A Manual on Vegetable Seed Production in Bangladesh

M. A. Rashid
D. P. Singh



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Seed Production of Hyacinth bean, Radish and Cauliflower
Photograph courtesy of Shafiqul Akter, SSO, BARI

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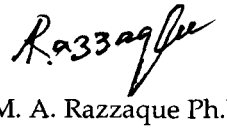
Contents

Foreword

Vegetables are protective food rich in vitamins and minerals which are essential for maintaining good health. Vegetable crops assume great importance in view of widespread malnutrition that exists in Bangladesh. Among food crops vegetables are the most easily affordable food. Increased production and consumption of vegetables could alleviate the malnutrition and improve nutritional standard of our people. But unfortunately the vegetable production in Bangladesh is far below the requirement leading to low consumption. Further, yields of vegetable crops are much below their potential yield. Short supply of quality seed of improved vegetable varieties has been identified as one of the major constraints for this low yield. The annual requirement of quality vegetable seeds in Bangladesh is estimated to be approximately 3000 tons, out of which only 375 tons of quality seed are produced in organized way. The organized production of vegetable seed has just been started in the country. Production and processing of quality seed require scientific knowledge and technical skill. Information on seed production technology and processing in Bangladesh context is scarce. I am happy to see that Dr. M. A. Rashid and Dr. D. P. Singh have prepared a **Manual on Vegetable Seed Production in Bangladesh.** I consider it to be an excellent contribution to vegetable research and development in this country.

I am confident that this manual will be of much help to research workers, seedsmen, teachers and students alike. I appreciate the authors for their hard work to produce such an informative manual and help of AVRDC-USAID Bangladesh Project to publish it.



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23 September, 2000

Preface

It is a recognized fact that the seed is the most vital input for vegetable crop production. Most vegetable crops have to be started from seed. The production of vegetable seed requires skill, knowledge and specialization. The production of vegetables in Bangladesh is constrained by the non-availability of quality seed. The vegetable seed industry in Bangladesh is still in the infantile stage. Lack of seed production technology is one of the major reasons for the proper development of seed industry in Bangladesh. It was, therefore, thought necessary to prepare a manual dealing entirely with vegetable seed production.

The manual is intended to provide a highly authentic technical information related to the production of vegetable seeds in Bangladesh covering the major crops grown in tropical, sub-tropical and temperate regions of the world. The manual is largely based on information gathered when the authors involved in vegetable variety development and seed production research in Bangladesh. The botany, varieties, methods of seed production, pests and diseases and post-harvest handling of the individual vegetable have been described. Basic principles of seed production including mode of reproduction and climatic factors for seed production are described through Chapter 1 to 3. Chapter 4, 5, 6 and 7 deal with the seed production of major vegetable crops while chapter 8 deals with hybrid seed production. Chapter 9 describes the post-harvest handling of vegetable seeds.

This manual is designed as a guide for seed technologists and seed producers in Bangladesh which in turn may help for the development of the emerging seed industry in Bangladesh. Not only as the guide for seed producers, the manual may also serve as a text book for the graduate students and a valuable source of reference to researchers.

The authors acknowledge the assistance rendered by vegetable scientists, seed technologists, publishers and others. The interest and untiring efforts put forth in printing this manual timly need special mention of Dr. M. Mustaque Ahmed, the Program Coordinator of the Project. The authors are deeply indebted to AVRDC-USAID-Bangladesh Project for providing financial support for printing this manual.

M. A. Rashid
D. P. Singh

23 September, 2000

CHAPTER I

MODES OF REPRODUCTION IN VEGETABLE CROPS

Successful seed production of a crop depends on a thorough knowledge of the reproductive process of a particular crop. The techniques of seed production must take into account several features of reproduction: whether it is sexual, asexual, or a combination of the two, the nature of floral structures, the amount of pollen transfer, the degree and means of self-incompatibility, and the effect of inbreeding on vigour. For most purposes the important consideration to the seed producers is the extent of cross-pollination. It is, therefore, necessary that before engaging himself in seed production, a producer must acquaint himself with the following details of reproduction in the particular crop.

Methods of Reproduction

The method of reproduction in vegetable crop plants may be broadly grouped in to two categories, asexual/vegetative and sexual.

A. Asexual/Vegetative Reproduction

Asexual reproduction does not involve fusion of male and female gametes. New plants are developed from vegetative parts of the plant or may arise from embryos that develop without fertilization. In nature, a new plant develops from a portion of the plant body. This may occur through modified underground and sub-aerial stems, bulbils, cuttings and grafting. As for example, taro, pointed gourd, potato etc. are reproduced through asexual means.

B. Sexual Reproduction

Sexual reproduction involves fusion of male and female gametes to form a zygote and the zygote develops into a new plant. The main difference between asexual and sexual reproduction is that in asexual reproduction one parent or sex is concerned, while in sexual reproduction both parental sexes are concerned. All self-and cross-pollinated vegetables are in this group.

Modes of Pollination

Pollination refers to the transfer of pollen grains from anther to stigma. Pollen from an anther may fall on stigma of the same flower leading to self-pollination or autogamy. When pollen from flowers of one plant are transmitted to stigma of another plant, it is known as cross-pollination or allogamy. A third situation, geitonogamy results when pollen from a flower of one plant falls on the stigmas of the other flowers of the same plant, e.g. in maize.

Self-Pollinated Vegetable Crops

Many cultivated vegetable species reproduce by self-pollination. These species, as a rule, have hermaphrodite flowers. But in most of these species, self-pollination is not exclusive and cross-pollination may occur from 5 to 50%. The degree of cross-pollination in self-pollinated species is affected by several factors, namely variety, environmental conditions like temperature, humidity, wind, location and abundance of pollinating insects. However, the essential conditions for self-pollination are :

- *Bisexuality :* In this both male and female reproductive organs are present in the same flower. Without this condition self-pollination is never possible.
- *Homogamy :* This is the condition in which the anthers and the stigmas of a bisexual flower mature at the same time resulting in self-pollination.
- *Cleistogamy :* In this condition the bisexual flowers never open and therefore, the self-pollination is only the way of pollination, e. g. lettuce.

Partial list of self-pollinated vegetables

Tomato *(Lycopersicon esculentum)*
Lettuce *(Lactuca sativa)*
Parsnip *(Pastinaca sativa)*
Peas *(Pisum sativum)*
Dwarf bean *(Phaseolus vulgaris)*

Cross-Pollinated Vegetable Crops

The majority of the cultivated vegetable species are cross-pollinated crops. Cross-pollination may occur both in bisexual and unisexual flowers but it is the rule in unisexual flowers. Nature favours cross-pollination and the agencies which help in bringing cross-pollination in flowers are:

1) Air (Anaemophily), e.g. Amaranthus, spinach, beet
2) Insects (Entomophily): All cucurbits, all brassica, onion, carrot.

There are many reasons for which cross-pollination takes place in the crops, some of which are listed below:

Decliny : Decliny or unisexuality is a condition in which the flowers either staminate (male) or pistillate (female) occur on the same plant or on different plants, e. g. cucumber, watermelon, pumpkin, squash, asparagus etc.

Dichogamy : The stamens and pistils of hermaphrodite flowers may mature at different times facilitating cross-pollination, e.g. sweet corn, suger beet etc.

Self-incompatibility : It refers to the failure of pollen from a flower to fertilize the same flower or other flowers on the same plant, e.g. cabbage, cauliflower, mustard, cole crops, root crops etc.

Male Sterility : Male sterility refers to the absence of functional pollen grains in otherwise hermaphrodite flowers. Male sterility is not very common in natural populations but is of great value in production of hybrid seed.

Partial list of cross-pollinated vegetable crops

1. Cabbage (*Brassica oleracea var. capitata)*
2. Cauliflower *(Brassica oleracea var. botrytis)*
3. Broccoli *(Brassica oleracea var. botrytis)*
4. Brussel's sprouts *(Brassica oleracea var. gemmifera)*
5. Knol khol *(Brassica oleracea var. caulorapa)*
6. Carrot *(Daucas carota)*
7. Radish *(Raphanus sativus)*
*8. Beet *(Beta vulgaris)*
*9. Spinach *(Spinacea oleracea)*
10. Cucumber *(Cucumis sativus)*
11. Muskmelon *(Cucumis melo)*
12. Watermelon *(Citrullus lanatus)*
13. Pumpkin *(Cucurbita moschata)*
14. Squash *(Cucurbita pepo)*
15. Other cucurbits *(bitter gourd, bottle gourd, ridge gourd, sponge gourd, snake gourd, pointed gourd, ash gourd etc)*
16. Amaranths *(Amaranthus tricolor, caudatus, spinosus)*
17. Onion *(Allium cepa)*

Often Cross-Pollinated Vegetables

In some vegetable crops, cross-pollination often exceeds 5% and may reach upto 50%. Such species are generally known as often cross-pollinated species, e.g. brinjal, okra, chilli, sweet pepper.

Cross Compatibility Among Cruciferous Vegetable Crops

Safe guarding the seed plants from foreign contamination through extraneous pollen transmitted by insects or transported by wind is essential for the production of pure seeds. Therefore, one should know the crossing patterns of different vegetables. The crossing pattern of the cruciferae vegetables is given in Table 1.

