicals mixed	Effectiveness (%)
	Single	Cocktail		
Hybrid	26	74	2.5	71
Open pollinated	45	55	1.9	78
Local	41	59	1.9	71
Overall	30	70	2.3	71
Sweet	0	100	3.2	75

Disease Control

Diseases were also a serious problem and got lots of farmers' attention as almost all sample farmers used fungicide to eradicate diseases in chili fields. Nearly 40 different types of chemicals were applied; the most common were Antracol, Dhithane and Curacron. Farmers used insecticides for the eradication of diseases (Appendix 1).

The fungicides were more specific compared to insecticide, as about one-half of chili parcels were treated with single chemical and the rest were given about three chemicals. On average, about three chemicals were used to make a cocktail. All sweet pepper parcels were treated with cocktails (Table 27).

The fungicides were even less effective than insecticide, as 36% of disease losses, irrespective of chili type, cannot be controlled through chemicals.

Both insecticide and fungicide applications continued until harvesting started. Less than one-half of the respondents wore mask or other protective clothing.

Table 27. Extent of fungicide and their perceived effectiveness on chili in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Farmer applying[1] (%)			Number of chemical mixed	Effectiveness (%)
	Single	Cocktail	Total		
Hybrid	45	50	95	3.0	63
Open pollinated	55	33	88	2.5	70
Local	59	32	91	2.5	63
Overall	50	44	94	2.8	64
Sweet	-	100	100	3.2	66

[1]The sum of the two columns is not equal to 100 because some farmers were not applying chemical for disease control.

Weed Control

All chili farmers, except those who grew sweet pepper, practiced weeding. Almost all farmers applied manual weeding regardless of variety (Table 28). In addition, three percent of farmers applied herbicide while 21% used both manual as well as herbicide for weed eradication. No cocktail (mix of herbicide) was reported. Gramoxon, and Roundup were the most common products used to control weeds.

On average, farmers had four manual weeding operations and applied three chemical sprays to control weeds. However, some farmers applied as many as 12 weedings because of recurrence of weeds. The sample farmer of hot chili revealed that weeding was 76% effective, on average, with slight variation across varieties.

Table 28. Weeding, number, type and their perceived effectiveness in the sample areas by chili type, Indonesia, 2002

Chili type	Percentage of farmer			Farmers using weeding(%)	Weeding number		Effectiveness (%)
	Manual	Chemical	Manual+ chemical		Manual	Chemical	
Hybrid	77	4	19	100	4.3	4.3	76
Open pollinated	67	-	33	100	2.0	2.2	81
Local	74	-	26	100	3.4	3.0	75
Overall	76	3	21	100	4.2	3.2	76
Sweet	-	-	-	-	-	-	-

Other Methods of Pest Control

In the sample areas, about ten percent of farmers reported that sanitation, mulching, crop rotation, intercropping, early sowing, more picking, and weeding helped in controlling pests in chili field. However, the quantitative effectiveness of these methods was not indicated.

Adiyoga et al. (undated) found manual methods of controlling insects, such as removing the insect eggs, killing the insect, and removing the infected leaf/branch or even the whole plant, quite popular in their study area. According to the respondents in their study, the mechanical method of pest and disease control sufficiently helped when conducted at the right time. However, the method became ineffective when the attack intensity increases. Field observation, primarily to note the attack incidence and to estimate the intensity of attack was regularly conducted by most respondents. Nevertheless, this activity apparently tended to be followed by the decision to spray.

Harvesting

On average, farmers reported nine harvestings for hot chili. The highest number of harvest was for sweet pepper and lowest for open pollinated chili. Majority of farmers, regardless of chili type, combined family and hired labor in harvesting the crop. Only 11% of fields in hot-chili were harvested using only family labor, and ten percent using only hired labor (Table 29).

Table 29. Number of harvests and type of labor used (%) in chili harvesting in the sample areas, by chili type, Indonesia, 2002

Chili type	Number of harvest	Type of labor used (% of farmers)		
		Family labor	Hired labor	Both
Hybrid	10	12	13	75
Open pollinated	7	25	-	75
Local	8	8	4	88
Overall	9	11	10	79
Sweet	35	22	-	78

Marketing

Channels

Farmer sold chili output mainly to local trader/commission agents (72%), wholesale market at district level (17%), local market at sub-district level (7%) and farmer's associations (4%) (Figure 4). In case of sweet pepper, farmers sold all the products to their association, which was directly linked with a multinational company.

From the local trader, 74% of the chilies were directly sold to the wholesalers at the province level and the rest to the wholesalers at the district level. While the farmer's association sold to wholesalers at the district level, wholesalers at sub-district level, wholesalers based at Jakarta, local trader and directly to consumers. The local market at sub-district level sold 60% to retailer, 24% to wholesaler at district level and the remaining 16% to processors.

The wholesaler at the district level sold 85% to the wholesaler at the province level and rest to the processor. The wholesaler at the province level sold 48% to retailers and rest to processors (27%) and to the exporters (25%). The wholesalers in Jakarta sold 37% to retailers, 35% to vendors and 28% to chili processors. The processors sold the output mainly to the exporters (75%), and the remaining 25% back in the wholesale market. Retailers sold 65% to vendors and the rest directly to consumers. The vendor sold all chilies to the consumers (Figure 4).

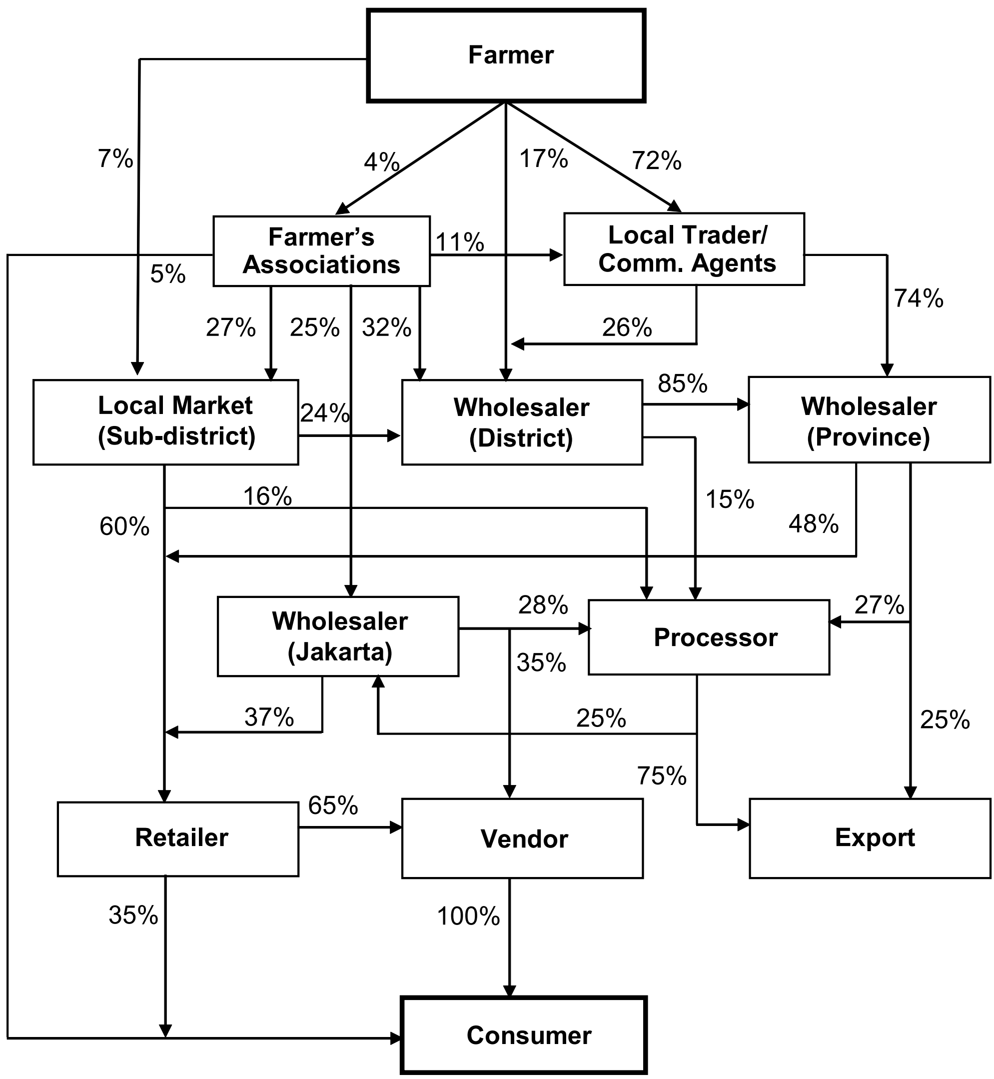


Figure 4. Chili marketing channels in the sample areas in Indonesia, 2002

Constraints

A large majority of farmers were not happy with the prevailing chili marketing system in the country, and only 15% were satisfied with the existing market structure (Table 30). Uncertain market prices were the major marketing constraint expressed by a large number of the farmers, while lack of price information and its unreliability and untimeliness, even if there was any, were the second major marketing constraints. However, low chili price was not a concern for a large majority of chili farmers.

About one-half of the sample farmers were not satisfied with the middlemen/commission agent's role. They complained about their exploitations in the form of low weighting, lower price, little premium for quality, and lack of grading system.

Table 30. Farmer's perception about constraints on chili marketing in the sample areas, Indonesia, 2002

Market constraints	Percentage of farmers
Price uncertainty	30
Lack of price information	19
No market problem	15
Exploitative role of middlemen	12
Low price	6
Weak bargaining power of farmer	3
No farmer organization	2
Others	13

Input Use

Seed Rate and Treatment

Eighty percent local and 56% open pollinated chili parcels were planted using home-produced seed, while all sweet pepper seeds were purchased (Table 31). Thirty four percent of hybrid-chili farmers used own-farm produced seed or they took it from neighboring farmers. Farmers applied higher seed rate for home-produced compared to purchased seeds, mainly because the former had better germination rate and purchased seed was usually taken better cared of before packing.

Higher seed rate was used to plant local and open pollinated compared to hybrid chili and sweet pepper. Special care was taken for sweet pepper nursery by applying more treatments to it. The higher seed rate for local and open pollinated types helped to refill the dead or weak seedling in the field.

Direct seeding was not practiced; seeds were first sown in the nursery and then transplanted in the field. Similarly, there was no practice of purchasing or selling of seedling. In a few cases, farmers shared seedling with neighboring farmers.

Table 31. Seed rate (kg/ha) in the sample areas, by source and chili type, Indonesia, 2002

Chili type	Seed rate (kg/ha)			Farmers using (%)	
	Self produced	Purchased	Average	Own-farm produced seed*	Purchased seed
Hybrid	0.91	0.26	0.48	34	66
Open pollinated	2.55	1.05	1.89	56	44
Local	1.48	4.95	2.17	80	20
Overall	1.29	0.86	1.07	49	51
Sweet	0	0.23	0.23	0	100

* Also include seed taken from neighbor farmer.

Fertilizer Use

On average, 8.7 t/ha organic fertilizer (manure) was applied to chili crop (Table 32). None of sweet pepper fields received manure. The highest amount of manure was applied in hybrid fields. Overall, about 279 kg/ha of all nutrients (from inorganic source including zinc) was used on hot chili. The amount of nitrogen was slightly higher than each doses of phosphorus, potash, or zinc.

Table 32. Fertilizer use in the sample areas, by chili type, Indonesia, 2002

Chili type	Organic fertilizer (t/ha)				Total fertilizer nutrient (kg/ha)			
	Cattle manure	Poultry manure	Mixed	Total	N	P	K	Zn
Hybrid	0.93	4.84	3.53	9.3	93	93	91	62
Open pollinated	0.00	2.76	1.84	4.6	67	40	52	19
Local	2.83	2.84	0.63	6.3	81	44	50	13
Overall	1.45	4.49	2.72	8.7	88	75	76	40
Sweet	0	0	0	0	187	104	112	0

The highest dose of inorganic nutrients was applied to sweet pepper followed by hybrids. The total nutrients applied to open pollinated and local chili types were similar, although the mix of nutrients was different. The farmers in the sample areas generally applied more than the recommended level of fertilizer to chili crop, which was 69 N, 36-54 P, and 60-90 K (DAE 2002).

Insecticide

On average, nearly 31 liters-kg/ha chemicals (single as well as cocktail form) were used to control insects in chili fields (Table 33). Farmers mostly mixed as many as seven different chemicals to prepare a "cocktail". About two-thirds of the total pesticide applied was in the form of cocktail. On average, 21 sprays of insecticide were applied on hot chili and 25 on sweet pepper in a crop growing season. The quantity of insecticide applied was relatively higher for hybrid chili and sweet pepper, but number of sprays was highest in open pollinated chili.

Table 33. Quantity of insecticide and number of sprays in the sample areas, by chili type, Indonesia, 2002

Chili type	Insecticide (Single)			Insecticide (Cocktail)			Overall insecticide applied (kg/ha)[a]	Number of spray
	Lit/ha	Kg/ha	Overall[a]	Lit/ha	Kg/ha	Overall[a]		
Hybrid	7.2	5.4	12.6	21.0	3.4	24.4	37.1	21
Open pollinated	12.0	0	12.0	17.0	0.0	17.0	29.1	29
Local	8.5	4.0	12.5	7.6	2.4	10.0	22.5	19
Overall	7.8	3.7	11.5	16.9	3.0	19.9	31.4	21
Sweet	0	0	0	20.7	14.6	35.3	35.3	25

[a] Liquid and solid pesticide were combined by assuming one liter is equal to one kg.

Fungicide

On average, 59 kg/ha of chemicals (liquid and powder) were applied to control diseases in chili (Table 34). The quantities of pesticide applied were highest for local chili and lowest for sweet pepper but the numbers of sprays was highest in open pollinated chili.

Table 34. Quantity of fungicide and number of sprays in the sample areas, by chili type, Indonesia, 2002

Chili type	Chemical (Single)			Chemical (Cocktail)			Overall pesticide applied (kg/ha)[a]	Number of spray
	Lit/ha	Kg/ha	Overall[a]	Lit/ha	Kg/ha	Overall[a]		
Hybrid	6.2	7.3	13.5	32.0	14.7	46.7	60.2	24
Open polinated	10.7	3.6	14.1	12.9	7.1	20.0	34.1	40
Local	8.2	7.2	15.4	32.0	14.0	54.0	69.4	39
Overall	6.6	7.1	13.7	31.2	14.2	45.4	59.1	29
Sweet	-	-	-	5.0	17.5	22.5	22.5	13

[a] Liquid and solid fungicide were combined by assuming one liter is equal to one kg.

Herbicide

On average, 1.63 kg/ha of herbicide (liquid and powder) were applied (Table 35). The quantities of herbicide as well as numbers of sprays were highest for hybrid.

Table 35. Quantity of herbicide and number of sprays in the sample areas, by chili type, Indonesia, 2002

Chili type	Overall herbicide applied (kg/ha)[a]	Number of spray
Hybrid	3.05	4.3
Open pollinated	1.69	2.2
Local	0.31	3.0
Overall	1.63	3.2
Sweet	-	-

[a] Liquid and solid herbicide were combined by assuming one liter is equal to one kg.

Irrigation

Overall, the chili fields received an average of 75 irrigations. The sweet pepper fields were irrigated with drip irrigation in the hydroponics system. Among hot chili types, the hybrid type received 82 irrigations, while open pollinated and local chili types received 67 and 58 irrigations, respectively.

Labor

On average, 345 labor days/ha were used for land preparation, crop management, harvesting, and post harvest operations of hot chili in the sample areas (Table 36). Sweet pepper utilized the highest labor (425 days/ha) and local chili the lowest (265 days/ha).

More than one-half of labor went to crop management activities, regardless of variety. Depending upon the variety, another 9-14% of labor went to land preparation, about 25% for harvesting, and another 6-7% for post-harvesting.

Table 36. Distribution of labor among different activity groups in the sample areas, by chili type. Indonesia, 2002

Chili type	Percentage distribution				Total labor
	Land preparation	Management	Harvesting	Post-harvesting	(day/ha)
Hybrid	12.6	56.0	25.3	6.1	385
Open pollinated	14.1	55.4	24.7	5.8	330
Local	13.3	54.9	25.4	6.4	265
Overall	12.9	55.5	25.4	6.2	345
Sweet (hybrid)	9.2	64.3	19.7	6.8	425

Credit

In Indonesia, only 21% of farmers had access to loan facility (Table 37). The major source of credit and loan was informal, mainly from relatives/friends, merchants, shopkeepers, etc. The average loan amount for hot chili farmers was IDR 656 thousand for a period of only seven months with 11% interest rate per annum. About 92% availed of loans to purchase inputs, while three percent purchased tractor/power tiller; only one percent used the loan to purchase machinery and the remaining four percent for other purposes which included marketing, social, construction of shed or tunnel, etc.

Table 37. Loan source, duration, interest rate and purposes by farmer type in the sample areas, Indonesia, 2002

Type of grower	Loan (% farmer)	Average loan (000IDR)	Sources					Duration (month)	Interest (%)	Purposes			
			Govt. bank	Friends & relatives	Merchants	Shop keeper	Others*			Input	Machinery	Tractor	Other
Hybrid	17	803	4	56	11	11	18	9	8	96	-	4	-
Open pollinated	11	11	-	-	100	-	-	6	10	100	-	-	-
Local	31	499	9	76	-	5	10	5	16	74	4	-	22
Overall	21	656	5	56	14	9	16	8	11	92	1	3	4
Sweet	25	26,250	100	-	-	-	-	24	13	-	-	-	100+

* Private bank, commission agents, etc.

+ Construct shed house and other material.

Sweet pepper production system was capital intensive. Therefore, farmers sought more loans for longer period for its cultivation than for other types: an average of IDR 26,250 thousand for the duration of 24 months. The major purpose of the loans for sweet pepper cultivation was for the construction of shed and other materials.

Production

Chili Yield

On an average, per ha yield of hot chili was 12.6 t in the sample areas (Table 38). Sweet pepper produced the highest yield with low coefficient of variation (CV). Among hot chili types, hybrids produced the highest yield but also gave highest CV. Variations in the management practices for hybrid type, which was relatively a new variety, explained high variation in its yield. Cultivation of F_2 and F_3 seed from previous years' crops also increased the CV. Overall yield of open pollinated and local varieties were similar, but the latter was more risky to produce as it has higher CV.

Table 38. Chili fresh yield (t/ha) by irrigation source in the sample areas, and by chili type, Indonesia, 2002

Chili farmer	Irrigated	Non-irrigated	Overall
Hybrid	17.9[a] (0.87)	9.4[b] (1.23)	13.9[b] (0.95)
Open pollinated	12.2[a] (0.53)	6.6[b] (0.73)	11.0[c] (0.61)
Local	11.2[a] (0.85)	3.0[b] (0.94)	10.0[c] (0.88)
Overall	15.6[a*] (0.82)	7.3[b] (1.35)	12.6[*] (0.91)
Sweet pepper	64.2 (0.69)	-	64.2[a] (0.69)

Note: Figures in parenthesis are coefficients of variation in yield.
The different superscripts across a row imply that the yields are significantly different across the two environments at the 10% level of significance. The different superscripts in the overall column imply that the yield is different across different chili types. The * in the overall row implies the statistical difference between the average of hot-chili types and sweet chili.