*** Wind pollinated crops**

Table 1. The pattern of crossability of cruciferae crops

Chrono-some Number	Crops	B. nigra	Cabbage	Cauli-flower	Brussel's Sprout	Kohlrabi	Radish	Turnip	Taisai	Chinese cabbage	Leaf Mustard	B. napus
		8	9	9	9	9	9	10	10	10	18	19
n=8	Black mustard (*B. nigra*)		x	x	x	x	x	x		●	●	
n=9	Cabbage	x		o	o	o	x	x	x	●		
	Cauliflower	x	o		o	o	x	x				
	Brussel's sprout	x	o	o		o	x	x				
	Kohlrabi	x	o	o	o		x	x			●	
	Radish	x	●			●		x	x	x	x	x
n=10	Turnip	x	●	x	x	x	x		o	o	Δ	●
	Taisai (*B. chinensis*)		●				●	o		o	Δ	●
	Chinese cabbage (*B. pekinensis*)	x	●			x	●	o	o		●	Δ
n=18	Leaf mustard (*B. juncea*)	●						Δ	Δ	Δ		Δ
n=19	Rape (*B. napus*)							Δ	Δ	Δ	Δ	

o = Hybridized easily
● = Hybridized with difficulty
Δ = Hybridization possible but very difficult
x = Cannot be hybridized

CHAPTER II

PRINCIPLES OF VEGETABLE SEED PRODUCTION

Production of genetically pure and quality pedigree seed requires high technical skill and specialization. Seed production must be carried out under standard and well-organized conditions. The producer should be familiar with genetic and agronomic principles of seed production.

Genetic Principles

During the course of seed production, it is necessary to ensure that the product is true-to-type. Genetic purity of a variety can deteriorate due to several factors during production cycle. The important factors of apparent and real deterioration of varieties are as follows as suggested by Kadam (1942) :

1. Developmental variations
2. Mechanical mixtures
3. Mutations
4. Natural crossing
5. Minor genetic variation
6. Selective influence of diseases
7. Technique of the plant breeder

Of these, mechanical mixture, natural crossing and selective influence of diseases are perhaps the most important reasons of genetic deterioration of varieties during seed production followed by raising the seed crops in areas outside their adoption which may cause developmental variations and genetic shifts in varieties.

Maintenance of Genetic Purity

For the maintenance of varietal purity various methods have been suggested by Horne (1953) and Hartman and Kester (1968). The important safeguards for maintaining genetic purity during seed production are :

Control of Seed Source : The use of seed of an appropriate class and from an approved source is necessary for raising the seed crop. Four classes of seeds, namely, breeder's, foundation, registered and certified seeds have been defined by the Association of Official Seed Certification Agencies (AOSCA) :

Breeder's Seed : Breeder's seed is the genetically pure seed produced by the concerned breeder or by the institution which is used for the production of foundation seed.

Foundation Seed : Foundation seed is also genetically pure seed produced from breeder's seed under strict supervision. Foundation seed is the source of registered and/or certified seed.

Registered Seed : Registered seed is the progeny of foundation seed that is so handled as to maintain satisfactory genetic identity and purity, and that has been approved and certified by a certifying agency. This class of seed should be of a quality suitable for production of certified seed.

Certified Seed : Certified seed is the progeny of foundation or registered seed. Certified seed is so handled as to maintain satisfactory genetic identity and purity and that has been approved and certified by the certifying agency.

Crop Rotation : Satisfactory intervals between related or similar crops is required to minimize the risk of plant material or dormant seeds remaining from the previous crops, which are likely to cross-pollinate or make admixture with the planned seed crop. In addition to these the reasons for crop rotation include plant nutrition, maintenance of soil physical condition and minimizing the risk of soil-borne pests and diseases. In practice, therefore, attention must be paid to the numbers of years since a related crop was grown in the same soil.

Isolation : One major factor during the course of seed production is to ensure that the possibility of cross-pollination between different cross-compatible plots or fields is minimized. In addition to the question cross-pollination, adequate isolation also assists in avoiding admixture during harvesting and the transmission of pests and pathogens from alternative host crops. Vegetable seed crops can be isolated by time and by distance.

Isolation by time : This type of isolation is possible within individual farms of multiplication stations. In this system seed production is arranged in such a manner that the cross-compatible varieties are grown in successive years or seasons provided the rules regarding rotation are applied.

Isolation by distance : When isolation by time is not possible, then isolation by distance is to be followed. Isolation distance primarily depends on the nature of pollination of the crop. In general, highly cross-pollinated (by insects) vegetable crops like onion, radish, cabbage, cauliflower and cucurbits require isolation distance of 800-1000 meter while wind pollinated vegetables like spinach, beet require isolation distance of about 2000 meters. Isolation distance also varies according to category of seeds like foundation and certified seeds. Table 2 gives the isolation requirements necessary for producing foundation and certified seeds.

Table 2. Minimum isolation distance requirements for vegetable seed crop

Crops	Minimum isolation distance (meter)		To be isolated by the distance in column 2 or 3 from fields of
(1)	Foundation seed (2)	Certified seed (3)	(4)
Potato	5	5	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Tomato	50	25	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Brinjal	200	100	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Capsicum/ Chilli	400	200	**Other varieties :** the same variety not conforming to varietal purity requirements for certification:
Dolichos bean, Cowpea, French bean, Cluster bean	50	25	**Other varieties;** the same variety not conforming to varietal purity requirements for certification.
Garden pea	20	10	**Other varieties:** the same variety not conforming to varietal purity requirements for certification.
Lettuce	50	25	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Kasuri methi	50	25	Other varieties : the same variety not conforming to varietal purity requirements for certification.
Cabbage, Knol-khol	1600	1000	**Other varieties;** the same variety not conforming to varietal purity requirements for certification. broccoli (including sprouting), Brussel's sprouts, cauliflower, collards and kale including karam sag, cabbage from knol-khol, knol-khol from cabbage
Cauliflower	1600	1000	**Other varieties :** the same variety not conforming to varietal purity requirements for certification. Broccoli (including sprouting), Brussel's sprouts, cabbage, knol-khol, collards and kale including karam sag.

Contd.

Table 2. Continued

Crops	Minimum isolation distance (meter)		To be isolated by the distance in column 2 or 3 from fields of
(1)	Foundation Seed (2)	Certified seed (3)	(4)
Chinese cabbage	1600	1000	**Other varieties :** the same variety not conforming to varietal purity requirements for certification. Rutabaga, rape, mustard and turnip.
Garden beet Spinach beet	1600	1000	**Other varieties :** the same variety not conforming to varietal purity requirements for certification. Swiss chard, sugar beet, garden beet from spinach beet, spinach beet from garden beet
Carrot	1000	800	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Radish, Turnip	1600	1000	**Other varieties :** the same variety not conforming to varietal purity requirements for certification. Chinese cabbage, rape, mustard, and rutabaga for turnip
Onion	1000	400	**Other varieties :** the same variety not conforming to varietal purity requirements for certification.
Okra (bhindi)	400	200	Other varieties : the same variety not conforming to varietal purity requirements for certification. wild *Abelmoschus* spp.
Amaranthus	400	200	**Other varieties :** the same variety not conforming to varietal purity requirements for certification. wild Amaranthus spp.
Cucurbits Bitter gourd Bottle gourd Cucumber Indian squash (tinda) long melon, muskmelon, pumpkin, ridge gourd, snake gourd, sponge gourd, summer squash, water melon, winter squash	800	400	**Other varieties :** the same variety not conforming to varietal purity requirements for certification, wild *Cucurbita* spp. muskmelon from long melon, long melon from muskmelon, pumpkin from summer and winter squashes, summer and winter squashes from pumpkin.

Roguing of Seed Crop : The existence of off-type plants in the seed crop is a potential source of genetic contamination. The removal of such plants is termed as roguing. Not only the off-types but the diseased and abnormal plants are also to be removed. The number of roguing required for the seed crop will vary with the kind of vegetables, purity of the seeds sown, nature of the previous crop etc. Roguing may be done at the following stages as soon as the off-types are recognizable:

i) Vegetative stage
ii) Flowering stage
iii) Maturity stage

In the seed crop, off-type plants should be rogued out at different times of the day by walking in different directions of the plot. In general the cross-pollinated vegetable crop for seed production should be thoroughly rogued before flowering. Regular supervision by trained manpower is important.

Seed Certification : The genetic purity in the commercial seed production is maintained through a system of seed certification. Seed certification implies that the crop and seed lot have been duly inspected and that they meet requirement of good quality pedigree seeds. To achieve this purpose, qualified and well-trained personnel of seed certification agencies carry out field inspection at appropriate stages of crop growth. They also make seed inspections to verify that the seed lot is of the requisite genetic purity and quality. In addition to inspections, seed certification agencies also lay down the field and seed standards which the seed crop and seed lot respectively must conform to get approval as certified seed. The field standards include land requirements, isolation requirements, maximum permissible off-types etc.

Grow-out Tests : Varieties being grown for seed production should periodically be tested for genetic purity by grow-out tests to make sure that they are being maintained in their true form.

Agronomic Principles

Besides genetic principles of seed production, there involves the application of the following agronomic principles for the production of good quality seeds.