The yield of chili grown under irrigated condition was about double with a lower CV than the yield under rainfed condition. The yield of open pollinated and local types were similar but the latter had higher CV.

Yield and number of intercrops were negatively correlated, regardless of chili types (Table 39). The CV in yield also increased with higher number of intercrops. Although yield and number of intercrops were negatively correlated, the return to the production system including return from the intercrops were not.

Table 39. Chili yield (t/ha) by number of intercrops and by type of chili in the sample areas, Indonesia, 2002

Chili type	Number of crops intercropped				
	Zero	One	Two	Three	Overall
Hybrid	17.3 (0.86)	11.6 (1.02)	8.9 (1.55)	4.5	13.9 (0.95)
Open pollinated	11.0 (0.61)	-	-	-	11.0 (0.61)
Local	11.1 (0.81)	9.7 (0.89)	-	-	10.0 (0.88)
Overall	15.6 (0.84)	10.4 (0.95)	9.1 (1.09)	4.5	12.6 (0.91)
Sweet pepper	64.2 (0.69)	-	-	-	64.2 (0.69)

Note: Figures in parenthesis are coefficients of variation in yield.

One can perceive of a number of pros and cons of inter/multiple cropping. It reduces the risk of losses: in case one crop fails, revenues from other crops provide the buffer; seasonality in labor demand can be evened out; some crop rotations reduce pest attack; multiple cropping increases food security for small producer; cash-flow evened out and income from one crop can be a source of capital for the other, etc (Table 40). There are also some disadvantages of inter/multiple cropping such as cultivating more crop requires more knowledge and skill; labor planning become difficult if crops overlaps;

more capital and inputs are needed; number of pests may increase so does the risk of failure of individual crops, etc. The efficiency in land use and maintenance cost and reduced risk of obtaining additional income were cited as main reasons for intercropping by farmers in the Adiyoga et al. (undated) study.

Table 40. Advantages and disadvantages of inter/relay/multiple cropping as perceived by the authors

Advantages	Disadvantages
▪ Low prices or failure of one crop may not result in total loss (reduction in risk). Also provide food security for small farmers.	▪ The risk of failure of individual crop increases, although total risk of income from all crops in the system decreases.
▪ May be possible to keep labor employed for a longer time period, thus increasing the chances of obtaining the needed hired labor. ▪ Farmers become specialized in the cultivation of one crop, which improve efficiency in production.	▪ Labor planning and management may become more difficult if planting and harvesting period overlap for different crops. ▪ Growing more than one crop requires more management skills and knowledge about each crop's cultural practices.
▪ Some crop rotation may decrease pest build-up. ▪ More than one crop per year may be obtained from the same field. ▪ Low pre-harvest capital requirement crop may be used to provide cash for a high pre-harvest capital requirement crop	▪ Some crop rotation may increase pest buildup ▪ More than one crop may increase the amount of field machinery and /or packing equipment needed which would increase the capital investment requirement. ▪ Number of pest problems may increase.
▪ If using direct marketing, the ability to sell more than one product in the market might increases traffic to the market, generate repeat customers, and allow the market to stay open over a longer season.	

Chili Grades and Prices

The percentage of chili output produced according to different grade was estimated. Before presenting the results of the estimation, the specification of different grades are elaborated in Table 41.

Table 41. Specification of chili grades at the farm level in the sample areas, Indonesia

Grade	Quality	Characteristics
1	High	Fresh, highest number of seeds, long and straight, shiny and smooth surface, high fragrance, and dark red or green color.
2	Medium	Fresh, high number of seeds, medium size, clean surface, medium fragrance, and red or green color.
3	Normal	Average number of seeds, normal size, rough or wavy surface, little fragrance, light color.
4	Mix	Poor quality chilies mixed with different varieties.

The survey results suggested that majority of the hybrid chili marketed in the sample areas were of grade 2, while the majority of other chili types were of mixed grade (Table 42).

Table 42. Chili production grades and prices in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Percentage of output				Price (000 IDR/kg)				
	Grade 1	Grade 2	Grade 3	Mix grade	Grade 1	Grade 2	Grade 3	Mix grade	Overall
Hybrid	5	56	3	36	7.10	4.80	2.00	3.50	4.36[b]
Open pollinated	12	11	11	66	7.00	3.50	1.50	2.50	3.69[c]
Local	5	17	22	56	5.00	4.10	2.00	3.03	3.08[c]
Overall	6	42	9	43	6.43	4.53	1.96	3.31	3.89[*]
Sweet	26	25	12	37	8.00	7.50	5.00	6.50	6.96[a]

Different superscripts in a column imply that the figures are statistically different at 10% level across chili type. The * in the overall row implies that average prices of hot-chili and sweet chili are significantly different.

The overall average hot chili prices received by the sample farmers were IDR 3,890/kg of fresh weight. The maximum price of IDR 6,960/kg was fetched for sweet pepper and the lowest of IDR 3,080/kg for local chili. The highest prices for hybrid chili among hot chili types were partly because of its quality such as attractive color and size, and partly because of the difference in the growing season. Open pollinated improved varieties were also grown during the off-season, therefore fetching higher prices than local type but lower than hybrids.

Economics of Chili Cultivation

Cost and Factor Share

The overall per ha total cost of production of hot chili was calculated at IDR 17.79 million and per kg output cost at IDR 1.30 thousands (Table 43). The respective total and per unit costs for sweet pepper were IDR 133.2 million and IDR 2.76 thousand, respectively. Total per ha cost of chili was significantly lower in case of local chili, but the per kg costs of local and hybrid varieties were statistically similar. Although total per ha costs of open pollinated and hybrid were similar, per kg cost of open pollinated varieties was higher than the hybrids because of the lower yield of the former.

The factor share of chemicals was highest in all hot chili types, while structures claimed the highest share in sweet pepper because of its peculiar production system that required large amount of initial investment on its basic infrastructural development. The lowest factor share of 4% of labor was found in sweet pepper production. In all hot chili types, the labor share ranged from 16-17% in hybrid and open pollinated to 23% in local chili. Fertilizer was the next important input, except in sweet pepper where irrigation share exceeded that of fertilizer. It is worth mentioning that seeds played the major role in productivity but had the lowest factor share, i.e., only one percent or less in case of local chili and sweet pepper, to two percent in hybrid and open pollinated chili types.

Table 43. Cost of production, factor share, cost per kg, and prices received in the sample areas, by chili type, Indonesia, 2002

Chili type	Cost of production		Factor share (%)						
	Total (000 IDR/ha)	Per unit output (000 IDR/kg)[1]	Labor	Seed	Fertilizer	Irrigation	Pesticide	Others[2]	Structures
Hybrid	19,742[b]	1.21[c]	17	2	13	12	39	12	5
Open pollinated	18,950[b]	1.83[b]	16	2	12	8	41	15	6
Local	13,725[c]	1.41[c]	23	1	16	5	31	15	9
Overall	17,791*	1.30*	18	2	14	10	37	13	6
Sweet	133,210[a]	2.76[a]	3.5	0.5	4	11	8	14	59

[1]Output cost is based on fresh form of chili.

[2] Others includes machinery cost, land rent, interest rate, taxes, and transportation cost.

Different superscripts in a column imply that the figures are statistically different at the 10% level across chili types. The * in the overall row implies that averages of hot-chili and sweet chili are significantly different.

Economics of Chili Cultivation

The per ha gross revenue from chili cultivation ranged from IDR 29.5 million in open pollinated to IDR 481.6 million in sweet pepper (Table 44). The highest revenue from sweet pepper was because of its high yield and price.

Net return from chili ranged from IDR 16.8 million/ha in case of local chili to IDR 348.4 million/ha in sweet pepper. The benefit-cost ratio was lowest for local and open pollinated chili types and highest for sweet pepper. Although open pollinated varieties had higher yield (difference was not significant) and higher prices compared to local chili, its higher production cost produced benefit-cost ratio similar to the local chili type. However, significantly higher yield and prices, despite higher production cost, gave higher benefit-cost ratio for the hybrid compared to the local and open pollinated chili types.

Table 44. Economics of chili cultivation in the sample areas, by chili type, Indonesia, 2002

Chili type	Gross return (000 IDR /ha)	Net return (000 IDR /ha)	B-C ratio (%)	Inputs productivity			
				Labor (000 IDR/ day)	Fertilizer (000 IDR/kg)	Irrigation (000 IDR/No)	Chemicals (000 IDR/kg)
Hybrid	69,360[b]	45,618[b]	251	171	197	817	614
Open pollinated	40,850[c]	20,900[c]	116	115	217	587	510
Local	29,541[d]	16,816[d]	115	100	145	497	274
Overall	54,999*	39,208*	209	150	188	710	526
Sweet	481,575[a]	348,365[a]	262	1,122	1,182	3,134	8,147

Different superscripts in a column imply that the figures are statistically different at the 10% level of significance. The * in the overall row implies that averages of hot-chili and sweet chili are significantly different.

Hybrid chili and sweet pepper production were capital intensive but generate generally higher benefit-cost ratio and resource use efficiencies compared with the other chili types. The benefit-cost ratio and labor, fertilizer, irrigation, and pesticide use productivities were all higher in sweet pepper than in hybrids.

Many farmers used home-produced hybrid seeds from previous years' F_2 and F_3 progenies to save on seed cost. The average yield per ha of F_1, F_2, and F_3 was 16.9 t, 8.5 t, and 4.5 t, respectively (Table 45). It is worth noting that the yield of F_2 is comparable with the yield of open pollinated and local types. The quality of the F_2 and F_3 output was also reduced as farmers obtained lower output prices thus further reducing the corresponding gross returns. Farmers also used less inputs especially fertilizer and pesticide, but partial input productivities were lower in both F_2 and F_3 compared to F_1.

The economics of F_1 and F_2 with respect to local and open pollinated varieties however was not as bad. In fact, net returns for F_2 were very similar to open pollinated, but higher than local varieties. Input productivities including benefit-cost ratio of F_2 were comparable or higher than local varieties, but lower than in open pollinated, except pesticide productivity. The F_3 seed produced lower return, benefit cost ratio, and input productivities compared to both open pollinated and local type varieties except pesticide productivity in local types.

Table 45. Economics of cultivation of chili in the sample areas, by hybrid type, Indonesia, 2002

Hybrid type	Gross return (000 IDR/ha)	Total cost (000 IDR/ha)	Net return (000 IDR/ha)	B-C ratio (%)	Inputs productivity			
					Labor (000 IDR/day)	Fertilizer (000 IDR/kg)	Irrigation (000 IDR/No)	Pesticide (000 IDR/kg)
Hybrid F_1	88,635	23,630	65,005	275	199	224	991	1978
Hybrid F_2	38,425	18,868	19,557	104	93	159	465	764
Hybrid F_3	17,892	11,761	6,131	52	42	114	256	416

Attraction and Constraints in Chili Production

Major Attraction

The profitability in chili cultivation was ranked as number one attraction in hybrid chili and sweet pepper, while tradition of growing chili was number one ranking attraction in open pollinated and local chili (Table 46). Other attractions in chili cultivation included personal motivation, experience in cultivation, and adaptability of the crop in local environment and cropping system.

Table 46. Ranking of attraction in chili cultivation in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Profitable	Traditional	Well experience	Personal motivation	Well adopted	Others
Hybrid	1	2	5	3	4	-
Open pollinated	2	1	4	3	-	-
Local	2	1	3	4	5	-
Sweet	1	-	4	2	3	5*
Overall	1	2	4	3	5	-

* Availability of enough labor.
Note: 1 is the highest attraction; 5 is the lowest.

Major Constraints

Insects or diseases were number one or two ranking constraints in all chili types, except in local where low yield potential was the second-ranking and insects the third-ranking constraints (Table 47). It seemed that even in sweet pepper, where hybrid varieties were used, disease and insect resistance were not foolproof. Difficulty in marketing was ranked as third constraint in hybrid and open pollinated chilies, while in sweet pepper the high seed cost was ranked as third constraint.[2] Unstable environment was ranked as fourth constraint in all except hybrid types.

Table 47. Ranking of major constraints faced by farmers in the sample areas, by chili type, Indonesia, 2002

Chili farmer	Disease	Insects	High seed cost	Low yield	Environment	Market	Others
Hybrid	2	1	5	-	-	3	4+
Open pollinated	2	1	-	5	4	3	-
Local	1	3	-	2	4	5	-
Sweet	1	2	3	-	4	-	-
Overall	2	1	5	-	4	3	-

+ Low price
Note: 1 is the highest rank; 5 is the lowest.

Chili Processing

At the local and district levels, small processing units of the trader/commission agents were used to dry chilies before marketing. It is important to mention that all farmers in Indonesia sold chili in fresh form immediately after harvest. In the country, there were generally small chili-processing units, as well as very large multinational chili processing factories mainly for exports. Four chili grades were most common in Indonesia as indicated by processors (Table 48). Chili with dark red color, good pungency, less seeds, and of course without any infection were considered high grade. In their selection, small chilies with

[2]It should be noted that the ranking of seed cost constraints also connote the difficulty in getting modern seed varieties. In hybrid and open pollinated, the share of seed cost was two percent, while in sweet pepper it was only 0.5%. Despite this, the rank of seed constraint was lower in hybrid and open pollinated compared to sweet pepper because a significant proportion of farmers produced their own seed in the former.

high pungency, good fragrance, and lower prices were given first, second, and third rank, respectively. The chili entrepreneurs expressed their concerns about poor grading and quality of chili supplied by the farmers, price fluctuation, inadequate supply, and lack of capital. They also preferred to import chilies from India, China, Thailand, and Burma, which were cheap and of high quality.

Table 48. Dry chili grade in the sample areas, Indonesia, 2002

Grade	Quality	Characteristics
A	Super	Processed only fresh chili (mesocarp) without seed and stalk.
B	Medium	Processed fresh chili (mesocarp) without seed but there are still some stalk.
C	Normal	Processed whole chili (mesocarp, seed and stalk).
D	Mix	Poor quality chili processed with seed and stalk.

Chili Consumption

Per Capita Consumption and Expenditure

Overall, per capita weekly consumption of chili and its products converted into fresh weight was 185 g (Table 49). The consumption was higher among the chili farmers and their families than the other consumer groups. The "Sambals" (home-made crude chili sauce) was the major form of chili consumed in Indonesia. None of the respondents in the entire sample indicated consumption of dry or powder form of chili in cooking. However, in preparing ready-made noodles, some consumers made available powder chili as well as chili paste in the noodle’s packet. Urban dwellers consumed substantially higher amount of chili sauce, a substitute for sambals, and "other" chili products than other consumer groups.

Table 49. Relative quantity share (%, converted into fresh weight) of different chili types in total consumption in the sample areas, by consumer type, Indonesia, 2002

Type of chili/products	Chili farmer	Non-chili farmer	Urban consumer	Overall[1]
Green	33.5	31.3	35.9	33.6
Red	54.6	43.8	34.4	39.3
Chili sauce	5.5	9.0	12.1	10.5
Chili dipping sauce	-	6.6	5.5	6.0
Other chili products	6.4	9.3	12.1	10.6
Total (g/week)	201.5	188.5	181.7	185.3

[1] Chili consumption in overall Indonesia was estimated assuming 1%, 50%, and 49% weights for the chili producer, non-chili producer, and urban consumer, respectively.

On average, Indonesian consumers spent about IDR 1,234/week on chili consumption (Table 50). Despite less quantity of chili consumed by urban consumers than their counterpart farmer groups, they spent more money on chili consumption, as they consumed more high-value chili products and purchased at the end of the retail marketing chain. While red fresh chili was the main product consumed on chili and non-chili farms, green and red fresh chili and chili products, including sauce, claimed almost equal share in the expenditure on chili by urban consumer.

Table 50. Relative share of expenditure (%) on different chili types in the sample areas, by consumer type, Indonesia, 2002

Type of chili/products	Chili farmer	Non-chili farmer	Urban consumer	Overall[3]
Green fresh	33	31	36	33
Red fresh	55	44	34	40
Other chili products[1]	12	25	30	27
Overall weekly per capita expenditure (IDR)[2]	949[b]	1,007[b]	1,472[a]	1,234

[1] Other chili products include grounded dry and processed chili products.
[2] The different superscript on the figures across this row implies that they are significantly different at the 10% level.
[3] The chili consumption in overall Indonesia was estimated assuming 1%, 50%, and 49% weights for the chili producer, non-chili producer, and urban consumer, respectively.

Retail Value of Chili and its Products

Expenditure divided by per capita consumption of chili multiplied by one thousand generated an average per kg price of chili and its products of IDR 6,659 at the retail level. This price was about 71% higher than the farm gate price of IDR 3,890 reported in Table 42. This ratio was used as factor in converting the annual farm gate value of chili production in Indonesia of US$676 million during 2003 (Table 1) into retail prices of chili and its product at US$1,157 million.

Demand Elasticity

An increase in the price of chili had very little effect on its demand. Even if prices were doubled the consumers would continue eating chili and there would only be a 13-14% decrease in the consumption of green and red chilies (Table 51). The decrease in chili products would only be around three percent. Conversely, a 50% reduction in chili prices would increase consumption of chili and its products by less than only two percent.

Table 51. Consumer response to changes in chili prices in the sample areas, by chili product, Indonesia, 2002

Change in price (%)	Percentage change in consumption		
	Green	Red	Product
Increase in price			
110	-4.19	-2.12	0
125	-4.59	-4.70	-0.07
150	-5.80	-5.58	-0.08
175	-7.62	-8.64	-1.98
200	-13.95	-12.71	-3.32
Decrease in price			
90	0	0.24	0
80	0	0.24	0
70	0.03	0.29	0.14
60	0.05	0.72	0.95
50	0.53	1.56	1.15

Chili Purchasing Source

Respondents purchased chili mainly from the local market or vegetable shops, followed by main markets and wholesale markets (Table 52). A significant portion of chili was also purchased from other sources especially by urban consumers, which included special day markets, superstore, or combination of different sources. For farmers, other sources included own-farm harvest, gift from friends, and others.

Table 52. Sources of purchased chili (% of consumer) by consumer and chili type in the sample areas, Indonesia, 2002

Chili type	Chili farmer				Non-chili farmer				Urban consumer			
	Local market	Main market	Whole-sale market	Other	Local market	Main market	Whole-sale market	Other	Local market	Main market	Whole-sale market	Other
Green	68	2	6	24	71	8	10	11	73	11	4	12
Red	54	3	4	39	68	9	12	11	59	9	6	26
Sweet	13	13	-	74	-	-	-	-	28	31	4	37
Chili sauce	65	19	12	4	72	27	-	1	50	3	14	33

Consumers' Preference for Chili Attributes

Urban consumers ranked freshness as number one characteristic in purchasing both green and red chilies (Table 53). The second factor considered for all green, red, and chili products was higher number of seeds. This may be because they prepared "Sambals" from fresh chilies and having more chili seeds made it hotter and tastier. Color was ranked as third among red chili and fifth for green chili. For chili product, hotness was the most important factor, and market prices got the third rank; fragrance and packaging of chili products scored fourth and fifth ranks, respectively.

Table 53. Factor considered in the purchase of chili by urban consumers in the sample areas, Indonesia, 2002

Characteristics	Overall rank		
	Green	Red	Product
Freshness	1	1	-
Number of seeds	2	2	2
Market price	-	-	3
Packaging	-	-	5
Disease/insect free	3	4	-
Color	5	3	-
Fragrance	-	-	4
Pungency	4	5	1

Note: Highest rank = 1 and lowest rank = 5

Consumers' Preference for Packaging

Majority of consumers preferred unpacked green/red chilies or in paper package mainly because of their high consideration for freshness (Table 54). They also preferred sweet pepper unpacked or in paper packaging mainly for freshness, cheap price, number of varieties available in paper packaging, and visibility of quality. In case of chili product the most preferred packaging was in plastic because it gave the best image of the product, and was ideal for active and modern people because of its convenience in storage and preservation, visibility, and cheap price.

Table 54. Consumer preferences for different types of chili packaging by chili type in the sample areas, Indonesia, 2002

Chili type	Packing type	Preference (%)	Main reason (% of consumer)						
			Freshness	Presentability	Cheapness	Variety	Ideal*	Visibility	Other
Green/red									
	Unpacked	44	92	1	1	-	-	2	4
	Paper	37	80	1	7	-	7	-	5
	Glass	9	14	28	-	-	-	1	57
	Plastic++	6	7	-	36	-	-	36	21
	Tin	4	-	-	-	-	25	-	75
Sweet									
	Unpacked	40	50	25	-	-	-	25	-
	Paper	32	-	-	25	25	50	-	-
	Plastic	24	100	-	-	-	-	-	-
	Glass	4	-	50	-	-	-	25	25
Product									
	Unpacked	16	-	-	-	-	25	75	-
	Paper	15	-	20	-	80	-	-	-
	Glass	10	6	35	-	-	-	-	59+
	Plastic	45	5	50	10	-	15	15	5
	Tin	14	-	-	-	-	100	-	-

* Ideal for active and modern people, + Good presentation, ++ Grocery ‘bags’ in various sizes.

Development Impact of Chili Cultivation

This section compared the development impact of hot chili and sweet pepper with rice and tomato.

Input Demand

The cultivation of chili, like other vegetables, was labor-intensive as it required many times more labor than rice. For example, hot chili production, which was less labor-intensive than sweet pepper, needed almost 2.6 times higher labor days than rice and about similar with tomato (Table 55). Sweet pepper cultivation engaged more labor than rice, tomato, and hot chili. In general, in vegetables and particularly in chili production, labor was engaged throughout the production period compared with other field crops. Therefore, expansion in chili area will generate employment opportunities in the rural areas.

The application of fertilizers on sweet pepper was also higher than in competing crops; the difference was significant when both hot chili and sweet pepper were compared with rice and tomato, but not significant when hot chili was compared with tomato. Similarly, the application of manure in hot chili was more than four times higher compared to rice and 74% higher than in tomato. Chili attracted more insects and pests than rice that was why it received more than 13 times pesticides spray than rice. It also needed many times more irrigation compared to rice.[3] Seed cost of both hot and sweet chili was also higher than rice and tomato.

Table 55. Relative per ha input use of chili and its competing crops in the sample areas, by farmer type, Indonesia, 2002

Crop	Labor (days)	Seed (000 IDR)	Fertilizer (Nutrient kg)	Manure (t)	Irrigation (number)	Pesticides spray (number)
Hot-chili	345[b]	356[b]	239[b]	8.7[a]	75[b]	53[a]
Sweet pepper	425[a]	666[a]	403[a]	0.0	149[a]	38[b]
Rice	132[c]	126[d]	169[c]	2.0[c]	18[d]	4[d]
Chili framer	125	112	156*	1.0*	14*	4
Non-chili farmer	135	129	170	2.5	20	4
Tomato	350[b]	274[c]	215[b]	5.0[b]	66[c]	15[c]
Chili framer	356	312	236*	6.0*	72*	18*
Non-chili farmer	343	256	195	4.0	21	13

Different superscripts in a column of the rows of hot-chili, sweet chili, rice and tomato suggest that the value of the parameter is significantly different at the 10% level.

The * in the row of chili farmer suggests that the parameter value is significantly different from the non-chili farmer at 10% level.

However, generally higher input use for chili than rice was not true for local chili type. The low inputs used by resource poor farmers on local chili was mainly due to high cost of modern technologies, non-responsive varieties, and inefficient credit distribution system. In fact, the input use intensity in chili can be further increased if these inputs were available at low cost to local chili growers and if credit was financed through efficient financial institutions.

Chili farmers applied lesser inputs to their rice crop, but more inputs to their tomato fields compared to non-chili farmers.

Resource Use Efficiency

Farmers obtained higher gross and net returns for chilies than for its competing crops, although the differences in gross return between hot chili and tomato was not significant (Table 56). Both hot chili and sweet pepper required higher cost than its competing rice crop. However, net returns in hot chili were about 19 times the returns in rice. The benefit-cost ratio was more than four times higher in hot chili production compared to rice and 67% higher compared to tomato production. The resource productivity, such as for labor and fertilizer, was also higher in both hot chili and sweet pepper compared to rice production. However, fertilizer productivity in tomato was higher than in hot chili.

[3] Although number of irrigation applied on chili crop were higher than rice suggesting higher labor needs to operate these irrigations, quantity of water on chili may not be higher as rice needs continuous application of water during its growth cycle.

Interestingly, rice and tomato production by chili farmers was more efficient than by non-chili farmers. This was reflected by higher benefit-cost ratio in rice, and higher fertilizer and labor productivities for both rice and tomato produced on chili farms compared to those in non-chili farms. In rice cultivation, however, the difference in efficiency was not so great because many of the non-chili farmers grew highly profitable crops like other vegetables or cotton.

Table 56. Resource use efficiency in chili and competing crop cultivation in the sample areas, by farmer type, Indonesia, 2002

Crop	Yield (t/ha)	Total cost (000 IDR/ha)	Gross return (000 IDR/ha)	Net return (000 IDR/ha)	B-C ratio (%)	Labor productivity (000 IDR/day)	Fertilizer productivity (000 IDR/kg)
Hot-chili	12.6	17,791[b]	54,999[b]	39,208[b]	209	150	188
Sweet chili	64.2	133,210[a]	481,575[a]	348,365[a]	262	1,122	1,182
Rice	5.01	3,950[c]	6,012[c]	2,062[d]	52	36	24
Chili farmer	5.00	3,621*	6,000	2,379	66	38	27
Non-chili farmer	5.20	4,012	6,240	2,228	56	36	25
Tomato	13.21	21,439[b]	48,283[b]	26,844[c]	125	128	213
Chili farmer	15.56	26,731*	53,238*	26,507*	99	145	216
Non-chili farmer	12.78	21,371	43,895	22,524	105	113	211

Different superscripts in a column of hot-chili, sweet chili, rice and tomato rows suggest that the value of the parameter is significantly different at 10% level.

The * in the row of chili farmer suggests that the parameter value is significantly different from the non-chili farmer at 10% level.

Impact on Gender and Poverty

About 63% of the labor force engaged in hot chili production was composed of women (Table 57). Sweet pepper and hybrid chili production engaged higher female labor than do open pollinated and local chili types. The share of female labor was 89% and 85% in harvesting and post harvesting operations for hot chili, respectively, and similar or even higher proportions were observed in case of sweet pepper. Management activities seem to be equally shared by men and women, although it was higher for men in chili than in rice. The share of women was less than 50% only in land preparation, but still higher than rice. The study can therefore conclude that chili production is a female-gender friendly crop.

Table 57. Gender distribution of labor in chili and competing crop cultivation in the sample areas, by operation type, Indonesia, 2002

Chili type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Hybrid	24.2	75.8	55.3	44.7	89.2	10.8	88.3	11.7	64.7	35.3
Open pollinated	33.4	66.6	54.4	45.6	85.7	14.3	84.9	15.1	59.2	40.8
Local	28.3	71.7	56.2	43.8	88.6	11.4	69.3	30.7	57.4	42.6
Overall hot chili	25.2	74.8	55.3	44.7	88.8	11.2	85.4	14.6	63.1	38.5
Sweet pepper	32.9	67.1	47.6	52.4	92.7	7.3	85.5	14.5	65.5	44.5
Rice	14.5	85.5	44.8	55.2	45.1	54.9	35.4	64.6	38.6	61.4
Tomato	26.1	73.9	54.2	45.8	82.2	17.8	24.5	75.5	57.2	42.8

[1]The distribution between male and female under each operation adds up to 100.

As modern chili varieties utilized higher labor, including female labor, increase in their share implied more employment and income for the poor segment of the population. The average farm holding by chili farmers were lower than the non-chili farmers. In general, they were less resourceful and had lower income; therefore, helping these farmers means helping the poor and the women, which will help in eradicating poverty in Indonesia.

Impact on Hired Labor

Chili cultivation required more outsourced labor than rice, thus expanding the labor market. Overall, 35% of the labor used in hot chili cultivation was hired, compared to 30% in rice (Table 58). The proportion of the hired labor was higher in modern varieties, like hybrid and open pollinated, compared to the local chili types. The proportion of hired labor was highest in post-harvest operation followed by crop management operations, and lowest in land preparation.

Table 58. Distribution of labor source by chili and operation type in the sample areas, Indonesia, 2002

Chili type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Hybrid	70	30	40	60	65	35	20	80	65	35
Open pollinated	65	35	35	65	60	40	15	85	60	40
Local	73	27	70	30	60	40	90	10	69	31
Overall	70	30	45	55	64	36	32	68	65	35
Rice	60	40	35	65	80	20	70	30	70	30

[1]The distribution between family and hired labor under each operation adds up to 100.

Impact on Consumption

Overall, income as well as expenditures of chili farm families were less compared with urban and non-chili farm families (Table 59). Chili production was profitable and more efficient in using resources. However, other farms had bigger land area, and non-farm groups had higher incomes from various sources. Moreover, many of them planted other crops such as vegetable and cotton and these may be equally or more remunerative compared to chili. The gap between chili and non-chili farmer's income and expenditure can be reduced through the introduction of modern varieties and cost-efficient chili production technologies. There is a large room for the introduction of pest-resistant high yielding chili varieties. Chili farmers spent substantial amounts on pesticide, which can be saved.

Table 59. Monthly per capita household income and expenditure in the sample areas, by farmer and consumer type, Indonesia, 2002

Consumer type	Expenditures (000 IDR)		Average income (000 IDR)
	Food	Overall including food	
Chili farmer	93.9[c]	140.8[c]	248.0[c]
Non-chili farmer	142.0[b]	200.5[b]	357.6[b]
Urban consumer	174.1[a]	268.4[a]	502.7[a]
Overall	110.8	168.0	297.4

The different superscripts in a column implies that the figures are significantly different across consumer groups.

Overall, chili farmers spent less on food items compared with urban household and non-chili farmers, because of their overall lower income (Table 60). Interestingly, chili farmers consumed more vegetables as they had higher proportion of area under vegetable than non-chili farmers as shown in Table 11.

Table 60. Average daily consumption of different food, by consumer group in the sample areas, Indonesia, 2002

Food group	Quantity (g/capita)			
	Chili farmer	Non-chili farmer	Urban consumer	Overall
Cereals	374[a]	362[a]	331[b]	356
Livestock products	116[a]	132[a]	140[a]	136
Vegetables	210[a]	195[b]	189[c]	207
Fruits	91[b]	96[b]	116[a]	98
Seafood	80[a]	93[a]	105[a]	98
Others	134[a]	154[a]	168[a]	148
Overall	995[b]	1,032[a]	1,049[a]	1,022

The different superscripts in a row means that figures are significantly different across consumer groups.

Summary and Policy Implications

Chili is a high-value commercial vegetable crop in Indonesia. The semi-crushed fresh chili in the form of "Sambals" is an essential ingredient of the daily diet. In 2003, its farm value was estimated at US$676 million, and the retail value of chili and its products at US$1,157 million. Based on average chili area on each farm, over 463 thousand farm families are estimated to be engaged in its production, and it can be speculated that a similar number may be engaged in the processing and marketing activities. In view of the role of chili in providing livelihood to a large number of rural and urban households, this study provided a comprehensive overview of the production, consumption, and distribution aspects of chili in Indonesia.

Chili production is a labor intensive and small farmer activity in Indonesia. Chili farmers are younger with larger family size and smaller landholding than non-chili farmers. Being small landholders, they are engaged in more crop activities and possessed fewer animals, but attain higher cropping intensity compared to their non-chili counterparts.

Chili farmers allocated a substantial part of their land to chili (28%) and other vegetables (44%). Chili management practices in Indonesia were dominantly traditional and the institutional setup was not very conducive for its development. Nearly 60% of farmers obtained seed-related information from their neighboring farmers and village retailers. Connection between farmers and extension agents to seek independent information about seed quality was rather weak. A very small percentage treated nursery or field soil. A large majority of farmers cultivated their land manually. As alternative risk-covering mechanisms were not available, a large percentage (58%) used intercropping as a tool to cover risk, although the practice produced lower yield. To save high seed cost, a large proportion of hybrid seed (34%) was F_2 saved from the previous crop. Only one-fifth of the farmers availed credit, mainly from informal sources. At the same time, however, advanced sweet pepper cultivation system under hydroponics had all the ingredients of good crop management.

Large quantities of insecticides and fungicides were applied both as single and in cocktail form but with inappropriate brands and doses. The availability of a large number of pesticide brands in the market and the practice of making cocktail suggest that pesticide use was not targeted to specific disease or insect. Many pesticides were used as insecticide as well as fungicide; therefore, its effectiveness was very low. Despite high pesticide use, the average losses due to insects and diseases were as high as 63%. This worrying phenomenon was associated with the increase in losses overtime despite the adoption of modern chili varieties. All these made insect and diseases the number one constraint in chili production.

Farmers in Indonesia had quickly adopted modern varieties of chili. Among modern varieties, hybrids types were more common. These varieties brought along improved management practices, and revolutionizied the chili production system in the country. For example, a great majority of these fields had plastic mulching and were given higher number of harrowing. They were also given higher doses of fertilizer, pesticides/ fungicides and irrigations. Partly due to better resistance and partly because of better pest management practices, the yield losses due to diseases were much lower in hybrid fields. The modern hybrid varieties also engaged more labor, especially women and hired, in different operations compared to other hot chili types.

All these management practices produced higher yield. This, along with better quality attributes in hybrid seed (which enabled farmers to fetch higher prices), made its production economically more viable than other chili types and competing crops. The benefit-cost ratio and resource use efficiency were generally higher in hybrid than other hot-chili types. However, underpinning financial constraints forced the farmers to use F_2 and F_3 of hybrids, which reduced quality, yields and economic viability. A less costly and low input-demanding improved open pollinated varieties could help small poor farmers. Although certain open pollinated improved varieties were available to the farmers, its economic viability was equal only to the local unimproved varieties. Low yield potential despite high input use resulted to low economic competitiveness of these varieties. Collaboration with appropriate international organizations can greatly help to improve efficiency of research institutes and enable them to develop open pollinated varieties with high yield potential and desired attributes.

Chili cultivation in Indonesia covers different agro-climatic and cropping system domains. Intercropping of chili with different crops adds into the complexity. There is a need to develop separate chili production recommendation packages for different domains. The extension services should demonstrate the application of judicious, timely, and proper doses of fertilizers and pesticides. Besides, there are a number of non-production constraints such as unpredictability of prices, lack of price information, and exploitation by middlemen. Strengthening market infrastructure and information network can help resolve these issues.

Improvement in chili production and distribution systems will benefit the poor segment of the farming community, especially women and hired labor. The efficiency of resources engaged in chili production was comparable, if not better, with high-value vegetables such as tomato but better than cereal crop such as rice. However, as chili is an integral part of Indonesian diet as suggested by low demand elasticity, expansion in chili production should be carefully planned. Incorporation of consumers' preferred traits in chili varieties as identified in this study (such as freshness, more number of seeds, attractive color, and pungency) will improve its price and enhance farmer income. Stabilizing chili production by developing pest-resistant varieties and reducing environment stresses can reduce risk in chili production which will provide benefits for small poor farmers. Reducing production cost through judicious use of inputs, especially fertilizers and chemicals will not only reduce the cash requirements and enable small farmers to engage in highly profitable chili cultivation, but can also reduce environmental costs. In order to meet the cash requirements of modern technologies, farmers' access to credit should be improved. In this connection, the role of government and non-government financial institutes, private lenders, traders, and farmer's association is critical.

The link of chili producers with the market was relatively poor in Indonesia. Most of the farm output was sold to the local traders and very little went directly to the wholesale market at the district or provincial levels. Traders, in the absence of sophisticated market infrastructure, provided farmers links to several markets. Moreover, they supply liquidity in the absence of appropriate financial institutions. But the involvement of middlemen in many agricultural functions reduced farmers share in consumers price. Therefore, improvements in market infrastructure and financial institutions can help farmers supply chili as desired by the consumers, and also improve their share in consumers price.

Indonesians consumed mainly fresh chilies; only one-fifth of total chilies consumed were in dry form. Farmers sold fresh chili while local traders/commission agents dried a part of purchased chili under sun at open places. Moreover, no chili processing activity was practiced at the farm-level thus reducing their capacity of holding output for a longer period. If farmers carry out these activities by themselves, their share in the retail price of chili will be increased and their negotiation power will be enhanced. The extension department and processing units should motivate farmers on these practices. Cooperative marketing can also improve farmers' negotiation powers. The successful operation of some cooperatives in certain areas needs to be upscaled in other areas.

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Appendix 1. Frequency of different insecticide and fungicide used on chili, in the sample areas, Indonesia, 2002

Brand name	Chemical name	Frequency		Brand name	Chemical name	Frequency	
		Insecticide	Fungicide			Insecticide	Fungicide
Agrimec	Abamectin	12.95	6.61	Polyram	Metiram	-	0.44
Rotraz	Amitraz	0.55	0.66	Metindo	Metomil	0.55	0.66
Brent	Barium hydrox-ide octahydrate	-	0.44	Pounce	Permethrin	1.65	0.66
Bulldock	Beta-cyfluthrin	2.38	1.10	Folirfos	Phosphite acid	0.37	0.44
Spontan	Bisultap	-	0.66	Daitona	Poksim	0.37	-
Baycor	Bitertanol	-	0.44	Sportak	Prokloraz	1.10	-
Derosal	Carbendazim	0.37	3.52	Previcur	Propamocarb hydrochloride	-	1.32
Daconil	Chlorothalonil	-	0.44	Curacron	Prophenophos	21.75	12.59
Dursban	Chlorpyrifos	6.95	4.85	Antracol	Propineb	2.93	16.42
Kuproxat	Copper oxysulphate	0.55	0.88	Castle	Protiophos	-	0.44
Matador	Cyhalothrin	0.55	0.44	Larvin	Thiodicarb	4.02	3.52
Arrivo	Cypermetrin	0.55	0.44	Dilkran	Unknown	0.37	-
Trigard	Cyromazine	1.10	1.10	Dvsh	Unknown	0.37	-
Decis	Deltamethrin	8.91	6.39	Hik Kwang	Unknown	4.96	1.76
Pegasus	Diafenthiuron	3.47	2.86	Kampung	Unknown	0.37	-
Score	Difenoconazole	1.28	-	Kavidor	Unknown	0.55	0.66
Proclaim	Emamektin benzoat	4.57	2.64	Ousban	Unknown	0.55	0.44
Thiotan	Endosulfan	0.37	-	Phitan	Unknown	-	1.98
Rubigan	Fenarimol	-	1.10	Pilaan	Unknown	-	0.66
Regent	Fipronil	1.65	0.66	Pitvan	Unknown	-	0.44
Confidor	Imidacloprid	3.29	0.66	Suks	Unknown	-	0.44
Dhithane	Mancozeb	4.02	15.30	Supergo	Unknown	2.56	1.98
Pilaram	Maneb	0.73	-	Vegsus	Unknown	0.55	0.44
Ridomil	Metalaxyl	-	0.66	Vitame	Unknown	-	0.44
Tamaron	Methamidophos	0.55	-	Unnamed	Unknown	2.19	2.42

- implies that the chemical was not used for the purpose specified in that column.