Selection of Suitable Areas for Seed Production

The areas for seed production are based on climatic factors which ensure a relatively satisfactory environment for vegetable seed production. This factor includes moderate rainfall, humidity, suitable temperature and gentle wind. A crop variety to be grown for seed production in an area must be adopted to the photoperiodic and temperature conditions prevailing in that area, as for example the cole crops, cabbage, cauliflower, radish etc. are sensitive to photoperiodism and temperature for flower initiation and should be grown in a locality where low temperature prevails during short day conditions.

Regions of moderate rainfall and humidity are much more suitable for seed production than regions of high rainfall and humidity. Most vegetable crops require a sunny period and moderate temperature for flowering and pollination. High temperature during flowering causes descication of pollens resulting in poor seed set in wind pollinated vegetable crops. Bright sunny weather with gentle winds helps an even flow of pollen over the crop during flowering which is conducive to the best pollination and good seed set. However, very cold temperature may also damage seed quality especially in the early phase of seed maturation. In general, regions with extreme summer heat and very cold winters should be avoided for seed production, unless a particular crop is especially adapted to grow and produce under these conditions.

It is therefore, clearly evident that ample sunshine, relatively moderate rainfall and the presence of gentle winds have a decided advantage for high quality seed production and must be kept in view in the selection of areas for seed production.

Selection of Variety

The selection of a right variety is very important for a successful seed production. The following aspects should be considered for the selection of variety for seed production.

- The vegetable variety to be grown for seed production must be genetically pure and adapted to the photoperiod and temperature prevailing in the production areas
- The variety should be a high yielder
- The variety should possess other desirable attributes e.g. consumers' preference, disease-pest resistance etc.

Source of Seed

The seed used for raising a seed crop should be of known purity, appropriate class and invariably obtained from authorized official agency. The following factors should be carefully examined while buying the seeds.

- That the seed is of appropriate class. For raising a foundation seed crop, seed of the breeder's seed class is required and for raising a certified seed crop, the seed of the foundation seed class is required for sowing.
- That the tag and seals of the breeder's/foundation seed bags purchased are intact.
- That the validity period has not expired.

Seed Treatment

Seed treatment refers to the application of fungicide, insecticide or a combination of both to seeds so as to disinfect and disinfest them from seed borne or soil-borne pathogens and storage insects. There are several pre-sowing treatments which are used for vegetable seeds, including the application of pesticides for the control of seed or soil-borne

pathogens. The following types of seed treatments are followed for treating vegetable seeds.

- *Seed disinfection* : This refers to the eradication of fungal spores that have established within the seed coat or in more deep-seated tissues. For effective control the fungicidal treatment must penetrate the seed in order to kill the fungus.
- *Seed disinfestation* : Seed disinfestation refers to the destruction of surface-borne organism that have contaminated the seed surface. Fungicides applied as dust, slurry or liquid have been found effective.
- *Seed protection* : The purpose of seed protection is to protect the seed and young seedlings from organisms in the soil which might otherwise cause decay of the seed before germination.

The range of vegetable seed treatments and their methods of application for the control of fungi, bacteria and insect pests has been reviewed by Mande (1978). The available treatments range from the application of chemicals to the seed as dusts or slurries to the application of heat via hot water, dry heat or steam-air mixtures. The methods for the application of pesticides to seeds were reviewed by Zeffs and Tuppen (1978). Table 3 shows the schedule for vegetable seed treatment (cited from Agrawal, 1980).

Table 3. Schedule for vegetable seed treatment

Crop	Name of Chemical	Qty of of chemical for100Kg Seeds (g)	Nature of application
Brinjal & Chillies	Thiram 75% dust Captan 75% dust	250 250	dry dressing dry dressing
Tomato	Thiram 75% dust	335	dry dressing
Cabbage, Cauliflower, Knol-khol	Thiram 75% dust	85	dry dressing
Cucurbits	Captan 75% dust Thiram 75% dust	250 250	dry dressing dry dressing
Beans, peas, Cowpeas	Captan 75% WDP or Thiram 75% dust	125	dry dressing dry dressing
Leafy Crops	Thiram 75% dust	335	dry dressing
Root and bulb Crops	Thiram 75% dust	250	dry dressing
Okra	Captan 75% WDP or Thiram 75% dust	100 250	1.5 liter dry dressing

Better Agronomic Management

In general, the principles and practices to establish the seed crop are the same as for the production of vegetables. But as the final objectives is to obtain seeds to be used for the production of further crop generations, it is important to apply best possible agronomic practices for raising the healthy seed crop. Timely seed sowing, optimum plant population and optimum irrigation are some of the agronomic practices that needs to be taken into care for obtaining higher yield and better quality of seeds. The agronomic practices required for seed production may vary with the crop. The seed producer must have clear ideas about the agronomic practices of the concerned vegetable crop.

Nutrition

In the nutrition of seed crops, nitrogen, phosphorus, potassium and several other elements, e.g. boron, molybdenum, zinc, sulpher etc. play an important role for the proper development of plant and seed. It is, therefore, advisable to know and identify the nutritional requirements of seed crops and apply adequate fertilizers. Optimum fertilization results in maximum yields, seed quality and better expression of plant type which facilitate roguing and thereby helps in maintaining higher genetic purity as well.

Disease and Insect Control

Successful disease and insect control is very important in raising healthy seed crops. Pest infestation not only reduces the seed yield but also damages the quality. Generally the same control methods are used in seed production as for the production of market vegetables. The range of available pesticides differs from one country to another but only approved and proven products should be used in seed production, as possible adverse effects of pesticides include inadvertent killing of pollinating insects, modification of the seed's potential germination and a reduction in quality.

Supplementary Pollination

Supplementary pollination using honey bees in hives in the seed fields of crops cross-pollinated by insects ensure good seed set and increased seed yields. Also hand pollination in cucurbit vegetables helps uniform seed setting, resulting higher seed yield.

Harvesting, Drying and Storage of Seeds

It is of great importance to harvest the seed crop at the time that will allow both the maximum yield and the best quality seeds. In general, the seeds are harvested when their moisture content is about 15-20%. Cole crops are harvested when siliqua becomes yellow, the pods of legume vegetables are harvested when they are dry enough. In vegetables like tomato, brinjal, chillies and cucurbits well ripen fruits are collected. They are cut or smashed under pressure to extract seeds. In brinjal and tomato, crushed fruits are allowed to ferment for one or two days for quick and easy extraction of seeds. After extraction, seeds are cleaned and dried. In order to preserve seed viability and vigour it is necessary to dry seeds to safe moisture content level. The drying of seeds may be done by sunlight, chemical descicants and by mechanical driers. The air temperature of the drier should not exceed 38°C in order to maintain good vigour and viability of the seeds. Sensitive seeds like onion, carrot, leek etc require drying temperature below 27°C.

For short period storage clean and dried seeds should be filled in neat and clean sacks or bags and stored in a clean, cool godown.

CHAPTER III

CLIMATIC FACTORS AFFECTING VEGETABLE SEED PRODUCTION

Before seeds can be produced from vegetables it is necessary for the crop to flower. Flowering is required by the plant for sexual reproduction and maintenance of generation. The process of flowering is complex. Some plant species pass from vegetative phase to the reproductive phase with special requirement or stimulus, whereas in others such stimulus is not required. Species which have a special physiological requirement to pass from the vegetative phase to reproductive phase are generally either dependent on day length (photoperiod) or have a low temperature requirement (vernalization). Not only photoperiod and temperature but some other climatic factors, e.g. rainfall, wind etc. are also responsible for best yield of high quality seeds. The major environmental factors influencing vegetable seed production are :

A. Photoperiod
B. Temperature
C. Rainfall
D. Wind

A. Photoperiod

Photoperiod influences vegetable seed production by affecting photosynthesis and day length. Within the limits of each crop plant, the higher the light intensity, the higher will be the rate of photosynthesis required to manufacture the important constituents of the seed.

Different crop plants have different requirements of photoperiodism. According to Thomson (1979) the transition from vegetative to the reproductive phase in some vegetable crop plants can occur only at the season when the days are of particular length, and if the plants are kept in the wrong day length, they remain in vegetative phase for longer time. Crop species of temperate regions tend to flower in the long days of summer while tropical crop species require shorter days. Plants can be classified into three main groups according to the specific duration of light and dark requirement in each 24 hour period or cycle in order to initiate flower, viz. short-day plants, long-day plants and day-neutral plants.

Short-day Plants : This group includes species which will not flower unless the day light period is shorter than a particular critical time, which is between 10 and 12 hours, for example amaranthus sps, soybean, pepper (some varieties), kidney bean.

Long-day Plants : These include plants which will flower only when the light period is greater than a critical time. The critical photoperiod for most long-day plants is between 12 and 14 hours, for example, spinach, radish, cabbage, cauliflower, broccolli, turnip etc.

Day-neutral Plants : This group does not have a specific day length requirement for flowering, for example, tomato, brinjal, lettuce, cucurbits, carrot etc.

B. Temperature

Some vegetable species do not initiate flowers until the plant has received a cold tem perature stimulus. The requirement of cold temperature stimulus for flowering is called vernalization, e.g. cabbage, Brussel's sprout, beet, biennial radish, carrot, onion etc.

Depending upon the vernalization requirement, vegetable crops are grouped in to the following three classes :

Annual : Vegetable species which do not have vernalization requirements for flower initiation, such crops produce flower and seed in the first year, e.g. tropical radish, Batisak *(Brassica chinensis).*

Biennial : Biennial plants tend to remain in vegetative stage in the first year of growth and they flower and produce seed in the second year, e.g. beet, carrot, cabbage and biennial radish etc. Most of the biennial plants require vernalization for flower initiation.

Perennial : Perennial plants survive for several years producing flowers and seeds each year. Most vegetables are, however, annuals and biennials.

Temperature significantly influences the transition from the vegetative to the reproductive phase of the crop species having specific critical temperature requirements for flowering. Not only the flowering, the prevailing temperature during growth and developmental phases of plant determine the final seed yield.

C. Rainfall : An appropriate balance between sufficient rainfall for crop growth and establishment and sufficiently dry conditions for satisfactory pollination and seed ripening is the most important factor in the vegetable seed production. Sufficient soil moisture must be ensured during flowering stage when the crop is moisture sensitive, owing the reduced root growth. Seed viability can be seriously affected by high rainfall during the seed ripening period.

D. Wind : Excessive wind increases water loss from the crop and soil, prevents maximum activity of pollinating insects, carries wind-borne pollen over long distances and increases loss of seed by enhancing shattering during seed ripening (George, 1980). Strong winds during the reproductive phase can cause severe crop losses through lodging, shattering and shedding of seed. On the other hand gentle wind facilitates increased pollination in cross-pollinated crops.

CHAPTER IV

SEED PRODUCTION IN SOLANACEOUS VEGETABLE CROPS

4.1. BRINJAL

Origin

The brinjal, eggplant or aubergine (French name) has originated in the Indian sub-continent and China (Thomson and Kelly, 1957, Purewall, 1957 and Martin and Rhodes, 1979). Brinjal is an important vegetable crop of the Far East, Bangladesh, India, China and the Philippines.

Taxonomy

Brinjal belongs to the family Solanaceae and is known under the botanical name *Solanum melongena* L. (2n = 24). There are 3 main botanical varieties under the species *melongena* (Chowdhury, 1976). The round or egg-shaped cultivars are grouped under var. *esculentum*, the long slender types are included under var. *serpentinum* and the dwarf brinjal plants are put under var. *depressum*.

Floral Biology and Pollination Habit

Brinjal flowers are large, violet coloured and solitary or in clusters of two or more. Flower consists of calyx : sepals 5, united, persistent; corolla : petals 5, united, usually cup shaped; Androecium : stamens 5, alternate with corolla; Gynoecium: carpels are united, ovary superior.

In most varieties the perfect flowers are borne singly and opposite the leaves. The stamens dehisce at the same time the stigma is receptive so that self-pollination is the rule although there is some cross-pollination by insects. Depending on the length of styles, four types of flowers are reported in brinjal (Krishnamurthi and Subramaniam, 1954), 1) long-styled with large ovary, 2) medium-styled with medium size ovary, 3) Pseudoshort-styled with rudimentary ovary and 4) true short-styled with very rudimentary ovary. It is observed that long and medium-styled flowers produce fruits whereas pseudo-short and short-styled flowers fail to set fruits.

The anthesis and dehiscence in brinjal are mainly influenced by the daylight, temperature and humidity (Sidhu et al., 1980). Usually anthesis starts from 7-30 A. M. and continues upto 11. A. M. Peak time for anthesis is 8-30 to 10-30 A.M. The pollen dehiscence starts from 9-30 to 10 A.M.

Varieties

In Brinjal, a large variation in plant types, fruit colour, shape and size are available. The following are the recommended varieties in Bangladesh.

Uttara : It is a selection from mixed "Jhumka" grown in Rajshahi. The plants are bushy, tolerant to fruit and shoot borer, prolific bearer, fruits are borne in clusters, 150 - 200 fruits per plant, yield 60 t/ha. This variety was developed and released by BARI in the year 1985.

F1 Tarapuri : Oblong dark purple fruits, erect plants with prolific bearing, 70-75 fruits/plant with yield potentiality of 80 t/ha. Early bearer, the hybrid variety was developed by BARI in the year 1992.

F1 Suktara : This is a hybrid variety with dwarf and spreading growth habit. This variety was developed by BARI in the year 1992. Slender purple fruits, number of fruits per plant ranges 100-120, yield is 75 t/ha.

BARI Begun-4 (Kazla) : This variety was developed through pedigree selection by BARI in the year 1998. Plants are semi-erect, leaves and stems are puplish in colour. Fruits are long having attractive shiny purple colour. On an average single fruit weight is 60-65 g having a yield potentiality of 65 t/ha.

BARI Begun-5 (Nayantara) : Semi-erect plants with medium height. Fruits are round having shiny dark purple colour, average single fruit weight is 120-130 g. Average number of fruit per plant is 25 having a yield potentiality of 45-50 t/ha. The variety has been developed by BARI in the year 1998 from an Indian cultivar.

Islampuri : Popularly grown in Mymensingh and Jamalpur area. Round deep purple fruits with yield potentiality 30-35 t/ha.

Soil and Climate

A long and warm growing season is desirable for successful brinjal production. The crop is susceptible to severe frost. Cool nights and short summers are unfavourable to its satisfactory growth and development. A daily mean temperature of 23 to 27°C is most favourable (Bose et al., 1986)

Seedling Raising

In Bangladesh condition brinjal seeds are sown in nursery during July - August. Sowing of the seed crop should be so adjusted that maturity does not coincide with rains. Nursery beds are to be prepared 15-20 cm high with finely prepared soil mixed with well-decomposed farmyard manure/compost. Usually the soil mixture for the bed should have one part soil, one part sand and one part compost. The standard size of the bed should be 1.0 x 3.0 m so that watering, weeding, mulching and after care become easy. The seeds should be sown in trays or in seedbeds in line. After 7-10 days of sowing the young seedlings should be transplanted in the second bed at a distance of 2-3 cm in both ways. Transplanting at the second bed helps the formation of fibrous roots which enable the seedlings to be sturdy and healthy. Uniform irrigation and mulching after each irrigation should be practiced to facilitate aeration. Three to four handful of urea dissolved in 30 litres of water can be sprinkled in nursery beds after about a fortnight of germination in order to get healthy and vigorous seedlings.

About 375 to 500 g of seeds are required for one hectare of land (Agrawal, 1980)

Land Preparation

Deep, fine loamy soil with a good drainage is most favourable for the growth of brinjal. Soil pH should be neutral or slightly acidic. The land should be thoroughly prepared by 4 to 5 ploughings. Farmyard manure or compost should be incorporated into the soil during 1st ploughing. Beds of suitable size are prepared after the land is well levelled.

Manures and Fertilizers

Balanced application of manures and fertilizers is very important for a successful crop. Brinjal being a long duration crop requires a good amount of manures and fertilizers. The Bangladesh Agricultural Research Institute has recommended 15-20 tons organic manures, 375 kg urea, 150 kg TSP and 250 kg MP for brinjal. The entire amount of organic manures and TSP and half of MP are to be applied during land preparation. The remaining half MP and entire urea are to be applied in three equal installments, 1st at 15 days after planting, 2nd at flowering and the 3rd at peak harvesting.

Planting

The seedlings are ready for planting when they attain a height of 15 cm with 4-5 leaves in 4-6 weeks. Seedlings are planted on raised bed which provides good drainage. The planting distance depends on the fertility status of the soil, growing season and variety. According to Chauhan (1981) brinjal plants are planted at 60 x 45 cm in case of long varieties, at 75 x 60 cm and 90 x 90 cm in case of round and high yielding cultivars respectively. However Seth and Dhandar (1970) reported that seed yield per plant were slightly better with a row to row spacing of 100 cm as compared to 75 cm.

Irrigation

Irrigation is essential for brinjal cultivation in regions where there is little or no rain during the growing season. Brinjal being a shallow rooted crop needs irrigation at frequent intervals. Yawalkar (1969) opined that irrigation should be given according to local needs. However the field should be irrigated every 10-12 days during the winter. Every irrigation should be followed with mulching to facilitate good aeration.

Isolation

Brinjal, although self-pollinated, can outcross to a considerable extent. It is, therefore, essential to isolate the seed crop from other varieties to avoid contamination and to produce pure seeds. Agrawal (1980) recommended an isolation distance of 400, 200 and 100m for breeder's, foundation and certified seed production, respectively. The breeder's seed plot should also be isolated from commercial seed crops.

Roguing

Seed growers should be well acquainted with the characterization of the variety so that they may effectively rogue out the off-types and undesirable plants at different stages of crop growth. The following three roguing stages have been suggested by George (1985) :

- Before flowering by examining plant colour, growth habit and foliage characteristics such as shape, size and posture.
- At early flowering and fruit development-by observing general plant habit, vigour, degree of spinyness.
- At fruiting off-types can be identified on the basis of fruit characteristics like shape, size, colour etc.

Rotation

Brinjals are susceptible to many of the soil pests and diseases associated with other members of Solanaceae and the rotation must be taken into consideration. Generally a period of four years should elapse between successive brinjal crop or other genera in Solanaceae.