Thailand

Thailand

Usman Mustafa, Mubarik Ali, Thongchai Satapornvorasak,
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Introduction

Chili is one of the major and essential ingredients in the daily Thai diet. Thais love spicy and hot food. The trend for spice food is rising fast in the country. Some foods are so hot that even the marketing research section wonders how people can eat them but the products are becoming very popular (Atthakor 2003).

Chili is not a native crop, and different hypothesis are presented about its introduction in the country. Some believe that Portuguese traders imported it during the Ayutthaya Period, in early 1511. Another assumed that chili came in the region during the King Songtham and King Narai era (1723), when trade was active with many countries such as China, India, Malaysia and western countries (WSN 2001).

Thailand has vast natural resources; it consists of a land area of 51.3 million ha, of which about 19.4 million ha (37.7%) is under permanent crops (OAE 2001). In 2003, the total area under chili was about 72 thousands ha with a total production of 420 thousands t (Table 1). Chili occupies 17.6% of the total area under vegetables including spices.

The country is geographically divided into four regions and 76 administrative provinces. These regions are Northern, Northeastern, Central Plains, and Southern. The Central Plain region is the largest region; therefore, the Department of Agricultural Extension for its administrative function has divided it into Central, Eastern and Western regions (Dissataporn 2002). The major production areas of chili are in the Northeastern and Northern parts of Thailand, which comprise 59.4% and 18.5% respectively of the total production area of the country. The production areas in the Western, Southern and Central parts make up 15.4%, 2.5%, and 3.4% respectively, of the total production area. The major chili growing provinces are Nakhon Ratchasima, Chaiyaphum, Si Sa Ket in the northeastern, Kanchanaburi and Ratchaburi in the western, and Phetchabun and Chiang Mai in the Northern province.

Growing chilies is a labor-intensive activity; it provides employment to families who are engaged in all aspects of the enterprise: propagation, production, harvesting, marketing preparation and even selling (FAO 1999). It is the only high-value crop grown in the rainfed areas by a large number of poor farmers; therefore, all of its production and marketing aspects are crucial for their livelihood. Chili production is increasingly shifting from an essentially subsistence farming to a commercial venture and becoming a source of revenue for thousands of families in urban, peri-urban and rural communities in Thailand.

Despite the importance of chili and its products in the Thai diet and their role in generating income for farmers and other stakeholders in the food chain, no comprehensive study was available on the issues in the chili sector as the commodity moves from the farm to consumers table. This study intended to fill this gap by conducting comprehensive surveys from various stakeholders in the food chain and analyzing the data from secondary sources.

Table 1. Chili area, production, and yield, by province, Thailand, 2002

Region/province	Area (ha)	Production (t)	Yield (kg/ha)
Northern	**13,937**	**119,759**	**8.6**
Phetchabun	2,509	14,819	5.9
Chiang Mai	2,334	23,779	10.2
Nakhon Sawan	2,000	20,981	10.5
Sukhothai	1,621	11,291	7.0
Others	5,472	48,889	8.9
Northeastern	**44,735**	**229,270**	**5.1**
Nakhon Ratchasima	17,510	54,287	3.1
Chaiyaphum	11,747	62,444	5.3
Si Sa Ket	6,135	32,485	5.3
Others	9,343	80,054	8.6
Central Plain	**2,595**	**14,131**	**5.4**
Eastern	**597**	**3,333**	**5.6**
Western	**11,575**	**70,195**	**6.1**
Kanchanaburi	5,968	18,242	3.1
Ratchaburi	2,692	30,665	11.4
Others	2,915	21,288	7.3
Southern	**1,888**	**7,775**	**4.1**
Total (2002)	75,327	444,463	5.9
Total (2003)	72,000	420,000	5.8

Source: Official files of Department of Agricultural Extension (DOAE), Statistics of Individual Vegetable Growing for the Year 2001-2003, Bangkok, Thailand.

Primary Data Collection

The total sample of 250 farmers was proportionately allocated to the three major chili-producing regions based on the share of each region in the total chili area. Primary data on various aspects related to production, consumption, marketing, and processing of chili and production of competing crops were collected from Chiang Mai and Sukhothai provinces of Northern Region, Ubon Ratchathani, Si Sa Ket and Chaiyaphum of Northeastern Region and Suphan Buri and Kanchanaburi of Central Plain Region of the country.

One to two major chili-growing districts were chosen from each province and at least two to three villages were selected from each district in consultation with the provincial Department of Agricultural Extension. In each village, 10-25 chili and two to five non-chili farmers and housewives were interviewed. A total of 21 villages were visited by the survey team. The survey was conducted in December 2002 and January 2003 covering the 2002 crop production aspects.

A total of 255 chili and 30 non-chili adjacent farmers were interviewed (Table 2).[1] Production data were collected by parcel covering a total of 486 chili and 52 non-chili parcels. A total of 267 housewives in rural areas and 40 housewives in urban areas were interviewed on their preferences for chili and its products. Three chili processors in Bangkok, and 11 marketing agents were also interviewed to study the chili marketing channels and processing practices.

Table 2. Frequency distribution of the sample farmers and parcels by farmer type and region, Thailand, 2002

Type of respondent	Northern region	Northeastern region	Central Plain region	Total
Chili farmer	45	191	19	255
Non-chili farmer	14	13	3	30
Farmers housewives	42	195	30	267
City housewives (Bangkok)				40
Chili processors (Bangkok)				3
Market agents	2	8	1	11

Macro Trends

Production

The annual growth in chili production was at around two percent per annum from 1991-2003 (Table 3). The growth in area contributed mainly to this increase while per ha yield remained almost stagnant over this period at a low level of around 6.0 t/ha. The value of chili fluctuated between THB 2.5 billion in 1993 to THB 12.7 billion in 1999, suggesting large variations in production and farm prices. The farm value in 2003 was THB 5.5 billion (US$136 million).

[1] We took five extra sample to cover unsatisfactory case, if any.

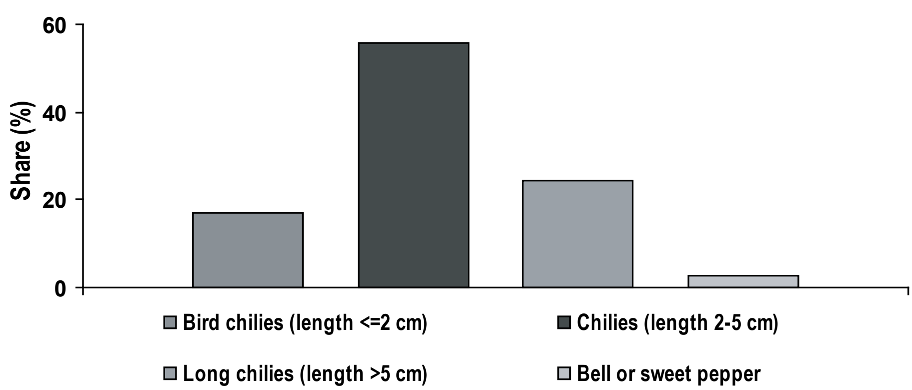
Table 3. Chili area, production, yield, and farm value, Thailand, 1992-2003

Crop year	Planted area (ha)	Production (fresh weight)[1] (t)	Yield/ha (fresh weight)[1] (kg/ha)	Farm value[2] (Million THB)
1991	73,542	488,310	6.6	4,932
1992	77,357	454,633	5.9	5,228
1993	66,212	393,350	5.9	2,517
1994	68,248	369,176	5.4	4,319
1995	75,237	358,731	4.8	3,910
1996	81,644	398,655	4.9	3,707
1997	98,545	511,312	5.2	6,749
1998	110,678	620,409	5.6	9,927
1999	125,875	744,700	5.9	12,660
2000	96,573	602,430	6.2	10,181
2001	89,833	538,127	6.0	8,395
2002	75,327	444,463	5.9	5,689
2003	72,000	420,000	5.8	5,460
Annual growth (%)	1.83	1.98	0.15	6.45

Source: Official files of DOAE, Statistics of Individual Vegetable Growing (various issues), Bangkok, Thailand.
[1]The area and production include small, bird, big chili and sweet pepper. The pimento production reported in dry weight was converted into fresh weight by multiplying it with four.
[2]Estimated using the FAOSTAT-Agriculture (producers' price) data. The prices for sweet chili were taken from Indonesia data. The prices in local currency were converted using the exchange rate reported in www.fftc.agnet.org (various issues).

Production Types

Medium-sized chili with a length of more than two to five cm is the major form produced in Thailand contributing more than one-half of the total production. This is followed by long-sized and bird chili with the size of greater than five cm and less than or equal to two cm contributing 24% and 17% in total production, respectively. The contribution of sweet pepper in the total production is small at less than 3% (Figure 1).



Source: Department of Agriculture, Ministry of Agriculture & Co-operatives, Bangkok, Thailand, 2002.

Figure 1. Distribution of chili production by shape/length in 2001-2002

International Trade in Chili

The international trade of chili from Thailand experienced a turnover in 1991-2003. While its imported quantities and values increased at 17.3% and 16.4% per annum, respectively, no significant trend was observed in exported quantities and values during these years (Table 4). These trends converted the country into a net importer from a net exporter of chili in the early 1990s. The highest positive trade surplus of US$4.5 million was achieved in 1992. In 2003, it exported 16.1 thousand t of fresh chili worth of US$4.1 million, and imported 76.2 thousand t worth US$11.1 million. This left a trade gap of US$7.1 million. The major chili exporting countries to Thailand in 2000-2002 were Malaysia and Singapore. Interestingly, Malaysia was also the major importing country of Thai chili in 2002.

Although the country became a net importer of fresh chili, it has expanded its trade in value-added products such as chili sauce. For example, in 2001, the country exported 14.8 thousand t of chili sauces worth US$16 million, up from 7.4 thousand t worth US$8 million in 1997 (DOA 2001). If processed chili items are included, the country is considered a net exporter in chili trade.

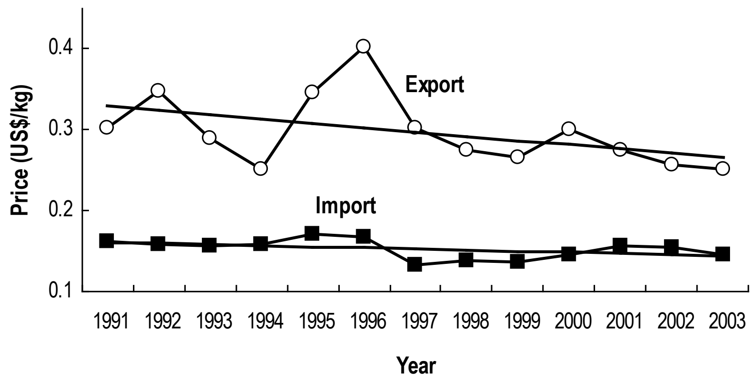
Table 4. International trade in chili, Thailand, 1991-2003

Year	Import		Export		Total trade		Trade surplus	
	Quantity (t)	Value (1000 $)	Quantity (t)	Value (1000 $)	Quantity (t)	Value (1000 $)	Quantity (t)	Value (1000 $)
1991	8,792	1,432	12,407	3,761	21,199	5,193	3,615	2,329
1992	7,104	1,119	16,099	5,606	23,203	6,725	8,995	4,487
1993	10,542	1,648	19,921	5,759	30,463	7,407	9,379	4,111
1994	21,720	3,452	16,743	4,209	38,463	7,661	-4,977	757
1995	8,201	1,404	12,722	4,392	20,923	5,796	4,521	2,988
1996	13,750	2,298	10,689	4,302	24,439	6,600	-3,061	2,004
1997	20,339	2,691	14,198	4,296	34,537	6,987	-6,141	1,605
1998	16,337	2,254	12,603	3,458	28,940	5,712	-3,734	1,204
1999	18,602	2,554	17,183	4,571	35,785	7,125	-1,419	2,017
2000	31,315	4,549	12,615	3,781	43,930	8,330	-18,700	-768
2001	37,055	5,787	14,546	4,000	51,601	9,787	-22,509	-1,787
2002	58,953	9,097	13,172	3,385	72,125	12,482	-45,781	-5,712
2003	76,234	11,129	16,103	4,053	92,337	15,182	-60,131	-7,076
Growth rate (%)	17.3*	16.4*	-0.4^{ns}	-2.2^{ns}	10.0*	6.1*	-	-

Source: FAO-Agricultural data (Agriculture and Food Trade-Crop and Livestock Primary and Processed). The trade quantity of dry chili and allspice was converted into fresh weight by multiplying it with a factor of four.

The * on the figures in the last row suggest that the growth is significant, while ^{ns} implies that these growth is not significant at 10% level.

Thailand is exporting high-value chili products, while importing low-priced chilies. However, Thailand's competitiveness in the export market of chili is improving with the decline in its export prices while import prices remained stagnant over the period (Figure 2). Although export prices are still higher than import prices, most of the difference may be due to difference in quality.

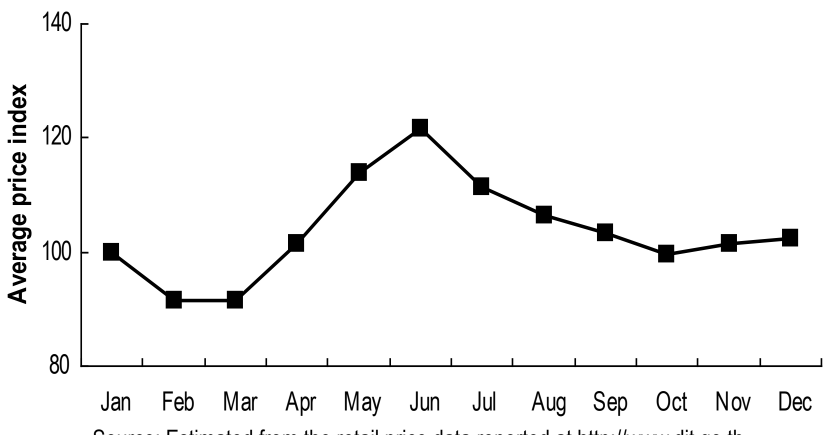


Source: Estimated from import and export quantity and value figures in Table 4.

Figure 2. Trend in import and export prices of chili in Thailand, 1991-2003

Seasonality in Supply

The index of retail prices of chili starts increasing in March and reaches its maximum in June when it starts declining (Figure 3). The extent of seasonality, defined as the percentage difference in the maximum and minimum prices, stands at 25%. The seasonality in chili prices in 1998-2000 dropped dramatically from 94% from 1989-1993 as reported by Sootsukon et al. (2000). This may be due to the spread of cultivation time and improvement in the transport and storage infrastructure.

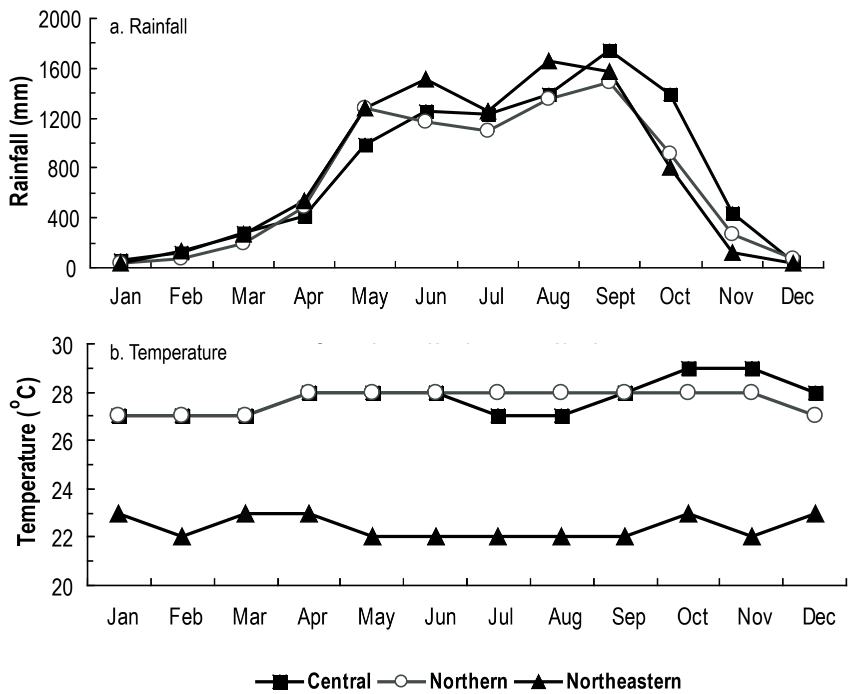


Source: Estimated from the retail price data reported at http://www.dit.go.th

Figure 3. Seasonality in chili retail prices in Thailand, 1998-2000

Climatic Situation

The rainfall patterns are very similar across the sample regions. May to October is heavily rainy, February to April moderately rainy, and December and January is almost dry season (Figure 4a). The Northeastern Region has lower and almost constant (22°C) temperature, while the temperature in the Central and Northern Region ranges 27~29 °C (Figure 4b).



Source: Downloaded from "http://www.weatherbase.com/weather/city.php3?c=ID&refer=" and then type city name

Figure 4. Mean monthly rainfall and temperature in the study areas in Thailand

Farm and Farmer Characteristics

Socioeconomic Characteristics

The household head of chili farms in the sample areas were slightly younger than non-chili farms, although the difference was not statistically significant; both groups had almost the same family size and had similar available family labor force in the farm (Table 5). They also had similar farm size, although chili farmers owned larger area but rented smaller farms, had more fragmented farms, and lower land use and cropping intensities, although the difference was not statistically significant in the later two parameter values. Interestingly, chili farmers' level of education was higher than non-chili farmers, had higher source of non-agricultural income and their farms were farther from paved roads. Both types of farms possessed similar agricultural experience, but chili farmers owned more water pumps and sprayers.

The percentage of farmers having motorbike, the main source of transportation in the area, was similar across the two groups.