Harvesting

In order to ensure that seed development is complete, the fruits are usually hand picked at a later or ripen stage than for the market crop. Petrov et al. (1981) suggested that seeds should be collected from first or second tier fruits as those have a higher seed weight and germination rate than seeds collected from fruits beyond the second tier.

Seed Extraction

There are two basic methods used for the extraction of brinjal seeds : wet extraction and dry extraction. The wet extraction is favoured for large-scale seed production while the dry extraction is employed for small-scale seed production.

In wet extraction, the harvested fruits are stored for 5-7 days at room temperature until they become soft. This allows the seeds to mature fully. The fruits are crushed or cut into thin slices. These are then softened by soaking till the seeds are separated from the pulp. Since the brinjal fruit pulp is relatively dry, it requires extra water during and after crushing and would be allowed to stand overnight to facilitate seed separation from the flesh.

In dry extraction, the ripened fruits are harvested and dried in the sun until they shrivel. During drying of purple and purple black fruits the skin colour turns to coppery brown. The fruits are then hand beaten to extract the seed. This method is used for small- scale seed extraction.

Cleaning and Drying of Seeds

After extracting and washing, the seeds are cleaned and dried. Drying is done by spreading the seeds in the partial sun light for few hours for one to two days upto a moisture content of 8% or below (Agrawal, 1980).

Seed Yield

The variation in seed yield is due to environmental factors, crop management practices and varieties. The average seed yield is 100-120 kg/ha (Chowdhury, 1976), but good yield may reach 600-700 kg/ha (Singh et al., 1964).

Pests and Diseases and Their Control

In the tropical climate brinjal is attacked by several insect-pests. Some of the insect-pests and their control measures are given below.

Insects	Control Measures
Fruit and shoot borer	Actellic 50 EC @ 2 ml/liter of water or Ripcord 10 EC @ 1 ml/liter of water should be applied as foliar spray. Spraying should be repeated at an interval of 7-14 days where necessary.
Epilachna beetle	Malathion/Fyfanon/Zithiol 50 EC @ 2 ml/liter of water can be applied as foliar spray.
Jassids	Nuvacron 50 EC @ 2 ml/liter, Ripcord 10 EC @ 1 ml/liter of water should be sprayed, repeat at 15 days interval.
Mealy bugs	Foliar Spray of Diazinon 50 EC @ 2 ml/liter water.

Diseases	Control Measures
Little leaf	Roguing out of affected plants, control of vectors by foliar spray of Parathion / Metasystox@1ml / liter of water.
Damping off	Soil sterilization by Formaldehyde with 50 times water upto 4" soil depth. Seed treatment with Captan @ 1 g per kg seed. Spray captan @ 2 ml/liter of water.
Bacterial wilt	Proper crop rotation can reduce the infestation. Use of resistant varieties Grafting on resistant solanum rootstock.
Phomopsis blight	Seed treatment with Ceresan/Agrosan Spraying Bordeaux mixture (4:4:50)
Root knot nematode	Use of resistant varieties Treatment of soil with Chloropicrin before 15 days of sowing.

4.2. TOMATO

Origin

Tomato is one of the most popular and widely grown nutritious vegetable in the world. Most of the cultivated types of tomato belong to Lycopersicon esculeutum. Cultivated tomato is generally accepted to have originated in the Americas since all related species of tomato are native to the Andean region compost of parts of Bolivia, chile, Colombia, Ecuador and Peru (Jenkins, 1948).

Taxonomy

Tomato*(Lycopersicon esculentum L.)* belongs to the family Solanaceae and genus Lycopersicon (2n=24). The genus includes 12 species. Although in tropical South America where it is native, tomato is a perennial crop. It is usually grown as an annual for both fruit as well as seed purpose. The plant is a large and heavily branched with alternate, pinnate compound leaves. Tomato is characterized by two types of plant : (i) Determinate type-inflorescence occurs more frequently in almost every internode until terminate ones are formed and elongation ceases at this point (ii) Indeterminate type-inflorescence cluster occurs at every third internode and the main axis continues growing indefinitely.

Floral Biology and Pollination Habit

Tomato inflorescence or flower cluster is borne laterally in small forked raceme cyme. The number of flowers per cluster in most cultivars varies from 4 to 5 and some times more. In most commonly grown field varieties about 2 to 4 flowers set fruits within each cluster.

Tomato flower has a 5 to 10 parted calyx which persists until fruit matures. The yellow petals are united in a short tube with five or more lobes which are often recurved. The five stamens are attached to the base of the corolla tube. The long anthers are partly united in the form of a cone surrounding the pistil. The latter consists of a multicelled ovary and a long slender style reaching the tip or projecting from the staminal cone as much as 2 mm with a capitate, single narrow or somewhat bulbous stigma. The buds, flowers, and fruits develop progressively within an individual cluster. There is no definite flowering peak in tomatoes. Anthesis appears to be correlated with temperature and soil moisture.

Tomato is normally self-pollinated crop. Self-fetilization being favoured by the position of the receptive stigma within the cone of anthers and the normal pendant position of the flower. Though the stigma is receptive at the time of anthesis, anthers do not dehisce until about 24-48 hours later. Cross-pollination of tomato flowers to the extent of about 5 percent may occur through insects.

Varieties

So far Bangladesh Agricultural Research Institute (BARI) developed and recommended 10 tomato varieties. Besides, some exotic varieties are also grown in Bangladesh. The main features of the important varieties grown in Bangladesh are given below.

BARI Tomato-1 (Manik) : Red coloured medium-large round fruits, determinate, plants are tolerant to bacterial wilt. Yield 90~95 t/ha.

BARI Tomato-2 (Ratan) : Early ripening, attractive red coloured medium sized round fruits, determinate, tolerant to bacterial wilt. Yield 85-90 t/ha.

BARI Tomato-3 : Fruits medium to large, fleshy globe and red in colour. Plants are determinate. Yield is 85-90 t/ha.

BARI Tomato-4 : Heat tolerant, resistant to bacterial wilt, semi-determinate plants. Fruits are red, round with medium ribbed, average fruit weight 40g. suitable for summer cultivation with the application of tomatotone (hormone), yield is 25-26 t/ha in summer.

BARI Tomato-5 : Heat tolerant, plants are semi-determinate with medium growth habit. Fruits are red, heart-shaped, slightly ribbed, average fruit weight 45 g. Yield is 20~22 t/ha in summer. Recommended for summer cultivation with the application of hormone.

BARI Tomato-6 (Chaiti) : Heat tolerant year round determinate variety. Yield during winter 90-95 t/ha and in summer 45-50 t/ha. Recommended for summer cultivation under protective culture with the application of hormone.

BARI Tomato-7 (Apurba) : Attractive orange coloured round fruits, rich in beta-carotene (6.9 mg/100g edible portion). Yield is 95-100 t/ha. Determinate variety.

BARI Tomato-8 (Shila) : Prolific bearer, 80-85 fruits per plant. Fruits are plum shaped, firm, thick-walled with longer shelf life. Yield is 80-85 t/ha. Determinate variety.

BARI Tomato-9 (Lalima) : Heat tolerant, suitable for year round cultivation. Firm fruits with longer shelf life. Yield is 75-80 t/ha. Determinate variety.

BARI Tomato-10 (Anupama) : Heat tolerant hybrid variety. Red coloured small fruits, average fruit weight 30g. Recommended for summer cultivation. Determinate variety. Yield is 85-90 t/ha.

Exotic Varieties

Pusa Ruby : Early variety, fruits are round with yellow stem end, uniform ripening. Semi-determinate variety.

Roma V. F : Determinate plants with luxuriant foliage and excellent bearing. Fruits are pear shaped, thick-walled with longer shelf life.

San Marzano : Plants indeterminate, fruits large, plum-shaped, firm with longer sheft life.

Soil and Climate

Tomato seed production is highly influenced by environmental factor, particularly temperature which has significant effect on all stages of plant growth and development. Day and night temperature and the variation between the two has pronounced effect on growth, flowering, fruiting and yield of fruits and seeds in tomato, but the night temperature is a critical factor for fruit set in tomato. Went (1944) reported that plants

could set fruits abundantly when the night temperature is between 15°C and 20°C and the day temperature is about 25°C. Various experiments have revealed that temperature above 32°C leads to reduction in fruit-set. Fruit set is also reduced at a temperature below 15.5°C due to poor pollen dehiscence.

Tomato can be grown on a rather wide range of soils from sandy to clay. The optimum soil pH is 6.5 to 7.0. To obtain good seed yield, fertile soil with efficient drainage and good water holding capacity should be selected.

Seedling Raising

Tomato seedlings are raised in the nursery beds. September-October is the optimum time for sowing seeds in the nursery. Seeds are sown in line on a well-prepared seedbed and lightly covered with soil. After 7-10 days of sowing the young seedlings are transplanted on the second bed at a distance of 2-3 cm in both ways. The seedbeds should be irrigated immediately after transplanting. The seedlings should be protected from strong sun and heavy rains. Three to four handful of urea dissolved in 30 litres of water can be sprinkled on nursery beds after about a week of transplanting the young seedlings in the second bed to get healthy seedlings.

About 250-300g seed would provide sufficient seedlings to cover one hectare of land.