Table 5. Household characteristics of chili and non-chili growing farm in the sample areas, Thailand, 2002

Characteristics	Chili farmer	Non-chili farmer
Age of the farmer (years)	46.8[a]	49.3[a]
Family size (number)	3.8[a]	4.1[a]
Time spent in agriculture (%)	77.5[a]	75.5[a]
Farm size (ha)	4.1[a]	4.2[a]
Owned	3.6[a]	2.9[b]
Rented	0.5[b]	1.3[a]
Fragment (number)	2.1[a]	1.7[b]
Cultivated area (ha)	2.8[a]	3.2[a]
Chili area (ha)	0.26	-
Land use intensity (%)	73[a]	78[a]
Cropping intensity (%)	103[a]	115[a]
Education (schooling years, head of the household)	5.2[a]	4.0[b]
Off-farm income (000 THB/year[1])	425[a]	1,679[a]
Distance from paved road (km)	1.5[a]	0.6[b]
Distance from nearest vegetable market (km)	9.2[a]	8.3[a]
Agricultural experience (years)	27.4[a]	30.0[a]
Chili production experience (years)	11.2	-
Ownership of farm equipment (% of farmers)		
Water pump	57[a]	40[b]
Sprayer	69[a]	53[b]
Power tiller and tractor	60[a]	43[a]
Ownership of motorbike (% of farmers)	68[a]	70[a]
Ownership of car (% of farmers)	37[a]	47[a]
Ownership of livestock (number)		
Hen and duck	11.8[a]	1.3[b]
Cow and draft bullocks	1.10[a]	0.16[b]
Standard Animal Unit (SAU[2])	2.81[a]	1.51[b]

[1] One US$= 40.43 THB.

[2] The SAU was estimated as: 0.93 buffalo +1.08 cow + 0.5 pig + 0.19 goat + 0.4 young sock+ 0.75.donkey.

Different superscripts in a row imply significant difference between chili and non-chili farmers at 10% level.

House and Household Belongings

Only two percent of the chili farmers and 10% of non-chili farmers rented houses (Table 6). The total house area was higher but cover area was almost the same in the former group. A lower percentage of chili farmers had bricked or cemented house, but they generally possessed more household belongings compared to non-chili farmer. They also had lower access to government water supply system and private pumps.

Table 6. Household living conditions and home appliances owned by chili and non-chili farmers in the sample areas, Thailand, 2002

Characteristics	Chili farmer	Non-chili farmer
House status (%)		
Own	98	90
Rented	2	10
House area (m^2)		
Covered area	207	206
Total area	887	795
House condition (%)		
Below average	20	20
Average	61	70
Above average	19	10
House construction (%)		
Mud, local stone	67	40
Bricked, cemented	33	60
Household belonging (no.)		
TV	1.09	0.87
Radio	0.39	0.90
Cassette player	0.69	0.40
Refrigerator	0.78	0.70
Stove	0.82	0.43
Source of drinking water (% of farmers)		
Government water supply	12	27
Private pump	9	27
Open well/artisan well/others	79	46

Land Form, Drainage, and Soil Texture

The distribution of soil structure, land drainage situation, and slope of the land were not significantly different across chili and non-chili farms (Table 7).

Table 7. Land form, drainage, and soil texture in the sample areas by chili type, Thailand, 2002

Characteristics	Chili farmer	Non-chili farmer
Soil texture (%)		
Heavy	49	33
Medium	44	57
Light	7	10
Drainage (%)		
Well drained	51	47
Medium drained	35	44
Poorly drained	14	9
Land form (%)		
Slope with terrace	7	3
Slope without terrace	17	4
Plain on the river bed	27	53
Plain away from the river bank	49	40

Varieties and Cropping Pattern

Chili Varieties

The majority of the sample chili farmers (81%) cultivated improved open pollinated varieties, which include Jin-da, Yod-son and Hua-rea (Table 8). Only eight percent of farmers, concentrated mainly in Nakhon Phan province of Northeastern and Chiang Mai province of Northern Regions, used local varieties, which include Rod, Tae, Sai-pla-rai and Doikai; six percent cultivated sweet pepper varieties of Gada and Hot Beauty. The main hybrid varieties were Tango, Jomthong and Mon cultivated by five percent of farmers. All the sweet pepper and 90% of hybrid chili farmers in the sample areas were found in Chiang Mai province of Northern Region. All the sweet chili farmers were from the same locality. They were all organized into a co-operative that purchased inputs collectively and supply outputs to supermarkets and Thai Air Lines.

Table 8. Chili varieties planted in the sample areas, by chili type, Thailand, 2002

Chili type	Name of variety	Percentage of parcels[1]
Hybrid		5
	Tango	2
	Jomthong	2
	Mon	1
Open pollinated		81
	Jin-da	35
	Yod-son	30
Local		8
	Rod	4
	Tae	2
	Sai-pla-rai	1
	Doikai	1
Sweet		6
	Gada	4
	Hot Beauty	2

[1] Total number of parcels is 486.

Intercrops and Crop Rotation

In Thailand chili was mainly cultivated as a single crop. About 86.9% parcels were single cropped, and 13.1% of only open pollinated type was intercropped. Red shallots and maize were the main crops used for intercropping (Table 9).

Table 9. Intercropping in the sample areas, by chili type, Thailand, 2002

Intercrop	Percentage of parcels[1]				
	Hybrid	Open pollinated	Local	Sweet	Overall
Chili alone	4.0	68.3	8.3	6.3	86.9
Chili with one other crop	-	13.1	-	-	13.1
Red shallot (onion)	-	6.3	-	-	6.3
Maize	-	2.4	-	-	2.4
Cabbage	-	0.8	-	-	0.8
Coriander	-	1.2	-	-	1.2
Soybean	-	0.8	-	-	0.8
Garlic	-	0.8	-	-	0.8
Other	-	0.8	-	-	0.8
Total	4.0	81.4	8.3	6.3	100.0

[1] Total number of parcels is 486.

The main chili-based rotations in the sample area were chili-rice-chili, chili-fallow-chili, and chili-corn-chili (Table 10). The major rotation in hybrid was chili-corn-chili, while chili-rice-chili was the major rotation in open pollinated and local chili types.

Table 10. Chili-based crop rotation in the sample areas, by chili type, Thailand, 2002

Chili farmer	Crop rotation	Percentage of parcel[1]
Hybrid	Chili – Fallow – Chili	10
	Chili – Rice – Chili	30
	Chili – Corn – Chili	50
	Chili – Other – Chili	10
Open pollinated	Chili – Fallow – Chili	18
	Chili – Rice – Chili	56
	Chili – Red shallot – Chili	7
	Chili – Corn – Chili	11
	Chili – Other – Chili	8
Local	Chili – Rice – Chili	38
	Chili – Corn – Chili	33
	Chili – Other – Chili	20
	Chili – Fallow – Chili	9
Sweet pepper	Chili – Fallow – Chili	100
Overall	Chili – Rice – Chili	53
	Chili – Fallow – Chili	17
	Chili – Other – Chili	16
	Chili – Corn – Chili	14

[1] Total number of parcels is 486.

Cropping Pattern

Commercial crops occupied the majority of area on both chili and non-chili farms (38% and 57%) (Table 11). Chili farmers allocated more area under vegetables including chili (9+7=16%) but less to commercial crops compared to non-chili farmers (5%). They also allocated proportionately more area for cereal, which included mainly corn for chili and rice for non-chili farmers.

Table 11. Cropping pattern in the sample areas, by chili type, Thailand, 2002

Crop group[1]	Chili farmer		Non-chili farmer	
	Area (ha)	Share (%)	Area (ha)	Share (%)
Chili	0.26	9	-	-
Other vegetables	0.20	7	0.18	5
Cereals	0.64	22	0.33	9
Commercial crop	1.10	38	2.11	57
Beans and pulses	0.26	9	0.22	6
Others	0.43	15	0.85	23
Total cropped area (ha)	2.89	100	3.69	100

[1]Cereals include rice and corn; Commercial crops include flower, cassava, sugarcane; Beans and pulses include soybean; Others include fruits, tobacco, and cassava.

Cultivating and Harvesting Time

The chili cultivating and harvesting times varied greatly depending upon the geographical area, irrigation condition, and seasons. The major growing season started in May, except for hybrid chilies where planting time on average started at the end of August (Table 12). Harvesting started in October for open pollinated and local type chili, September for sweet pepper, and January for hybrids. Among hot chilies, local varieties had the longest span. The hybrids not only reduced the growing season and harvesting span, but also enabled farmers to produce chili during the off-season for higher prices

Table 12. Cultivation and harvesting time (week and month) in the sample areas, by chili type, Thailand, 2002

Chili farmer	Planting time	Start of harvesting time	End of harvesting time
Hybrid	3rd August	1st February	2nd April
Open pollinated	3rd May	4th October	4th January
Local	1st May	2nd October	1st February
Overall	2nd May	2nd October	4th January
Sweet	2nd May	3rd September	2nd December

Information Source

Seed

Overall, the major sources of seed-related information were the neighboring farmers, friends, village retailers, and extension workers (Table 13). In sweet pepper, village cooperatives, extension workers, and village retailers were all important sources, while village retailers and neighboring farmers were the major sources for farmers of open pollinated and hybrid varieties. For local varieties few farmers got information only from government seed store.

Table 13. Seed-related source of information in the sample areas, by farmer type, Thailand, 2002

Chili farmer	Source of information about seed (% of farmer)			
	Extension worker	Village retailer	Neighboring farmer	Government seed store
Hybrid	10	25	50	15
Open pollinated	17	42	33	8
Local	0	0	0	5
Sweet	31	25	44**	0
Overall	21	32	37	10

** Village cooperative.

Market Information

All farmers who grow hot chili ranked traders or middlemen to whom they also sell their chili output as the number one source of information (Table 14). They ranked neighboring farmers as the second major source of information followed by farmer cooperative associations, government departments and radios. Sweet pepper growers ranked farmers' associations as top ranking information source followed by traders and neighboring farmers.

Table 14. Ranking of market information sources in the sample areas by farmer type, Thailand, 2002

Chili farmer	Trader	Neighboring farmer	Farmers' association	Government department	Radio
Hybrid	1	2	3	4	-
Open pollinated	1	2	4	3	-
Local	1	2	-	3	4
Sweet	2	3	1	4	-
Overall	1	2	3	4	5

Note: 1=highest rank, and 5=lowest rank

Seed Selection

Ability to fetch high market prices was the number one criterion in the selection of chili seed, regardless of its type (Table 15). The second characteristics preferred were high yield, also in all chili types, except in green where farmers considered high number of pods as second most desirable characteristic. Attractive chili color was placed as third ranking criterion by all types of chili farmers, again except in green chili where yield was ranked fourth. It should be noted that insects and diseases were ranked very low.

Table 15. Ranking of factors considered in the selection of chili seed in the sample areas, by chili type and product, Thailand, 2002

Characteristics	Green	Red	Sweet	Powder
Market price	1	1	1	1
Yield	3	2	2	2
Disease	-	-	-	6
Insect free	5	4	4	-
Chili color	4	3	3	3
Number of pods	2	-	-	-
Fragrance	-	-	-	5
Hotness	6	5	-	4
Freshness	-	-	5	-

Note: 1=highest rank, and 6=lowest rank.

Insect and Pest Problem

Insects

A vast majority of farmers reported insect problems. The insect problem was more severe in hybrid than other chili types (Table 16). Sweet pepper grown in shade houses/ tunnels had the lowest insect problem. Overall, thrips and caterpillar were reported as most frequently-occurring insects by 30% and 27% farmers, respectively. Either one of these two insects was more widely-spread regardless of varieties. Mite was also widely encountered by more than 20% hybrid chili and sweet pepper farmers.

Thrips was ranked as the most problematic insect in all chili types, except in open pollinated where caterpillar was ranked as number one insect. Number two ranking insect was mite in local chili and sweet pepper, caterpillar in hybrid, and thrips in open pollinated type. The number three ranking insect was mites in hybrid and open pollinated, and aphids in local chili and sweet pepper.

Insects were a problem in chili cultivation almost every year. Average annual losses due to insect were 24% in 1998-2002. The losses were lowest in sweet pepper and highest in hybrid. According to farmers' perception, the losses due to insect had increased overtime.

Table 16. Major insects and extent of losses due to insects in chili in the sample areas, by chili type, Thailand, 2002

Chili type	Insect problem (%)	Farmers reporting insects as problem (%)						Rank[1]				Occurrence (years out of 5)		Average losses (%)	
		T	C	M	A	MB	Other	1	2	3	4	1993-1997	1998-2002	1993-1997	1998-2002
Hybrid	90	19	35	27	8	4	7	T	C	M	-	4.6	4.8	18	28
Open pollinated	70	31	27	16	17	3	6	C	T	M	A	4.6	4.4	13	25
Local	75	29	23	17	13	6	12	T	M	A	C	4.7	4.7	10	20
Sweet	69	32	26	24	15	3	0	T	M	A	-	-	2.0	-	12
Overall	71	30	27	17	16	3	7	C	T	M	A	4.6	4.3	13	24

Note: A=Aphids (*Aphis gossypii*); C=Caterpillar (*Helicoverpa armigera* and *Spodoptera litura*); M=Mites (*Polyphagotarsonemus latus*); MB= Mealy Bug (*Planococcus sp*. and/or *Pseudococcus sp*.) or White fly (*Aleurodicus dispersus*); T=Thrips (*Scirtothrips dorsalis*).

[1]The rank of 1 is the most devastating, and 4 the least devastating insect.

Diseases

The majority of farmers also reported diseases as a serious problem. However, the problem was less serious in sweet pepper than in other chili types (Table 17). Anthracnose, Fusarium wilt, viruses, bacterial spot and bacterial wilt were the most commonly occurring diseases in the sample areas.

Anthracnose was ranked most devastating disease in all chili types, except in hybrid where Fusarium wilt was ranked as number one. Fusarium wilt was the second ranking disease in all chili types except in hybrids where anthracnose was ranked second (Table 17). Viruses in hybrids and open pollinated and bacterial spot in local chili and sweet pepper were ranked third. The loss due to diseases was a regular phenomena occurring every

Table 17. Major chili diseases and extent of yield losses due to diseases in the sample areas, by chili type, Thailand, 2002

Chili type	Disease problem (%)	Farmers reporting diseases (%)						Rank[1]				Occurrence (yrs)		Average losses (%)	
		AN	FU	VS	BS	BW	OT	1	2	3	4	1993-1997	1998-2002	1993-1997	1998-2002
Hybrid	80	20	27	23	17	13	0	FU	AN	VS	BW	2.5	4.1	16.2	31.1
Open pollinated	82	39	22	14	11	8	6	AN	FU	VS	BW	2.5	4.1	15.7	31.5
Local	75	38	17	14	7	14	10	AN	FU	BS	VS	2.2	4.2	15.7	41.0
Sweet	50	26	16	10	9	13	26	AN	FU	BS	-	0	1.1	0	13.2
Overall	78	37	22	14	11	9	7	AN	FU	VS	BW	2.3	3.9	15.0	30.8

Note: AN=Anthracnose (*Colletotrichum acutatum*, *C. capsici* and *C. gloeosporioides*); FU= Fusarium wilt (*Fusarium oxysporum f. sp. Capsici* and *Fusarium solani*); VS= Virus; BW=Bacterial wilt (*Ralstonia solanacearum*); BS=Bacterial spot (*Xanthomonas campestris pv. Vesicatoria*); OT=Other.

[1]The rank of 1 is the most devastating, and 4 the least devastating disease.

four in five years. The average loss in a season, as perceived by farmers, was 31% in 1998-2002, which had increased from 15% from 1993-1997. The frequency of occurrence had also increased overtime.

Weeds

Almost all farmers reported weed problems in chili fields. Overall, *Dactyloctenium aegyptium*, *Pennisetum polystachyon*, *Amaranthus gracilis* and *Cyperus rotundus* were identified as most commonly occurring weeds (Table 18).

Table 18. Major weeds and extent of losses due to weeds in chili in the sample areas, by chili type, Thailand, 2002

Chili type	Weed problem (%)	Farmers reporting weed (%)					Rank				Occurrence (yrs)		Average losses (%)	
		DA	AM	PE	CR	OT	1	2	3	4	1993-1997	1998-2002	1993-1997	1998-2002
Hybrid	100	6	60	5	10	19	AM	CR	DA	PE	3.6	4.6	3.1	3.9
Open pollinated	92	22	7	12	9	50	DA	PE	CR	AM	3.2	4.7	7.1	11.2
Local	90	22	7	2	6	63	DA	AM	PE	CR	3.1	4.2	7.0	15.0
Sweet	93	40	13	-	-	47	DA	AM	-	-	-	5.0	-	10.0
Overall	97	24	9	12	8	47	DA	PE	CR	AM	3.1	4.6	6.7	10.8

Note: DA=*Dactyloctenium aegyptium*, AM=*Amaranthus gracilis*, PE=*Pennisetum polystachyon*, CR=*Cyperus rotundus*, *OT=Other weeds.*

Dactyloctenium aegyptium was ranked as the most devastating weed in all chili types, except in hybrid where it was ranked third and *Amaranthus gracilis* was ranked first. *Amaranthus gracilis* was ranked as second in local and sweet pepper, *Pennisetum polystachyon* in open pollinated, and *Cyperus rotundus* in hybrid. *Dactyloctenium aegyptium* belongs to the monocotyledonous weeds type family while *Amaranthus gracilis* belongs to dicotyledonous family of weeds. Other weeds found in chili fields in the study area are reported in Appendix 1.

Weeds are becoming a regular problem in chili cultivation. Average weed losses in one season were reported at 11%, which had increased from 7% in the last five years.

Farm Management Practices

Preparation of Nursery Seedling

All farmers in the sample area practiced transplanting and none used direct-seeding to grow chili crop. Therefore, all farmers prepared nurseries. For this purpose, seedbeds of size 1 x 5-20 m depending upon the area to be cultivated, were prepared in fields close to a water source. Approximately 10-15 m^2 of seedbed area was needed for one rai (0.16 ha) of planting. The soil was broken into small granules using broad blade hoe.

It was ploughed; the surface was smoothed and allowed to dry for three to seven days. Seeds were broadcasted, then mulched with rice stubs and dry rice-straw. The bed was watered daily. The mulch was removed seven days after sowing.

Seed Treatment

Seed soaking or dusting was not common; 12% sample farmers, only in open pollinated and local types, practiced seed soaking before sowing for an average of 0.3 hours (Table 19). Only 6% of farmers used seed dusting mainly in open pollinated chili type using an average of 0.11 kg chemical for one ha seed. Copper Hydroxide, Mancozeb, Captan (all fungicides) were the main chemicals used in seed treatment.

Table 19. Seed treatment by chili type, Thailand, 2002

Chili farmer	Soaking		Dusting	
	% Farmer	Hours	% Farmer	Chemical (kg)
Hybrid	0	-	0	-
Open pollinated	13	0.32	7	0.11
Local	18	0.38	1	0.60
Sweet	0	-	0	-
Overall	12	0.33	6	0.11

Nursery and Field Soil Treatment

Only 19% chili nursery and six percent chili fields were treated with chemicals to control soil-borne diseases, such as damping off (Table 20). No soil treatment was applied to local chili fields. Farmers mainly mixed the chemical with irrigation water for soil treatment. However, placement in open pollinated and broadcast in local chili types were the main methods of chemical application for soil treatment. An average of five kg or liter per ha of chemical was used for soil treatment in nursery, and 233 kg- or liter/ha for chili fields with some variation across chili types. The most commonly used chemicals were lime (to improve soil health), Methomyl (insecticide), and Lambda Cyhalothrin (insecticide).