Land Preparation

Tomato should be planted in well pulvarized field by ploughing first with soil turning plough and afterward with 4-5 ploughings. Ploughing should be followed by laddering. Farmyard manures/compost and basic dozes of chemical fertilizers are incorporated into the soil during ploughing.

Manures and Fertilizers

Maintaining adequate quantities of nutrients in the soil is important to get good seed yield. It is also reported that for tomato seed crop micro-nutrients like boron, zinc and manganese deserve special attention. The Bangladesh Agricultural Research Institute has recommended 15-20 tons organic manure, 300 kg urea, 200 kg TSP, 150 kg MP, 100 kg Gypsum and 10 kg borax per hectare. The entire amount of organic manure, TSP, Gypsum, Borax and half of the MP are to be applied during land preparation. The remaining half MP and entire urea are to be applied in three equal installments, first at 15 days after planting, 2nd at flowering and the third at fruit maturity.

Planting

Tomato seedlings are ready for planting when they are at 4-5 leaf stage in 4-5 weeks. For seed crop tomato is planted in raised beds. Two rows are planted on a 1 m wide raised beds at a spacing of 60 x 60 cm. Planting should be done in the late afternoon followed by light irrigation.

Irrigation

Tomato needs very careful irrigation which should be sufficient in right time but water logging should be avoided at all times during the crop growth. Quality of fruits improves by optimum moisture supply during flowering and fruit setting. Heavy irrigation after a long dry spell may result in fruit cracking. Similarly providing irrigation late in the season may result in watery fruits of poor quality. However, irrigation should be given according to the local need.

Training, Pruning and Staking

Training of tomato plants with the help of wires or ropes is claimed to result in early ripening, higher yield of better quality fruits and seeds, lesser disease incidence, easier intercultural operation and harvesting.

Pruning side shoots and staking have claimed to have higher yield, uniform and larger fruits (Fernandez, 1952).

Isolation

The minimum isolation distance between different cultivars of tomato for seed production is relatively short. This is because of the crop's high level of self-pollination. However, the minimum recommended isolation distance between different varieties varies from 30 to 200m in different countries (George, 1985).

Roguing

Plants showing different characters to the type must be removed. Roguing is done at different stages of crop growth.

- Before flowering-Plants showing different growth habit and foliage characteristics than the particular variety should be rogued out.
- Early flowering and fruit setting stage-Off-types are rogued out judging the size and shape of immature fruits.
- Fruiting stage-The off-types are identified examining the fruit characteristics like shape, size, colour etc.

Rotation

Tomatoes like brinjal crop are susceptible to many of the soil borne diseases and therefore rotation must be taken into consideration to prevent pest and disease build-up. Generally a period 3-4 years should elapse between successive tomato or brinjal crop.

Harvesting

Seed fruits are allowed to ripen to maturity on the plant. Only completely colored and matured seed fruits are harvested. The mark of the two sepals (calyx) cut off should be checked carefully to ensure that only pollinated fruits are harvested.

Seed Extraction

The following methods have been suggested by many workers for tomato seed extraction.

Fermentation Method : In this method the selected ripe fruits are harvested and kept in wooden or plastic containers for two to three days until the fruits become soft. They are crushed by hand and no fruit juice is allowed to drain out. Entire mass is kept for 24 to 72 hours depending upon temperature. Flesh will float at the top and seed will settle down at the bottom. The fermented mass is removed and the seeds are sieved and cleaned with fresh clean water and dried. Longer fermentation may damage the seed.

Separation With Sodium Carbonate : This method is relatively safe and can be used for small quantities of seed in cooler temperate areas where the fermentation method is not used. The pulp containing the extracted seeds are mixed with equal volume of a 10 percent solution of sodium carbonate (washing soda). The mixture is left upto two days at room temperature after which time the seed is washed out in a sieve and subsequently dried. The sodium carbonate method of extraction tends to darken the testa of the seed and is, therefore, not normally used for commercial seed.

Separation With Hydrochloric Acid : This method is often favoured by large commercial producers as it produces a very bright clean seed sample. The hydrochloric acid treatments is often combined with later stages of fermentation. George (1985) reported that 567 ml of concentrated hydrochloric acid stirred into 10 litres of seed and pulp mixture and left for half an hour is successful. After the extraction seeds must be dried as quickly as possible. A common method as described by Webster (1944) is to spread the seed in screen-bottom trays which are placed on racks out of doors so that the air passes both above and below the screens. The trays are often stirred to get the full effect of the solar energy. Occasional stirring of the seed speeds the drying process. Drying of tomato seed is done up to the moisture content of 8% (Agrawal, 1980)

Seed Yield

Tomato seed yields are highly variable, depending upon several factors like the cultivar, season and management practices. However, in commercial field production of tomato, the rule is that seed weight should be 1% of the fresh fruit weight, i. e. one ton fruit yield should produce 10 kg of seeds. Thus seed yield will depend on yield of fresh fruits. However, under sub-continent condition Singh et al. (1964) recorded an average yield of tomato seed as 145 kg /ha.

Pests and Diseases and Their Control

Following are the major insect-pest and diseases of tomato

Insects	Control Measures
Tomato fruit warm	Malathion 50 EC or Thiodan 35 EC @ 2 ml/litre of water should be applied as foliar spray.
Epilachna beetle	Malathion/Fyfanon/Zithiol 50 EC @ 2 ml/litre of water can be sprayed.
Jassids	Nuvacron 50 EC @ 2 ml/litre or Ripcord 10 EC @ 1 ml/litre of water to be sprayed and repeated at fortnight interval.
Aphids	Malathion 50 EC or Dimacron 50 EC 2 ml/litre of water as foliar spray.
Mealy bug	Diazinon or Libacid 50 EC @ 2 ml/litre or Malathion/ Dimacron 100 EC @ 1 ml/litre of water to be sprayed.

Diseases	Control Measures
Damping off *(Pythium/Phytophthora Sps)*	Soil sterilization by Formaldehyde with 50 times water upto 4 inch soil depth. Seed beds should be kept clean and well drained. Seeds should be treated with captan @1 g per kg seeds. Spraying of 1% Bordeaux mixture at an interval of 8-10days of sowing.
Bacterial wilt *(Ralstonia solanacearum)*	Use of resistant varieties The land should be kept clean and well drained. High degree of control of bacterial wilt in Indonesia by spraying 20 ppm streptomycin sulfate (oxytetracycline) at 4 and 7 days intervals was reported.
Tobacco mosaic virus(TMV)	Roguing out of mosaic affected plants as soon as observed. Control of the vector (white fly) by spraying Dimacron @ 1ml/litre of water.
Late blight *(Phytophthora infestans)*	Use of resistant varieties Spraying of fungicides, Dithane, Z-78 and Parzate @ 2 g/litre of water is effective.
Early blight *(Alternaria solani)*	Use of resistant varieties Spraying of Dithane Z-78 @ 2 g/litre of water is reported to be effective. Spraying of Cysteene @ 150 mg/litre of water was found effective.

4.3. CHILLI

Origin

Chilli or Pepper (Capsicum sps) originated in South America and spread into the New World tropics before subsequent introduction to Asia and Africa. Chillies are now widely grown throughout the tropics, sub-tropics and warmer temperature region of the world.

Botany

The genus Capsicum is a member of the family Solanaceae. Early taxonomic classification of the genus resulted in description of nearly 100 good species and botanical varieties. There are many cultivars differing from each other in shape and colour of the fruits, pungency and position of fruits. Bailey (1949) divided pepper into five groups based on fruit shape.

Cerasiforme : The cherry pepper, a pungent variety.

Conoides : The cone pepper, also pungent with conical or oblong cylindrical fruits.

Fasciculatum : Red cluster with fascicled fruits, red in colour and extremely pungent.

Longum : Long pepper, with drooping enlongated pungent fruit.

Grossum : Bell or sweet pepper having large, puffy fruit with a depression at the base and usually furrowed sides. The fruit is red or yellow with a mild flavor.

Based on taxonomic and genetic studies, Heiser and Smith (1953) included all the types and varieties mentioned above under C. *annuum* and listed the pungent variety Tabasco, together with some other uncommon varieties, as belonging to *frutescens.*

Floral Biology and Pollination Habit

Chilli flower is normally solitary but occasionally borne in small cymes of leaf axils. The calyx is five lobed and corolla is five-parted and white, but occasionally purple in colour. The five stamens attached to the base of corolla are separated. The bluish anthers dehisce by splitting longitudinally. The single style is usually longer than the stamens and stigma is club-shaped. The ovary generally has three locules. Pepper tend to blossom and set fruit earlier under short day conditions.

Fruits of the capsicum is a pod like berry with a short, thick peduncle. The shape of the fruit varies from a flattened oblate to long slender and tapering, the size also ranges from very small to large fruit of sweet pepper.

Seeds within the fruits mature as the fruit ripens. The seed is borne in a compact formation on the plancentae and usually at the basal end of the fruit.

Peppers are generally self-pollinated, but some cross-pollination can occur between and within the cultivars of the two species *(C. annuum* and C. *frutescens).* Murthy and Murthy

(1962) reported upto 68 percent cross-pollination in India. Bees, ants and thrips are the possible agents of pollination. Anthesis takes place some times after the flowers have opened. Flowers remain open for 2-3 days. The flowers open in the morning between 2 and 10 A. M. (Gopalratnam, 1933). The anthers normally dehisce an hour after the flower opening. Flower opening and anther dehiscence to a large extend depend on the weather condition. During cold and as well as cloudy days, the opening is delayed (Purseglove, 1977).

In case of sweet pepper, anthesis commenced at 7.0 A. M. which continued upto 11.0 A. M. With peak at 7-15 A. M. and anther dechisce after 30 minutes of anthesis. The stigma became receptive upto 2 days after anthesis (Vijay et al., 1979)

Varieties

In Bangladesh there are no recommended chilli varieties yet. Some popular local varieties are grown across the country, e.g. Balujuri of Sherpur, Bindu of Manikganj, Irrimarich of Comilla etc.

Soil and Climate

An ideal medium for growing chilli is a light loamy soil rich in lime. Still it can be grown in variety of soils provided they are well drained and rich in organic matter. Chilli is grown in both tropical and sub-tropical areas. A temperature ranging from 20 to 25°C is ideal for chilli. A warm humid climate favors growth while dry weather enhances fruit maturity.

Seedling Raising

In Bangladesh chilli crops are generally grown by broadcasting seeds directly in the field, but it is advisable to grow chilli by raising seedlings in the seed bed. Seeds are sown in well prepared seed beds in line spaced 5 cm apart. Sand and well decomposed compost are sprinkled over the seeds. To avoid damage by ants Sevin dust is applied along the borders as well as on the beds.

In Bangladesh chillies are grown round the year, but for seed crop chillies are to be grown during winter. The best time for sowing of seed is from 1st week of September to 15 th October.

1.0-1.5 kg seed is required for one hectare of land.

Land Preparation and Planting

The land is ploughed 3-4 times to get a fine tilth. Farmyard manure is incorporated during the last ploughing. For irrigated crop, ridges and furrows are made. Seedlings are transplanted 4-5 weeks after sowing at a spacing of 30 x 30 cm. Levy et al. (1983) reported that increased plant diversity resulted in less lateral branching making the fruits easier to harvest.

Manures & Fertilizers

Chilli has a long growing season and therefore, needs a judicious application of fertilizers. The following doses of manures and fertilizers have been recommended.

Cowdung/Compost	:	15 tons / ha
Urea	:	200 Kg / ha
TSP	:	300 Kg / ha
MP	:	200 Kg / ha
Gypsum	:	110 ~ 120 Kg / ha
Zinc oxide	:	5 Kg / ha

The entire amount of cowdung/compost, TSP, Zinc oxide, Gypsum and one-third of the urea and MP is applied at the time of final land preparation while the rest of the urea and MP is applied at two equal instalments, 25 and 50 days after planting.

Irrigation and Weeding

The uniform soil moisture is essential to blossom and prevent fruit drop. Generally 8-9 irrigations are given, depending upon rainfall, soil type, humidity and prevailing temperature.

Two to three weeding and mulching are necessary to keep the field clear of weeds.

Rotation

Like brinjals and tomatoes, chillis are also susceptible to many soil borne diseases. Therefore a period of 2 to 3 years elapse between successive chilli crop or other solanaceous crops is recommended.

Isolation

Chilli is considered as self-pollinated crop, but significant cross-pollination does occur if plants are placed together. A minimum distance of about 400m between two varieties is recommended.

Roguing

Plants should be rogued based on the plant and fruit characters as a whole rather than the individual character. Off-types should be removed as soon as they are observed. When the fruits begin to show their final colour of red or yellow, occasional plants with off-colour fruits have to be removed. In addition to off-types, diseased plants are also to be removed.

Harvesting and Threshing

Red-ripe fruit is picked, and macerated mechanically to separate the seeds. Early harvest of immature fruits will affect germination. Seeds are cleaned to free pulp and skins and dried in the partial sun to below 8 percent moisture content before storage.

Seed Yield

Average seed yield varies from 50 to 80 kg per hectare (Agrawal, 1980).

Disease & Pests and Their Control

Chillies are attacked by number of disease and insects

Disease	Control Measures
Damping off *(Pythium/Rhizoctonia)*	Soil sterilization by Formaldehyde with 50 times water upto 4î soil depth. Seed treatment with captan @ 1g per kg seed.
Anthracnose and Fruit rot *(Colletotrichum capsici)*	Seed treatment with Benlate or Bavastin @ 2 g/kg seed. Foliar spray of carbendazim followed by benomyle (Das and Mohanty, 1988)
Yellow mosaic virus	Use of resistant varieties Roguing of the diseased plants

Insects	Control Measures
Thrips	Malathion 507 EC@ 1ml/litre of water should be sprayed
Aphids	Malathion 50 EC @ 1ml/litre of water is to be sprayed

CHAPTER V

SEED PRODUCTION IN CRUCIFEROUS VEGETABLE CROPS

5.1. CABBAGE

Origin

Coast of the Mediterranean sea from Greece to England and Western Europe.

Botany/Taxonomy

Cabbage *(Brassica oleracea var. capitata L.; n=9)* is an important cole crop belongs to the genus Brassica and the family crucifereae. Cabbage is usually a temperate biennial crop, but tropical annual types are also available.

Floral Biology and Nature of Pollination

Cabbage is a temperate crop, thermoperiod is the most important factor for its flower induction. Most of the cabbage varieties are bred in the temperate region, tropical climate is not favourable for flower induction in cabbage. Miller (1929), Nakamura (1961), Kagawa (1965) and Rashid & Nagai (1985) reported that cabbage requires vernalization for its flower induction. Therefore the biennial cabbage does not produce seeds in the climatic condition of Bangladesh. As such the entire quantity of cabbage seeds are imported every year for domestic production.

Cabbage flowers are borne in terminal racemes which develop on the main stem and all its branches. The bright yellow hypogynous flowers borne on slender pedicels are perfect, regular, with four sepals, four petals, six stigma with a two-celled ovary containing many ovules per cell. According to Hawthorn and Pollard (1954) the spreading terminal portion of petals form a cross which is the chief diagnostic character of the crucifereae.

Cabbage is a cross-pollinated crop, pollination occurs mainly through bees. Bumble bees are also some times observed. The pollen viability is dependant on temperature, 15-20°C temperature is best for pollen germination. Temperature below 100c and above 25°C hampers pollen germination (Odland and Noll, 1950).

Varieties

Most of the varieties under cultivation in Bangladesh are hybrids and are imported from Japan, China, Europe. However, Bangladesh Agricultural Research Institute (BARI) has developed two tropical open-pollinated cabbage varieties which produce seeds under local climatic condition, particularly in Rangpur and Dinajpur areas. The brief characteristics of these two varieties are given below.

Probati (BARI Bandha Kopi-1) : A tropical open-pollinated cabbage variety having ability to produce abundant seeds under local climatic condition, particularly in northern region of Bangladesh. Head is compact and medium sized (2.5 kg/head). Head is harvestable between 80 days after transplanting. Head yield is 50-60 t/ha and seed yield is 500-600 kg/ha.

Agradut (BARI Bandha Kopi-2) : Open-pollinated variety and produces seeds locally. Compact flat heads. Head yield is 65-70 t/ha and seed yield is about 600-650 t/ha.

Method of Seed Production

Cabbage seed can be produced either by the head-to-seed method or by seed-to-seed method. The former method is usually employed for biennial cabbage and to produce stock seed. The later method is often used for tropical annual cabbage which needs less or no vernalization and also to produce commercial seeds. Here in this chapter the seed-to-seed production method is discussed.

Climate and Soil

Cabbage in general is very sensitive in its temperature requirement for seed production. Cabbage plants require vernalization for flower induction. The BARI developed varieties Probati and Agradut however, can produce seed under available low temperature during winter in Bangladesh, particularly in northern areas.

Well drained fertile loamy soil is best suited for seed crop. It can however, be grown in wide range of soils having high organic matter and good drainage. The soil should not be acidic, the pH range should be between 6.0-7.0.

Seedling Raising

Seedlings are raised on ideal seed-beds following double transplanting method, seed rate-250-300g/ha.

Time of Planting

For seed production of cabbage the time of planting is very important. The crop should be raised in such a time that the plants face lowest temperature at the head formation stage which facilitate quick vernalization. Longer cool season is also required for seed pod development. In Bangladesh condition seeds should be sown in the middle of September and the seedlings should be transplanted in the middle of October so that the plants are in head formation stage in the later part of November. Such planting time will enable the plants to flower in December and pod development upto February.

Manures and Fertilizer

Cabbage being a heavy feeder, responds well to the fertilizer application. BARI recommended 15-20 tons cow-dung/compost, 240 kg urea, 150 kg TSP and 220 kg MP, 100 kg Gypsum, 4 kg ZnO, 3 kg Sodium molybdate and 10-15 kg Borax per hectare. The entire

quantity of cowdung/compost, TSP, Gypsum, ZnO, Sodium molybdate, Borax and half of the MP are to be applied during final land preparation. The entire urea and the rest of MP are to be applied as top dressing in equal installments. It is recommended that one additional dose of urea and MP (100 kg/ha each) is to be applied during bolting.