Table 20. Nursery and field soil treatment in the sample areas, by farmer type, Thailand, 2002

Chili farmer	Farmers using the treatment (%)		Chemical used (kg or l/ha)		Method of soil treatment (%)			
	Nursery	Field	Nursery	Field	Broadcast	Placement	Mixed with irrigation	Spray
Hybrid	10	10	19	40	10	20	60	10
Open pollinated	21	6	4	212	10	50	30	10
Local	13	0	5	0	83	0	0	17
Sweet*	14	10	13	342	20	6	74	0
Overall	19	6	5	233	11	22	59	8

* Only for nursery soil, crop is in the hydroponics system.

Land Preparation

Tractors and animals were the main source of power for plowing. Some small farmers also prepared land manually. On average, farmers made 1.4 plowings (Table 21). In sweet chili no land preparation was done, because it was cultivated under hydroponics system on flat land which was prepared only once; the same bed may be used for the subsequent croppings.

Table 21. Land preparation method used in the sample areas, by chili type, Thailand, 2002

Chili type	Percentage of parcels										Number of operations	
	Plowing					Harrowing					Plowing	Harrowing
	Hand	Animal	Tractor	Others[1]	Total	Hand	Animal	Tractor	Power tiller	Total		
Hybrid	-	10	90	-	100	70	5	15	10	100	1.5	9.1
Open pollinated	5	20	70	5	100	80	8	9	5	100	1.3	8.2
Local	5	25	65	5	100	85	5	5	5	100	1.4	7.3
Sweet	-	-	-	-	-	-	-	-	-	-	-	-
Overall	3	17	68	2	100	75	6	14	5	100	1.4	7.9

[1]Others mean tractor+animal.

All chili farmers practiced around eight harrowings, mainly by hand, followed by tractors, animals, and power tillers. The highest number of harrowings were practiced in hybrids followed by open pollinated and local chilies. Due to the peculiar characteristics of sweet pepper cultivation, no harrowing was practiced.

Bed Type

Majority of chili fields, especially hybrid, had raised beds. However, one-third of the chili fields were flat, and 13% mainly in open pollinated had furrows (Table 22). All sweet chili fields were flat in the hydroponics system.

On average, the furrow or raised bed height, width, plant-to-plant and row-to-row distances were 25, 217, 38 and 75 cm, respectively with some variation across chili types. The row-row and plant-plant distance was highest in sweet chili.

Table 22. Bed type, height, width, plant–to-plant and row-to-row distance used in the sample areas, by farmer type, Thailand, 2002

Chili farmer	Bed type (% of parcels)			Furrow or raised bed structure (cm)			
	Furrow	Raised	Flat	Height	Width	Plant-to-plant distance	Row-to-row distance
Hybrid	0	80	20	39	106	43	49
Open pollinated	14	51	35	24	260	38	75
Local	5	57	38	24	138	37	89
Sweet	0	0	100	0	0	48	111
Overall	13	53	34	25	217	38	75

Mulching Material

Plastic sheets with an average life of two years were used only in sweet pepper fields in its hydroponics system. About one-third chili fields, mainly in hybrid and open pollinated, were mulched with straw (Table 23).

Table 23. Mulching material type and life used in the sample areas, by chili type, Thailand, 2002

Chili farmer	Plastic sheet		Rice straw
	Farmer using (% of parcels)	Life (months)	(% of parcels)
Hybrid	0	0	40
Open pollinated	0	0	34
Local	0	0	14
Overall	0	0	32
Sweet	100	24	0

Irrigation Sources

Chili cultivation in Thailand is mainly under rainfed condition; only 40% chili fields received supplemental irrigation (Table 24). The main supplemental irrigation sources were tube well, tank/lake and canal. A significant proportion of parcels were irrigated using a combination of all these sources.

Local and open pollinated varieties were mainly cultivated under the rainfed situation as they were more tolerant to water stress. However, hybrid chili and sweet pepper were mainly cultivated under irrigated conditions. The main sources of irrigation for hybrid chili were canals and tube wells while irrigation for sweet pepper was provided through the hydroponics system.

Manual pump was the main method of irrigation followed by sprinkle irrigation; the latter was the sole method in sweet pepper. Flooding with ridges and manual pump were the main irrigation methods for hybrid chili. Manual pump dominated in open pollinated, and flooding with and without ridges was used in equal proportion in local chili type.

Table 24. Irrigation methods and sources used in the sample areas, by chili type, Thailand, 2002

Chili farmer	Irrigation method (% of parcels)				Irrigation source (% of parcels)				
	Flooding		Manual (pump)	Sprinkle + trickle	Canal	Tube well	Tank/ lake	Rain	Mixed
	Without ridges	With ridges							
Hybrid	11	56	33	0	30	40	0	10	20
Open pollinated	0	6	78	16	3	9	10	60	18
Local	53	47	0	0	5	0	0	81	14
Overall	2	12	70	15	5	10	9	59	18
Sweet	0	0	0	100	0	0	0	0	100**

** Hydroponics system.

Fertilizer Application

Only 28% of chili fields, mainly of hybrid and open pollinated types, were applied with organic fertilizers (Table 25). The low application may be due to the rainfed condition in which most chili fields were cultivated. The major organic fertilizer used was poultry manure, followed by cattle manure and mixed/compost.

Table 25. Organic fertilizer type and method of inorganic fertilizer application used in the sample areas, by chili type, Thailand, 2002

Chili type	Farmers using manure (%)	Manure type (% of farmer)			Farmers using inorganic fertilizer (%)	Method of inorganic fertilizer application (% of farmer)			Inorganic fertilizer (number)
		Cattle	Poultry	Mixed		Broadcast	Placement	Irrigation	
Hybrid	31	60	14	26	100	10	50	40	3.5
Open pollinated	30	33	57	10	94	31	43	26	3.3
Local	10	33	-	67	81	64	24	12	3.2
Overall	28	34	53	13	93	33	42	25	3.3
Sweet	-	-	-	-	100	-	-	100	*

* Hydroponics system.

Over 90% of farmers applied inorganic fertilizers to chili, while all hybrid and sweet pepper fields received inorganic fertilizers. In general, three applications of inorganic fertilizer were done which were equally split over 3rd, 5th and 9th weeks after transplantation. The application of inorganic fertilizer was mainly through placement in hybrid and open pollinated, broadcast in local and with irrigation in sweet pepper.

Insect Control

All hybrid and sweet chili fields were sprayed with chemicals to control insects, and 76% and 55% open pollinated and local chili fields were also sprayed, respectively (Table 26). A vast majority of farmer sprayed single pesticide; less than one percent only in open pollinated applied mixture (cocktail) using an average of three pesticides. A total of 23 pesticides were used in the study area, each having a well-specified names of active ingredient. The most common insecticides reported in the area were Methamidophos and Parathion methyl (Appendix 2). The use of insecticide was found to be partially effective at around 70% with little variation across chili types.

Table 26. Extent of insecticide use and their perceived effectiveness in the sample areas, by chili type, Thailand, 2002

Chili farmer	Farmer applying (%)		Effectiveness (%)
	Single	Cocktail	
Hybrid	100	-	72
Open pollinated	75	0.8	70
Local	55	-	62
Overall	74	0.7	69
Sweet	100	-	75

Disease Control

Overall, more than half of chili fields were sprayed with fungicide to control diseases. The frequency of fungicide application to control diseases was highest among the hybrid and sweet pepper farmers. A total of 13 chemicals with well-specified ingredient names were applied as fungicides, although some of them were in fact insecticides. The most common fungicide reported in the study area was Carbendazim and Mancozeb (Appendix 3). The effectiveness of fungicide was even less than the insecticide at 55% with little variation across chili types (Table 27).

Table 27. Extend of fungicide use and their perceived effectiveness in the sample areas, by chili type, Thailand, 2002

Chili farmer	Farmer applying (%)		Effectiveness (%)
	Single	Cocktail	
Hybrid	90	-	69
Open pollinated	37	1	54
Local	45	-	58
Overall	40	1	55
Sweet	88	-	66

Weed Control

All chili fields were weeded except sweet chili because of their peculiar cultivation system. Both manual removal and chemical sprays were used to control weeds, although manual weeding dominated. Overall, 22% of parcels were treated with chemicals alone while 28% had both manual weeding and chemical treatments to eradicate weeds (Table 28). Seventy percent of hybrid fields had chemical treatments while 30% also had manual weeding. On average, four manual weedings and two chemical sprays were done in chili fields. Some farmers practiced up to eight weedings because of recurrence of weeds after each operation. The most commonly applied herbicides were Paraguat, Glayphosate, Difenoconazole, and Alachor. These weeding operations were very effective and controlled more than 90% of weeds.

Table 28. Number of weeding, type, and their perceived effectiveness in the sample areas, by chili type, Thailand, 2002

Chili farmer	Percentage of farmers			Number of weeding applications		Effectiveness (%)
	Chemical	Manual	Chemical + manual	Chemical spray (no.)	Manual (no.)	
Hybrid	70	-	30	3.3	3.6	92
Open pollinated	18	52	30	2.2	3.8	91
Local	38	57	5	1.8	4.7	94
Overall	22	50	28	2.2	3.9	91
Sweet	-	-	-	-	-	-

Other Methods of Pest Control

Around 15% of farmers also reported that picking and destroying the plants with disease, weeding, intercropping, and frequent picking helped in controlling the insects and diseases in chili fields, although their effectiveness was not indicated.

Harvesting

On average, hot chili fields were harvested five times, while sweet pepper fields were harvested 41 times (Table 29). In general, family members did the harvesting; only one percent hot chili fields were harvested by hired labor, and 17% were harvested by engaging both family and hired labor.

Only sweet pepper fields (about one-third) were harvested exclusively using hired labor; other one-third of sweet pepper fields were harvested by family labor, and remaining one third by engaging hired labor along with family labor.

Table 29. Number of harvest and type of labor used in harvesting in the sample areas, by chili type, Thailand, 2002

Chili farmer	Number of harvest	Type of labor used (% of farmers)		
		Family labor	Hired labor	Both
Hybrid	13.0	50	-	50
Open pollinated	3.8	86	3	11
Local	16.1	60	-	40
Overall	5.2	82	1	17
Sweet	40.7	34	33	33

Chili Marketing

Marketing played a very significant role in the economic viability of various farm enterprises. This affected farmer's production decisions. Marketing in Thailand was influenced by the product type, consumer's preferences (reflected in terms of price) and geographic specialization of production (Kohls and Uhl 1998). These in turn affected the quality of the product, market prices, and seasonality in the availability of the product.

Marketing Constraints

Over 90% of sample farmers believed that middlemen exploited them because of their weak bargaining power. They believed that middlemen/commission agents were getting higher than what was due margins for the services they rendered to farmers. The exploitations were in the form of low price and little premium for quality and grading.

Lack of collective bargaining power was considered as the major chili marketing constraint by more than one-half of the sample farmers. Lack of active government participation in chili markets was considered a major constraint by another 28%. About 10% of farmers were not satisfied with the fluctuation of chili prices. The remaining farmers expressed other constraints such as low prices, confused market channels, and others.

The majority of farmers engaged in chili marketing were males, and only 16% were females.

Marketing Channels

Farmers sold their chilies mainly to local traders, local markets, and farmer's associations (Figure 5). In sweet chili, farmers sold all their products to their associations which directly sold the same to consumers (In Chiang Mai the association supplied a major portion of their product to Thai Air Lines catering services in Bangkok).

From the farmer's association 60% of chilies were directly sold to the processing units while the remaining 40% went to the wholesalers at the province level. The local traders or commission agents sold 65% and 35% of their products to wholesalers at the province and district levels, respectively. From the local markets, 80% of chili flow to wholesale markets at the district level while the remaining 20% was distributed between retailers (90%) and directly to consumers (10%). The wholesalers from the provinces sold 75% to the processors and 25% to wholesalers in Bangkok. The wholesalers from the districts sold a major part (70%) to their counterparts in the provinces and the remaining 30% was distributed between wholesalers (65%) and retailers (35%) in Bangkok.

The Bangkok wholesale market is the biggest in Thailand where chili from throughout the country is brought. From this market, a major (90%) portion was sold to retailers while five percent each was sold to processors and exported to other countries. The processors exported a major portion (55%) of their products while a substantial amount (45%) was channeled to the wholesaler market in Bangkok. From this market the products reached consumers through retailers.

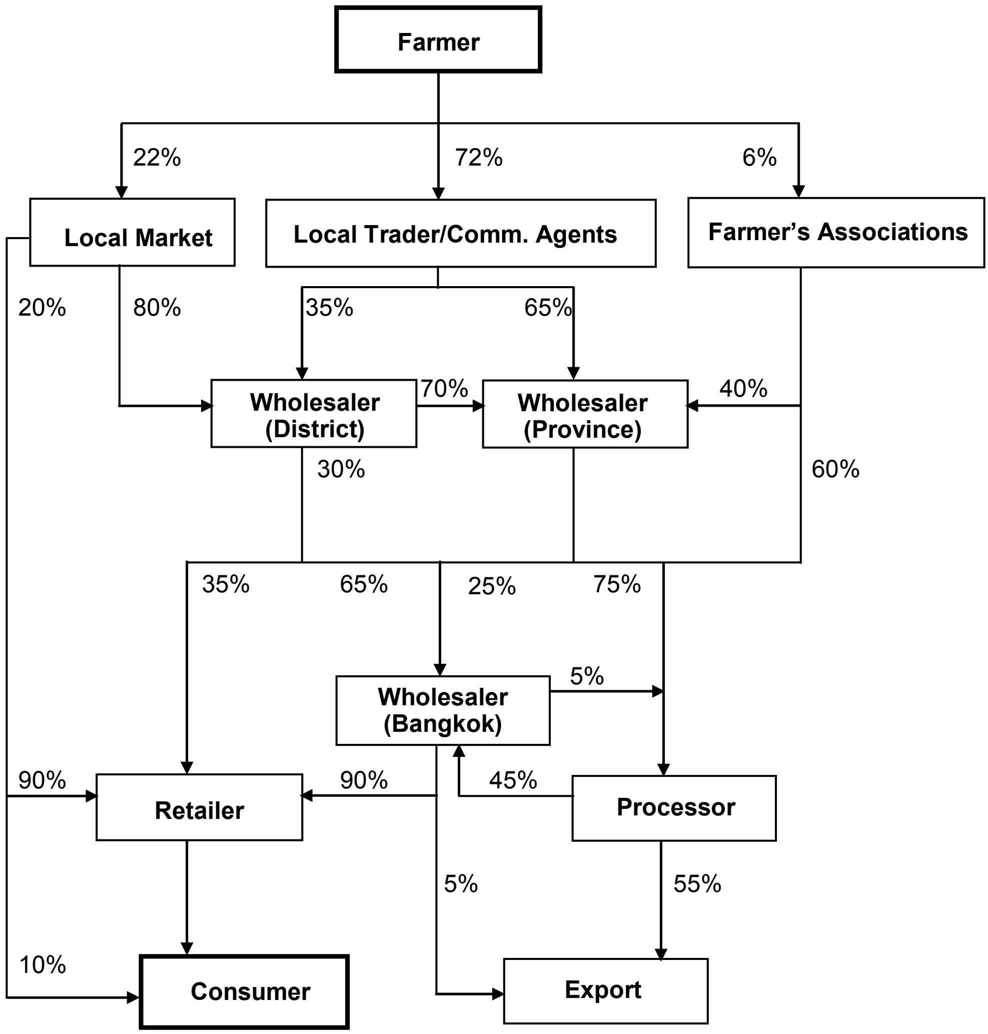


Figure 5. Chili marketing channels in the sample areas in Thailand, 2002

Input Use

Seed Rate

Overall, 91% of hot-chili farmers produced seed in their own farms (Table 30). All hybrid and sweet chili seeds were purchased, while all local-type chili seeds were home-produced. Farmers used higher rate of their own-produced seeds compared to the purchased seeds in refilling the dying or weak seedling. It was highest for the open pollinated chili produced at own farm and lowest for the purchased open pollinated chilies.

Table 30. Seed rate and seed source in the sample areas, by chili type, Thailand, 2002

Chili farmer	Seed rate (kg/ha)			Seed source (% of farmers)	
	Own	Purchase	Total	Own	Purchase
Hybrid	-	0.52	0.52	0	100
Open pollinated	2.74	1.60	2.68	95	5
Local	2.32	-	2.32	100	0
Overall	2.70	1.00	2.55	91	9
Sweet	-	0.36	0.36	0	100

Fertilizer Use

The use of organic fertilizer in chili fields was not common in Thailand. Overall, 2.46 t/ha of organic fertilizer was used (Table 31). The highest quantity was used in open pollinated, and no manure was used in sweet pepper. Cattle manure was mainly used; poultry manure was used only in open pollinated, and a significant quantity of mixed manure was also used in all chili types.

Inorganic fertilizers consisting of nitrogen, phosphate, and potash, were applied at the rate of 61, 28 and 30 kg/ha, respectively, on hot-chili fields. Overall, the quantity of fertilizer applied to chili was less than in other countries, and lower than the recommended level. Sweet chili received the highest amount, followed by hybrid and open pollinated chili types. The local chili, expected to be less responsive to fertilizer, received the lowest quantity of inorganic fertilizer.

Table 31. Extent and quantity of organic and inorganic fertilizer use in the sample areas, by chili type, Thailand, 2002

Chili farmer	Manure (t/ha)				Inorganic fertilizer nutrient (kg/ha)			
	Cattle	Poultry	Mixed	Total	N	P	K	Total
Hybrid	1.03	0.02	0.11	1.16	70	42	45	157
Open pollinated	1.06	1.35	0.24	2.65	60	29	30	119
Local	1.17	-	0.07	1.24	65	15	18	98
Overall	1.06	1.17	0.23	2.46	61	28	30	119
Sweet*	-	-	-	-	140	80	130	350

*Sweet chili was given liquid fertilizer because of its hydroponics system of cultivation. The amount applied was adjusted to dry form.

Insecticide

Overall, 2 kg or liter per ha of insecticide was applied to hot-chili fields and five sprays were done during the whole chili season (Table 32). The amount of insecticide applied was highest on sweet pepper and lowest on the local chili type. However, number of sprays was highest for hybrid, and lowest for open pollinated chili. The most common insecticides used by the farmers were methamidophos, parathion methyl and Sulfur (Appendix 2).

Table 32. Quantity and number of sprays of insecticide used in the sample areas, by chili type, Thailand, 2002

Chili type	Insecticide			Total number of spray
	L/ha	Kg/ha	Overall (kg or l/ha)[a]	
Hybrid	1.8	1.6	3.4	16.6
Open pollinated	1.2	0.9	2.1	4.2
Local	0.4	1.1	1.4	5.2
Overall	1.2	1.0	2.0	4.8
Sweet	0.7	14.6	15.3	8.3

[a] liquid and solid insecticide were combined by assuming one liter is equal to one kg.

Fungicide

Overall, 1.63 kg/l per ha of fungicide was used to control diseases in hot-chili by making about five sprays (Table 33). The application of fungicide by chili type was similar with insecticides; the highest quantity was applied on sweet pepper and lowest on open pollinated chili type. However, hybrid chili fields received the highest number of fungicide sprays. The major fungicides applied were carbendazim, mancozeb and metalaxyl (Appendix 3).

Table 33. Quantity and number of sprays of fungicide in the sample areas, by chili type, Thailand, 2002

Chili type	Chemical			Total number of spray
	L/ha	Kg/ha	Overall (kg or l/ha)[a]	
Hybrid	1.16	2.10	3.26	23.2
Open pollinated	0.65	0.90	1.55	3.7
Local	1.00	0.60	1.60	4.0
Overall	0.93	0.70	1.63	4.6
Sweet	3.50	1.10	4.60	5.2

[a] liquid and solid fungicide were combined by assuming one liter is equal to one kg.

Herbicide

On average, 10.3 kg or liter per ha of herbicide was used in chili fields (Table 34). The quantities of herbicide as well as the numbers of sprays were highest for hybrid chili. No cocktail was reported. Paraquat, glyphosate, and alachor were the most common herbicides used to eradicate weeds.

Table 34. Quantity and number of sprays of herbicide in the sample areas, by chili type, Thailand, 2002

Chili type	Chemical			Total number of spray
	L/ha	Kg/ha	Overall (kg or l/ha)[a]	
Hybrid	21.55	-	21.55	3.3
Open pollinated	9.82	0.10	9.92	2.2
Local	8.52	-	8.52	1.8
Overall	10.20	0.08	10.28	2.2
Sweet	-	-	-	-

[a] liquid and solid herbicide were combined by assuming one liter is equal to one kg.

Irrigation

When water was available, farmers irrigated their fields regularly. An irrigated chili farm typically received 41 irrigations. Sweet pepper was irrigated daily in the hydroponics system. Among hot chili, hybrids received the highest number of irrigations of 50, followed by open pollinated at 42 irrigations. The lowest number of irrigations of 23 was given to local chili.

Labor

On average, 265 labor days/ha were used for hot chili cultivation, management, picking, post-harvest handling and marketing (Table 35). The highest labor use was 394 days in sweet pepper and the lowest of 235 days was used in local chili type.

Table 35. Distribution of labor among different activity groups in the sample areas, by chili type, Thailand, 2002

Chili type	Percentage distribution				Total labor (day/ha)
	Land preparation	Management	Harvesting	Post-harvesting	
Hybrid	11.2	53.5	25.6	9.7	315
Open pollinated	12.2	55.4	24.5	7.9	266
Local	14.6	52.9	26.4	6.1	235
Overall	12.4	55.1	24.7	7.8	265
Sweet	4.9	64.6	24.7	5.8	394

Overall in hot chili, crop management activities utilized more than one-half of the total labor, harvesting consumed another one-fourth; while land preparation and post-harvesting claimed 12% and 8%, respectively. The share of crop management labor varied a little across chili types; it was highest for sweet pepper, and lowest for local chili types. The land preparation in sweet pepper claimed significantly lower share compared to hot chili types. The harvesting share did not vary so much across variety. The labor share for post-harvesting operation was highest for hybrid chili, and lowest for sweet pepper.

Credit

More than two-thirds of chili farmers obtained loans in Thailand with little variation across varieties (Table 36). The average size of the loans of hot chili-farmers was THB 34,660 for an average period of 18 months, while it was many times more for longer duration in case of sweet pepper growers. Banks were the main source for these loans.

Table 36. Loan source, duration, interest rate, and purposes by farmer type, Thailand, 2002

Type of grower	Loan (% farmer)	Average loan (THB)[1]	Source (% of farmers)				Duration (years)	Interest rate (%)	Purpose (% of farmers)		
			Bank	Coopera-tive	Mer-chants	Others			Inputs	Machin-ery	Other
Hybrid	80	46,800	66	23	11	-	3.4	9.4	100	-	-
Open pollinated	66	33,887	61	29	6	4	1.4	7.4	77	10	13
Local	75	36,430	80	20	-	-	2.2	8.9	87	6	7
Overall	67	34,660	63	28	6	3	1.5	7.6	79	9	12
Sweet	75	196,875	77	8	7	8	4.5	9.0	23	23	54

[1] One US$ = 40.43 THB.

The average interest rate was 7.6% per annum with little variation across chili types. About three-fourths of hot chili farmers obtained loans to purchase inputs, while more than half of the sweet pepper farmers used it to build fixed infrastructure (classified in "others"). Only 9% of hot chili but 23% of sweet pepper farmers borrowed money for machinery.

Production

Chili Yield

On average, yield of hot chili (hybrids, open pollinated and local varieties) in fresh weight was 5.8 t/ha. This yield is similar to the one reported in the DOAE statistics for the whole of Thailand (see Table 3). However, this is about half the potential yield reported in the experiment stations (DOAE 2005).

The yield under irrigated condition was many times higher compared to that under rainfed, regardless of chili type. Generally, the coefficient of variation for irrigated yield was also lower (Table 37). Despite these advantages, many chili farmers did not have access to irrigation.

The highest yield of 32.3 t/ha was obtained from sweet pepper under irrigation while the yield was lowest at 2.81 t/ha for open pollinated under rainfed condition. Among hot chili, hybrids produced the highest yield under irrigated condition, and the difference between irrigated and rainfed yields was also highest in hybrids.

Table 37. Chili yield in fresh weight (t/ha) in the sample areas, by mode of irrigation and chili type, Thailand, 2002

Chili type	Irrigated	Non-irrigated	Overall
Hybrid	20.81 (0.51)[a]	3.38 (0.00)[b]	19.07 (0.59)[b]
Open pollinated	9.85 (0.59)[a]	2.81 (0.76)[b]	5.27 (0.96)[c]
Local	10.47 (0.33)[a]	3.25 (0.60)[b]	4.62 (0.79)[c]
Overall	10.37 (0.64)[a]	2.87 (0.74)[b]	5.80 (1.19)*
Sweet	32.26 (0.22)	-	32.26 (0.22)[a]

Note: The figures in parenthesis are coefficients of variation in yield.
The different superscripts in a row of first two columns imply that the figures are statistically different across the two groups at least at 10% level. In the last column the different superscripts indicate the statistical difference across different chili types.
The * indicates that overall hot-chili yield is statistically different than sweet chili.

Product Quality and Prices

This survey estimated the percentage of chili output produced according to different grades. The specification of each grade in Thailand is given in Table 38.

Table 38. Specification of chili grades at the farm level in Thailand

Grade	Quality	Characteristics
1	High	Fresh, very hot with high fragrance, higher number of seed, straight, shine and smooth surface, red or green color, and small size in case of local species while long for improved varieties.
2	Medium	Fresh, hot, and medium fragrance, higher number of seed, medium size (small size in case of local species), clean surface, and red or green color.
3	Normal	Fresh, not so hot, with little fragrance, good number of seed, normal size, rough or wave surface, and light color.
4	Mix	Poor quality chilies with mixture of different varieties.

The survey results suggested that majority of the chili brought to the markets in Thailand was of mixed grade followed by grades 1 and 2 (Table 39). This was generally true across chili types, except for hybrid where nearly half of the product was of grade 2 followed by the mixed grade. Open pollinated and local chili types had the highest mixed grade of 66% and 56%, respectively.

The average price of hot chili received by the sample farmers was THB 11/kg. Sweet pepper of grade1 fetched the highest price of THB 65/kg and open pollinated of grade

3 the lowest at THB 9/kg. Interestingly, local chili attracted higher prices compared to open pollinated types due to its hotness, pungency, and other attributes preferred by consumers.

Table 39. Chili grades and prices in the sample areas, by chili type, Thailand, 2002

Chili farmer	Percentage				Price (THB/kg)				
	Grade1	Grade2	Grade3	Mix grade	Grade1	Grade2	Grade3	Mix grade	Overall
Hybrid	12	47	12	29	22	14	10	12	13
Open pollinated	22	11	11	66	14	12	9	11	11
Local	5	17	22	56	20	13	10	13	12
Overall	20	13	12	53	15	12	9	11	11
Sweet	26	25	12	37	65	55	40	50	50

Economics of Chili Cultivation

Cost and Factor Share

The overall total cost of production for hot chili was estimated at THB 47.21 thousands/ha and per unit output cost was THB 8.1/kg. The labor share in total cost was highest followed by irrigation, "others", and pesticide (Table 40).

The highest cost of production was for sweet pepper and lowest for local chili. About two-thirds of the total cost in local and open pollinated types and two-fifth in hybrids was for labor. The labor cost consumed only eight percent of the total cost in sweet pepper. The fixed cost had the highest share in sweet chili because of its peculiar production system which required large amount of initial investment on fixed infrastructure development. It is worth mentioning that the share of seed ranged only from one to three percent and fertilizer share from three to four percent across different varieties. The share of pesticide in total cost was highest at 11% in hybrid chili. The factor share for irrigation was lowest at three percent in local chili and ranged 9-13% in other chili types.

Table 40. Total and per unit cost of chili production and factor share in the sample areas, by chili type, Thailand, 2002

Chili type	Cost of production		Factor share (%)						
	Total (THB 000/ha)	Per unit output (THB/kg)[1]	Labor	Seed	Fertilizer	Irrigation	Pesticide	Others	Fixed
Hybrid	104.88[b]	5.5	42	3	4	11	11	18	11
Open pollinated	45.31[c]	8.6	64	3	3	9	7	9	5
Local	38.08[d]	8.2	66	1	4	3	7	10	9
Overall	47.21[*]	8.1	63	3	3	9	7	9	6
Sweet	594.20[a]	18.4	8	1	4	13	7	14	53

[1]Output cost is based on fresh form of chili.

Note: The different superscript in a column suggests statistical difference across chili types at 10% level of significance. The * in overall row implies that the value is statistically different with the sweet pepper in the respective column.

Economics of Chili Cultivation

Among different chili types, sweet pepper cultivation generated the highest gross and net revenues while local chili the lowest (Table 41). This is understandable because sweet pepper fetched not only the highest price but also produced the highest yield. Hence, sweet pepper showed the highest benefit-cost ratio followed by hybrid, open pollinated and local types.

Hybrid chili and sweet pepper production were capital intensive but provided highest benefit-cost ratios and resource productivities compared to other chili types. The pesticide productivity was highest across all chili types indicating the significance of pest control in chili production. The overall economic performance of open pollinated varieties, as measured by economic indicators such as benefit-cost ratio and resource productivity, was not very impressive when compared to local chili. Therefore, improvement is needed in these cultivars. Besides lower yield, open pollinated also fetched lower prices compared to the local land races.

Table 41. Economics of cultivation in the sample areas, by chili type, Thailand, 2002

Chili type	Gross revenue (THB/ha)	Net return (THB/ha)	B-C ratio (%)	Inputs productivity			
				Labor (THB/day)	Fertilizer (THB/kg)	Irrigation (THB/no.)	Pesticide (THB/lit)
Hybrid	247,910[b]	123,030[b]	117	674	1,532	4,727	10,188
Open pollinated	63,240[c]	18,930[c]	42	129	520	1,408	15,017
Local	55,440[c]	15,360[c]	40	129	550	2,361	13,192
Overall	70,344*	23,886*	51	146	694	1,431	2,862
Sweet	1,613,000[a]	918,800[a]	155	3,974	4,540	7,678	302,194

Note: The different superscripts in a column suggest statistical difference across chili types at 10% level of significance. The * in overall row implies that the value is statistically different with sweet pepper in the respective column.

Constraints in Chili Production

Major Constraints

Disease and insect infestation were ranked as first and second constraints, except in hybrid chili where marketing was ranked as number one constraint (Table 42). Insects were also reported as the major constraints in open pollinated and sweet pepper, while drought and low output price were ranked as second constraint in local and hybrid chili types, respectively. Hybrid seeds were considered to be of good quality with good disease and insect pest resistance but still diseases and insects were ranked as third and fourth level constraints.

Table 42. Ranking of major constraints faced by farmer in the sample area, by chili type, Thailand, 2002.

Chili farmer	Diseases	Insects	Low yield variety	Drought	Others
Hybrid	3	4	-	-	1[a], 2[b]
Open pollinated	1	2	5	4	3[c]
Local	1	3	4	2	5[d]
Sweet	1	2	4	-	3[b]
Overall	1	2	5	4	3

[a] Marketing, [b] Low price, [c] Weeds, [d] Poor plant stand.
Note: The rank of 1 is the most devastating, and 5 the least devastating constraint.

Chili Processing

In Thailand, chili-processing units are generally small. Some very large multinational chili-processing factories are located in Bangkok mainly to produce export quality products. The processors preferred chilies that were hot and with less number of seeds (to give chili an attractive color in cooking) and red shining surface. The chili entrepreneurs showed their concerns about poor grading and quality of chili supplied by the farmers, price fluctuation, inadequate supply, and lack of capital among others.

Consumption Pattern

Per Capita Consumption

On average, per capita weekly consumption of all chili types and its products converted into fresh weight was 218 g (Table 43). About 30% of this was consumed as fresh, 43% in dry and powder forms, and the remaining 27% in processed forms. These estimates for dry and powder chili were higher than the estimates of DoH (1995) at 14.7 g/week of dry weight of dry and powder chili. The concentration of our survey in the major chili producing areas may have produced these results.

The major form of consumption was chili powder for all consumer types, followed by green fresh except for urban consumer. Fresh chili was consumed raw, cooked, or in crush form (sauce). Thai people love hot foods; they also put semi crushed dry chili in their food for hotness. Chili in fresh and semi crushed forms as well as in various processed products, i.e. chili paste, sauce, dipping sauce, among others, can be found in all hotels, restaurants or food stalls.

The total consumption of chili was significantly higher among the chili farm families than with other groups, mainly because of higher consumption of green fresh chili and chili powder by this group. The urban dwellers consumed substantially higher level of chili sauce and dipping sauce than other groups.

Table 43. Average weekly per capita consumption of chili and its products (g of fresh weight) in the sample areas, by consumer type, Thailand, 2002

Type of chili/products	Chili farmer	Non-chili farmer	Urban consumer	Overall*
Green fresh	50[a]	38[b]	24[c]	31
Red fresh	34[a]	32[a]	32[a]	32
Sweet fresh	0[a]	0[a]	1[a]	1
Dry chili	8[a]	8[a]	8[a]	8
Chili powder (crushed)	136[a]	104[b]	68[c]	86
Chili paste	4[a]	0[a]	4[a]	2
Chili sauce	22[b]	23[b]	40[a]	32
Chili dipping sauce	3[b]	4[b]	28[a]	16
Chili curry	17[a]	14[a]	7[b]	10
Total	274[a]	223[b]	212[b]	218

* The overall consumption for the whole country was estimated assuming 1%, 48%, and 51% weight of population for chili producer, non-chili producer, and urban consumer, respectively.
Note: The different superscript on the figures in a row implies that they are significantly different at least at 10% level of significance.

On average, THB 4.9 per person/week was spent on chili (Table 44). The total expenditure on chili consumption by urban consumers and chili farm families was almost the same, despite the lower amount of chili consumption in the former. This was because urban consumers spent more on high value chili products grouped in "other" products such as chili dipping and chili sauce. Chili farm families spent more on chili powder and green fresh chili.

Table 44. Relative share of expenditure (%) on different chili types in the sample areas, by consumer type, Thailand, 2002

Type of chili	Chili farmer	Non-chili farmer	Urban consumer	Overall[1]
Green fresh	18	17	11.3	14.1
Red fresh	12	14	15.0	14.5
Sweet fresh	0	0	0.5	0.3
Dry chili	3	4	4.0	4.0
Chili powder	50	47	32.0	39.4
Other chili products	17	18	37.2	27.7
Overall weekly expenditure (THB)[2]	5.59[a]	4.68[b]	5.18[a]	4.9

[1]The shares and consumption for overall Thailand was estimated assuming 1%, 48%, and 51% weights of population for chili producer, non-chili producer, and urban consumer, respectively.
[2]The different superscript on the figures in this row implies that they are significantly different at the 10% level of significance.

Retail Value of Chili and its Products

The expenditure divided by per capita consumption multiplied by one thousand generated the average price of THB 22.48/kg of fresh weight chili and its products at the retail level. This is about 104% higher than the average farmgate price (THB 11/kg) reported in Table 39. Applying this ratio, the annual farmgate value of THB 5.46 billion (US$135 million) in 2003 (Table 3) was converted into the annual retail value of chili and its products at THB 11.16 billion (US$276 million).

Demand Elasticity

According to consumer perception, decrease in the prices of chili will have little impact on its consumption. Even if chili prices were reduced to half, its consumption will increase very little in percentage terms (Table 45). The highest increase in consumption will be in powder form at 2.52%. Similarly, increase in chili prices will not have any significant impact on its consumption. A 100% increase in prices will have strongest impact on powder chili by decreasing its consumption of about 4.2%.

Table 45. Effect of change in chili consumption due to change on its price by chili type and product, Thailand, 2002

Change in price (%)	Green	Red	Powder	Product
Increase	Change in consumption (%)			
110	- 0.16	- 0.67	- 0.81	- 0.32
125	- 0.47	- 0.83	- 1.08	- 0.40
150	- 1.02	- 0.43	- 2.17	- 0.86
175	- 1.74	- 1.95	- 3.14	- 1.69
200	- 2.06	- 2.56	- 4.21	- 2.58
Decrease				
90	0	0	1.82	0
80	0	0	1.82	0
70	0	0	1.85	0
60	0.31	0	1.85	0
50	0.31	0.32	2.52	0.32

Chili Purchasing Place

The majority of chili farmers consumed green, red, and sweet, dry and powder which were produced on their own farms, and a significant portion of chili sauce, chili curry and other chili products were also prepared at home suggesting significant processing activities at the farm households (Table 46). However, majority of chili sauce, and about one-fourth of green and red chilies were purchased from local market; a smaller percentage of dry and powder chilies were obtained from local and wholesale markets when farm harvest was not available.

Non-chili farmers bought majority of different chili forms (green, red, sweet, and dry) from local market. Although majority of chili products also came from the local markets, a significant proportion of chili powder, curry powder, and other chili products were also prepared at home, suggesting significant chili processing activities taking place in the non-chili farm families. A very small proportion of green, red, and dry chilies also came from the home garden. The wholesale and main markets were only a minor source for chili products for non-chili farmers.

For urban consumers, wholesale market was the major source for green, red and sweet chilies, and chili curry powder. However, main market was the main source for dry chili, chili sauce and other chili products. Local market was also a significant source for fresh chili and other chili products.

Table 46. Chili purchasing place in the sample area, by chili and consumer type (% of farmers), Thailand, 2002

Chili type	Chili farmer				Non-chili farmer				Urban Consumer			
	Local market	Main market	Whole-sale	Farm/ home	Local market	Main market	Whole-sale	Farm/ home	Local market	Main market	Whole-sale	Others**
Fresh												
Green	29	2	7	60	82	4	9	5	23	11	58	8
Red	26	1	3	70	77	8	8	7	23	18	56	3
Sweet	26	0	13	61	100	0	0	0	22	22	44	12
Dry chili	16	1	4	79	94	0	0	6	5	40	35	20
Chili powder	15	3	2	78	50	0	10	40	9	39	39	13
Chili sauce	61	5	7	27	67	17	5	11	11	75	13	1
Curry powder	34	3	4	59	50	13	12	25	10	20	55	15
Others	65	4	0	31	67	11	0	22	21	45	31	3

** Includes other market places, such as street vendor, street market, etc.

Consumers' Preferences for Chili Attributes

Thais love hot food that is why consumers ranked pungency as the number one desirable characteristic for the purchase of green, red, and chili products while it was ranked third for powder chili (Table 47). Freshness was ranked first for sweet and second for green and red chilies. Color was the first-ranked characteristic for chili powder and third for both green and red chili among the urban consumers. Fragrance was the second most attractive characteristic for chili product, third for sweet pepper, and fourth for green and powder type of chilies. Consumers did not like any insect or disease in chili products. This was ranked second and third criterion, respectively for chili powder and chili products, fourth in red chili and sweet pepper, and fifth for green chili.

Table 47. Ranking of the factors considered important in the selection of chili by urban consumers in the study areas, Thailand, 2002

Characteristics	Green	Red	Sweet	Powder	Product
Pungency	1	1		3	1
Freshness	2	2	1		5
Chili color	3	3		1	
Disease/insect free	5	4	4	2	3
Overall appearance				5	
Pod shape		5	2		4
Fragrance	4		3	4	2

Note: Highest rank = 1 and lowest rank = 5.

Consumers' Preference for Packaging

Overall a large number of consumers preferred unpacked or paper-packed green/red chilies mainly because they can see the product and it remains fresh (Table 48). In case of sweet pepper, a large number of consumers preferred it unpacked because it kept the output fresh, gave the best image of the product, and the product could be seen. The second preference was paper packaging because it was considered ideal for active and modern people. Paper packaging was preferred for powder form because it was cheaper than other packaging and it was ideal for carrying. In case of chili products the packaging in plastic was most preferred by the consumers.

Table 48. Consumer preferences for different types of packaging by chili type, Thailand, 2002

Chili type	Packing	Preference (%)	Reason (%)					
			Fresh	Best image	Cheap	Ideal*	Visibility	Other
Green/red								
	Unpacked	49	35	6	-	-	52	7
	Paper	38	58	5	6	6	3	22
	Glass	4	13	22	4	9	13	39
	Plastic	9	24	27	-	-	-	49
Sweet								
	Unpacked	46	38	28	9	-	25	-
	Paper	32	-	-	25	50	-	25
	Glass	3	-	35	-	-	35	30
	Plastic	19	-	29	14	-	26	31

Cont…Table 48

Chili type	Packing	Preference (%)	Reason (%)					
			Fresh	Best image	Cheap	Ideal*	Seen	Other
Powder								
	Unpacked	35	10	6	20	-	52	12
	Paper	46	-	-	38	53	-	9
	Glass	8	-	41	1	23	34	1
	Plastic	11	-	-	36	45	12	7
Product								
	Unpacked	17	4	4	-	-	46	46
	Paper	4	-	-	67	-	-	33
	Glass	26	-	9	-	33	-	58+
	Plastic	34	3	19	-	-	-	78
	Tin	19	-	-	15	85	-	-

* Ideal for active and modern people, + Good presentation.

Development Impact of Chili Cultivation

Input Demand

Substantially higher amounts of inputs were used on chili compared to its competing crops. Chili production is labor-intensive as it involves many times more labor than rice (Table 49). On average, 167 additional labor days will be required if one ha of rice is converted to hot-chili production, and nearly 300 additional days in case of conversion to sweet pepper. In general, labor force is engaged throughout the production period in vegetables including chili production.

Table 49. Relative per ha input use of chili and its competing crops, Thailand, 2002

Farmer type	Labor (days)	Seed (THB)	Fertilizer (nutrient kg)	Manure (t)	Irrigation (number)	Pesticide (number)
Hot-chili	265^b	$1,416^b$	119^b	2.46^a	41^b	12^a
Sweet pepper	394^a	$5,942^a$	350^a	-	300^a	14^a
Rice	98^c	246^c	86^c	0.96^b	18^c	3^a
Chili farmers	114^*	265^*	95	1.44	22^*	4^*
Non-chili farmers	91	215	82	1.54	15	3

Note: Different superscripts in a column of the rows of hot chili, sweet pepper and rice suggest that the value of the parameter is significantly different at 10% level; The * in the row of chili farmer suggests that the parameter value is significantly different from the non-chili farmer at the 10% level.

The cost of seed was higher in chili than in rice, even though the majority of farmers used relatively low-cost open pollinated chili seed. The application of fertilizer, manure, and number of sprays on chili was also higher compared to its competing crops. The hot chili fields had more than twice as many irrigations as rice, while in sweet chili irrigation operation was done almost daily (Table 49).[2] All these implied that chili cultivation requires much more input, and therefore generates demand for agricultural business activities in rural areas. On the other hand, its successful cultivation requires more cash liquidity than in other crops, which many small farmers could not afford.

Chili farmers not only applied more inputs to chili but they also gave more inputs to rice crop compared to their counterpart non-chili farmers.

Resource Use Efficiency

Although input use on chili crops was higher than other field crops, the differences in both gross and net returns between the two crops were even bigger (Table 50). This resulted to an improved efficiency of resources when shifted from other crops to chili. For example, resource productivities for labor and fertilizer were higher in chili production. However, benefit-cost ratio of hot chili was lower, but sweet pepper was double than rice.

Table 50. Resource use efficiency in chili and competing crops in the sample area, by farmer type, Thailand, 2002

Crop/farmer type	Yield (t/ha)	Total cost (000 THB /ha)	Gross return (000 THB /ha)	Net return (000 THB /ha)	B-C ratio (%)	Labor productivity (THB/day)	Fertilizer productivity (THB/kg)
Hot-chili	5.80	47.21	70.34	23.90	51	146	694
Sweet pepper	32.30	594.20	1,613.00	918.80	155	3,974	4,540
Rice	4.31	12.39	21.74	9.35	76	122	243
Chili farmer	4.75	13.22	23.09	9.87	75	102	233
Non-chili farmer	3.97	10.74	18.46	7.72	72	103	215

Resources used in chili cultivation not only had higher efficiency than those in rice, its presence on the farm improved the efficiency of resources engaged in other crops. This was indicated by higher fertilizer use efficiency and benefit-cost ratio in rice cultivation on chili as compared to non-chili farms. These results were attributed to higher input use and yield obtained by the former group. As farmers learn more sophisticated management techniques in chili cultivation and marketing, they applied these for rice as well.

[2] Higher number of irrigation on chili crop does not necessarily imply that it requires more water. As rice fields are flooded while chili fields receive only surface irrigation, chili crop may require less amount of water than rice. Nevertheless, higher number of irrigation in chili implies more labor requirement for crop management.

Impact on Gender and Poverty

Chili production involved more than three-fourths of female labor compared to less than one-third in rice cultivation (Table 51). This can help in eradicating rural poverty as women are the most vulnerable and poorest section of rural poor. The share of female labor was higher for harvesting and post-harvesting operations than in land preparation.

Modern chili varieties utilize higher labor, including more female labor. Therefore, expansion in chili area will generate not only additional employment and income, but most of the benefits will go to the neglected segment of the society, such as women.

Table 51. Gender distribution of labor used in chili and rice in the sample areas, by crop and operation type, Thailand, 2002

Crop type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Hybrid	34.8	65.2	66.6	33.4	89.9	10.1	90.3	9.7	75.5	24.5
Open pollinated	43.5	56.5	65.3	34.7	87.3	13.7	86.8	13.2	75.8	24.2
Local	38.3	61.7	63.4	36.6	88.3	11.7	79.4	20.6	67.5	32.5
Overall	42.7	57.3	65.2	34.8	87.5	12.5	86.3	13.7	75.1	24.9
Sweet	32.8	67.2	56.6	43.4	91.6	8.4	86.5	13.5	76.4	23.6
Rice	31.3	68.7	36.1	63.9	25.5	74.5	35.6	64.4	30.4	69.6

[1] The distribution between male and female under each operation adds up to 100.

Impact on Hired Labor

Chili cultivation helps in expanding labor market as it demands more hired labor. Overall, 46% of the labor force engaged in chili cultivation was hired while 25% of the labor was hired in rice (Table 52). The use of modern varieties in chili cultivation enhanced the demand for hired labor. The proportion of hired labor was highest in post-harvest and crop management operations, and lowest in land preparation and harvesting.

Table 52. Distribution of labor source in chili and rice cultivation in the sample areas, by crop and operation type, Thailand, 2002

Crop type	Percentage distribution[1]									
	Land preparation		Management		Harvesting		Post-harvesting		Overall	
	Family	Hired	Family	Hired	Family	Hired	Family	Hired	Family	Hired
Hybrid	55	45	45	55	50	50	50	50	48	52
Open pollinated	75	25	45	55	70	30	35	65	54	46
Local	60	40	50	50	70	30	70	30	58	42
Overall	73	27	45	55	69	31	39	61	54	46
Rice	70	30	35	65	85	15	75	25	75	25

[1]The distribution between family and hired labor under each operation adds up to 100.

Impact on Consumption

Higher income from chili production and off-farm sources enabled chili producers to spend more, especially on food. Overall expenditure as well as expenditure on food of chili-producing families were significantly higher than non-chili farm families (Table 53). The income and food expenditure of chili farmers, however, were still lower than urban consumers. Introducing high yielding chili varieties and low cost technologies in its cultivation can reduce this difference. Moreover, encouraging the production of vegetables, including chili on non-chili farms, can reduce the difference in expenditures between chili and non-chili farmers.

Table 53. Monthly household income and expenditure in the sample areas, by farmer and consumer type, Thailand, 2002

Consumer type	Expenditures (THB)		Average monthly income (THB)
	Food	Overall	
Chili farmers	1,940[b]	4,477[b]	9,156[b]
Non-chili farmers	1,793[c]	3,710[c]	7,127[c]
Urban consumers	3,978[a]	10,525[a]	18,242[a]
Overall	2,670	6,451	11,614

Note: The different superscripts in a column imply that the figures are statistically different across the group at 10% level of significance.

The difference between chili and non-chili farm families in terms of overall quantity of food consumed was not significant (Table 54). However, chili farm families consumed better quality food as reflected in higher consumption of vegetables and seafood and less cereals. Higher proportion of area under vegetable crops that can generate more income contributed to these. This would improve the supply of micronutrients among chili farm families.

Table 54. Average daily consumption of different food types in the sample areas, by consumer groups, Thailand, 2002

Food group	Quantity (g/capita)			
	Chili farmer	Non-chili farmer	Urban consumer	Overall*
Cereals	422[c]	532[a]	490[b]	509
Livestock products	126[a]	118[a]	104[b]	111
Seafood	70[b]	58[c]	107[a]	83
Vegetables	229[a]	188[b]	210[a]	200
Fruits	146[a]	126[b]	159[a]	143
Others	156[b]	167[a]	178[a]	173
Overall	1,147[b]	1,189[b]	1,239[a]	1,214

*The overall consumption was estimated assuming 1, 48, and 51 percent weight for chili producer, non-chili producer, and urban consumer, respectively.

Note: The different superscripts in a row imply that figures are statistically different across the consumer group at 10% level.

Summary and Recommendation

Chili is one of the major and essential constituents of the Thai diet. Thais love spicy and hot food. Most of the consumption is in dry, powder or processed form, while 30% is consumed as fresh. The trend for spice food is rising fast in Thailand. A large segment of rural and urban population is engaged in its production, marketing, and processing. Based on average chili area on each farm, it was estimated that about 277 thousand farm families are directly engaged in its production. There is a large scope for boosting chili production and income of these groups. According to estimates of this study, farm value of chili production was US$135 million, and the retail value of chili and its products at US$276 million in 2003.

The demand for chili is on the rise. However, domestic production failed to respond to the increasing demand including demand for processing. This is reflected by the slow increase in its area and yield, while there was surge in its import. This study was designed to provide information on various aspects of chili production, consumption, and marketing in Thailand to overcome the supply constraints in the country, help small chili farmers to meet the consumers' demand, and improve the efficiency of the whole sector.

Farm size of the chili farmer was typical of the survey area. However, the level of education of these farmers was higher compared to non-chili farmers, and they had more sources of non-agricultural income. They possesed higher number of farm equipment including water pumps for timely irrigation. They enjoyed better life conditions as reflected by higher income and expenditure of these farmers compared to their counterpart non-chili farmers.

Chili production in Thailand was at a primitive level in the survey year. Mostly, open pollinated with low quality and locally produced seed was used in its production. A large majority of farmers (82%) used own-farm produced seed. A very small portion of farmers treated chili seed and soil for pest control. The nurseries were poorly managed using primitive methods. The majority of chili crop was cultivated under rainfed condition, and input level was low, therefore its per ha yield was lower compared to other chili-producing countries. However, the farmers growing sweet pepper under the hydroponics' system adopted advanced management practices and obtained high yields and returns. The cooperative marketing and advanced contract used in this system helped to overcome marketing risk, financial constraints, and economies of scale problem in the small farms. This system needs to be further studied to extend it to other types of chili farms.

Thais love hot food that is why hotness/pungency was ranked as the number one desirable characteristic for the purchase of green and red chili types and their products. Freshness of chili was also a very attractive characteristic for the purchase of chilies. It was ranked first for sweet pepper and second for red and green chili. On the other hand, farmers ranked highest those criteria of seed which can fetch high market prices, but had vague idea of consumer preferences. For example, pungency and freshness hardly surfaced as seed selection criteria among farmers. Therefore, there is a need to improve market awareness among farmers.

Insects and diseases were ranked as number one constraint among farmers. Despite the high use of chemicals, the annual losses due to insects and diseases averaged at 24% and 31% respectively. Insect and disease occurrences were regular phenomena happening in three to four in every five years. The major cause of concern was increasing frequency and intensity of pest attack, and the consequent losses in yield and revenues. This was despite the adoption of improved chili varieties. Therefore, there is a need to improve the farm management practices aimed to control insects and diseases in chili fields.

Anthracnose was ranked as the most difficult disease among the entire chili-growing fields, followed by fusarium wilt, viruses, and bacterial wilt. The major insects in chili fields as identified by farmers were caterpillars, thrips, and mites. There is a need to identify appropriate chemicals to control these insects and diseases and specify the doses for each. The varietal research should also be targeted to develop multiple insect- and disease-resistant varieties. However, insect and disease resistance was not a major criterion for farmers in seed selection. Therefore, until these resistant characteristics are complemented with other criteria important for farmers in seed selection, such as high yield and ability of the output to fetch high prices, outputs of resistance research cannot be sold to farmers.

The public sector varietal improvement research in chili in Thailand had limited impact. While most farmers had adopted open pollinated varieties released by the public sector research institutes, the yield and price differences of these varieties was insignificant compared to the local unimproved varieties. All these factors produced similar net return, unit-output cost, and resource use efficiency for improved open pollinated varieties. On the other hand, the adoption of hybrid varieties that produced significantly higher yield, lower cost per unit of output, and higher resource use efficiency, was very limited. High production cost especially of seed and limited access to reliable irrigation sources were the main factors in the limited adoption of hybrid varieties. Therefore, public sector research institutes should try to improve their efficiency by developing economically viable chili varieties. This could be achieved through collaboration with appropriate international organizations. Extension of chili cultivation in irrigated areas can also improve Thailand's competitiveness in chili production in the international market.

Chili production requires higher inputs than do other crops; therefore, there is a need to help these farmers by providing credit for the purchase of inputs through government loaning agencies or farmers' cooperative organizations. In some areas, farmer's associations played very positive role in chili production and marketing. There is a need to encourage these organizations in other areas.

Farmers sold chili output mainly to local traders, who in turn brought the output to the wholesale market. There was no formal source from where farmers can seek information on chili markets. These factors hindered the direct link of farmers with the main markets and consumers. This not only reduced farmers share in consumer price, but also reduced their ability to adjust output quality according to consumer preferences. Therefore, most of the chili produce was sold as ungraded. On the other hand, farmers had complaints against middlemen/commission agent's exploitation in the form of cartel for lower price, and little premium for quality and grading. The middlemen/commission agents obtained high margins for the services they rendered to farmers.

Chili cultivation provided an economically better option compared to cereal crops grown under similar conditions. This was reflected by higher net returns, resource use efficiency, engagement of more women and hired labor in chili cultivation compared to cereal crops. Moreover, it had a spillover impact on the productivity of other crops. Another development impact of chili cultivation was through improved dietary habits. Therefore, if chili area was expanded and the number of chili farmers were increased, it will have positive impact on the overall resource use efficiency in the agriculture sector and stimulate development in rural areas. However, chili expansion strategies should be carefully implemented as it has low demand elasticities. Incorporating the consumers' attributes in chili and its products will not only shift its demand but also improve income of various stakeholders involved in its food chain.

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Appendix 1. Major weeds found in chili fields, Thailand

No.	Type	Scientific Name	Common name
1	1	*Eleusine indica*	Goose grass, Crowfoot grass
2	1	*Dactyloctenium aegyptium*	
3	1	*Cyperus rotundus*	
4	2	*Amaranthus gracilis*	
5	2	*Potulaca oleracea*	Common purslane
6	2	*Gynandropsis gynandra*	
7	1	*Echinochloa sp.*	
8	2	*Eupatorium adenophorum*	
9	1	*Pennisetum polystachyon*	Mission grass
10	1	*Ischaemum rugosum*	
11	1	*Imperata cylindrica*	Cogon grass, lalang grass
12	2	*Ageratum conyzoides*	Goat weed
13	1	*Phragmites karka*	Flute reed
14	2	*Heliotropium indicum*	
15	1	*Cyperus cyperoides*	
16	2	*Aerva sanguinolenta*	
17	1	*Aristida cumingiana*	
18	2	*Erechtites hieracifolia*	
19	2	*Merremia hastata*	
20	1	*Leersia hexandra*	
21	2	*Canthium dicoccum var. umbellatum*	
22	2	*Spilanthes paniculata*	Para grass

Type of weed

Type 1 = Monocotyledonous weeds

Type 2 = Dicotyledonous weeds

Appendix 2. Frequency of different insecticides used on chili, Thailand

Common name of insecticide	Frequency (% of occurrence)
Methamidophos	14.6
Parathion methyl	14.1
Sulfur	6.6
Endosulfan	5.6
Carbaryl	5.2
Carbendazim	5.2
Cypermethrin	5.2
Abamectin	4.7
Methomyl	4.7
Monocrotophos	4.2
Chlorpyrifos	3.3
Fipronil	3.3
Neem	3.3
Triazophos	3.3
Bacillus Thuringiensis	2.8
Dicrotophos	2.8
Lambda cyhalothrin	2.8
Carbofuran	1.9
Formetanate	1.9
Permethrin	1.8
Carbosulfan	1.3
Dicloxan + Captan (fungicide)	0.9
Amitraz	0.5

Appendix 3. Frequency of different fungicides used on chili, Thailand

Common name of fungicides	Frequency (% of occurrence)
Carbendazim	37.3
Mancozeb	23.9
Metalaxyl	9.0
Methamidophos	6.7
Benomyl	5.2
Chitozan	3.8
Copper hydroxide	3.7
Prochloraz	3.7
Captan	2.2
Copper oxychloride	1.6
Endosulfan (insecticide)	1.5
Propamocarb	0.7
Propineb	0.7

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