Planting Method

For cabbage seed crop 30-35 days old seedlings are planted on raised beds. Two lines of seedlings are planted in a 1m wide bed having 30cm wide drains in between beds. A spacing of 60 x 45 cm between lines and plants are maintained.

Irrigation

Cabbage requires a continuous supply of moisture particularly during bolting and pod formation stage. Moisture stress during bolting and pod formation stage results in poor seed yield.

Roguing

Off-type plants are removed at any time they are observed, but the general practice is to rogue the field at the time of head maturity so that the standard size, shape and firmness of the head is visible.

Isolation

The isolation of seed plants for cabbage seed production is very important as cabbage varieties not only cross easily with one another but with the sub-species of B. oleracea. For the purpose of isolation in the seed production, crucifers are divided into two groups.

- Cabbage, cauliflower, knolkhol, Brussel's sprout
- Radish, mustard, chinese cabbage, turnip

Varieties in each of these groups will cross readily with any other variety of the same kind of vegetables and any variety of any crop in the first group will cross easily with any other crop in that group. Natural crosses may also occur between the vegetables of the 2nd group, but such crosses do not occur as readily as in the 1st group. However, for the production of stock seed 1600 m and for certified seed 1000 m isolation is recommended.

Head Incision

When the cabbage head attains full maturity in December, head cut operation is necessary to help regeneration of the growing point of the core, i.e., facilitate the flower stalk emergence and development. The operation may be done in the following ways.

Cross cut : Two cuts at right angles across the head upto the core so that the seed stalk may develop normally. Too deep cut may injure the growing point.

Side cut : In this system all sides of the head is cut upto the core so that the flower can initiate easily.

After 5-7 days of incision seed stalk emergence will occur. The proper head cutting help the smooth emergence of the flower stalk by removing the binding leaves. Thereafter all the drying leaves are to be removed step by step.

Staking

The developing flower stalks need support. Stalks of about 2m height is given to individual flowering plant.

Harvesting and Threshing

Harvesting can be done when pods are brown. Too ripe pods dehisce. Seed should not crush or split when rubbed between the hands. The harvesting may be done in two lots. Generally the early plants are harvested first, when the pod colour of about 60 to 70 percent of the pods turn brown and the rest of the crop changes to a yellowish brown. After harvesting it is piled up for curing. After 4 to 5 days it is turned up side down and allowed to cure for another four to five days in the same way. It is then threshed with sticks and sifted with hand sifters. After thorough drying of seed in partial sun (up to 7 percent moisture content) it is cleaned and stored.

Seed Yield

Cabbage seed yield varies from 200 to 1000 kg/ha. The seed yield depends on prevailing temperature during the growing season, cool temperature during flowering and seed development results in higher seed yield. Arya (1983) reported an average seed yield of 568 kg/ha in India. In Bangladesh 500-600 kg/ha seed yield is reported from the variety Probati and Agradut when grown in the northern districts, Rangpur and Dinajpur.

Disease-Pests and Their Control

Indiscriminate use of insecticides against insect pests of cabbage seed crop during flowering seriously affects the insect-pollinators resulting in lower seed yield due to decreased population and activity of these pollinators. It is, therefore, essential to avoid indiscriminate use of insecticides. The major disease-pests of cabbage and their control measures are given below.

Insects	Nature of Damage	Control Measures
Aphid	Swarms of insects attack leaves, flowers, pods and suck the juice.	Spraying of Malathion/ Diazinon 50 EC@ 2ml/ litre water
Prodenta catterpiller	Feed on leaves, some times make hole in stem	Spraying of Malathion/ Diazinon 50 EC@ 2ml/ litre water
Diamond back moth	Small caterpillar attack the inner surface of the leaves and suck on them	Malathion/Sumithion/ Ripcord 50 EC @ 2ml

Diseases	Nature of Damage	Control Measures
Alterania leaf spot	Alternaria Bassicicola forms small spots on leaves, stems and pods. The disease is transmitted through seed and soil	Seed treatment with Thiram (10g/ seed) Faliar spraying with Rubral (2ml/ litre of water)
Cercospora leaf spot	Numerous tiny yellow spots appear on the leaves. The disease is transmitted through seed and soil	Seed treatment with Thiram 10 g/seed) Faliar spray of Bavistin or Knowin @1g/litre of water
Black rot	Seed borne disease caused by Alternaria. Small brown to black circular spots appear on leaves, petioles and flower stalks. Causes damage to cabbage and seed crop. cauliflower	Seed treatment with Thiram (10g/ seed) Faliar spraying with Rubral (2ml/ litre of water)

Nutritional Disorders

Cole crops are susceptible to micro-nutrient dificiency. In cabbage boron and molybdenum deficiency has been reported by many workers.

Boron : Boron deficiency has been reported very frequently in cabbage. In seriouly plants the stem becomes hollow and the plant growth is stunted which causes the condition known as 'whiptail'. This may be controlled by applying borax or sodium borate at the rate of 20 kg per hectare (Datta, 1963). In case of acute deficiency, spraying of 0.25 to 0.50 per cent solution of borax at the rate of 1 to 2 kg per hectare would give satisfactory control.

Molybdenum : Due to molybdenum deficiency young cabbage plants become chlorotic, the leaves become cupped and wither. Eventually the leaf dies and the growing plant also collapses and 'whiptail' develops. Application of 0.2 per cent Mo as foliar spray would give satisfactory control.

5.2. CAULIFLOWER

Origin

Cole crops have spread all over Europe from the Mediterranean region, which is supposed to be the centre of origin. Cauliflower was introduced in India in 1822 (Swarup and Chatterjee, 1972).

Botany/Taxonomy

Cauliflower (*Brassica oleracea* var. *botrytis* L.; n=9) belongs to the genus Brassica and the family cruciferae. Like cabbage, cauliflower is a temperate biennial crop and may require low temperature treatment for flower induction in late varieties. However, the Asian varieties are of annual type and can flower and produce seeds under tropical conditions.

Floral Biology and Pollination

The floral parts are formed from the cauliflower curd, the inflorescence is dwarfer and more umbrella-shaped than that of cabbage. There is an absence of central main stem above the point where branching begins. Other than this cauliflower does not differ with cabbage in respect of floral biology and pollination habit.

Varieties

In Bangladesh condition only the Asian/Indian varieties are capable of seed production. Such varieties are marketed by the name of month they mature like Kartika (October-November), Agrahayani (November), Poushali (December) and Maghi (January). These are open-pollinated varieties and are highly heterozygous in respect of all the characters whether vegetative or curd. The following varieties were long been adopted in this country of which seeds are being produced by the seed entrepreneurs also.

Kartika : Early tropical O. P. variety, crop duration 75 days, medium size white curd, yield 12 t/ha. Produces seeds locally.

Agrahayani : Early variety but two weeks late compared to Kartika, self-blanching type, yield 20-22 t/ha. Produces seeds locally, O. P. variety.

Poushali : Medium early variety, medium compact white curd, yield 15 t/ha. Produces seed locally.

BARI Fulkopi-1 (Rupa) : BARI bred open-pollinated variety. The variety has been developed through mass selection from a local strain named "Boiltoli". White compact head, self-blanching type. Yield ranges from 28-30 t/ha from early planting, produces seeds locally; seed yield is 350-400 kg/ha.

Climate and Soil

Cauliflower in general is very sensitive to its climatic requirements, particularly temperature for seed production like cabbage. Cauliflower needs vernalization for flower induction (late varieties). However, the above mentioned varieties, being tropical early varieties, tolerate comparatively high temperature but can not survive at a very high or very low temperature. An average temperature of 18-22°C is favourable for seed production.

Well-drained fertile loamy soil is suitable for cauliflower seed production, though it can be grown on wide range of soils with a high organic matter content. The soil pH should be in between 6.0-7.0.

Seedling Raising

Seedlings are raised on seed beds following double transplanting method. About 300-350g of seed is required for one hectare of land. Seeds are sown in early September.

Manures and Fertilizers

The cauliflower seed crop requires heavy manuring as it removes large quantities of major nutrients from the soil. The following doses have been recommended for cauliflower seed crop.

Famyard manure/compost	20-30 t/ha
Urea	150 kg/ha
TSP	250 kg/ha
MP	220 kg/ha
Borax	10-15 kg/ha
Sodium molybdate	2.0 kg/ha

The entire amount of compost, TSP, Borax, Sodium molybdate and half of the MP are to be applied during final land preparation. The entire urea and rest of the MP are to be applied in three equal installments. It is recommended that one additional dose of Urea and MP (100 kg each per hectare) is to be applied during flowering. Cauliflower crop often shows boron and molybdenum deficiency symptoms. If such symptoms are observed despite the basic doses being given, foliar spray of 0.2 percent borax & sodium molybdate may correct the deficiency.

Planting Time and Method

Like cabbage, cauliflower is very sensitive to temperature for flowering. The sowing time for cauliflower should be so adjusted that the plants have maximum leafy growth by December when the temperature goes down. In Bangladesh condition seeds should be sown in early or middle of September and the seedlings should be transplanted in the middle of October so that the plants attain maximum leafy growth by late November. Such planting time will enable the plants to flower inDecember and seed development upto February.

For cauliflower seed crop 30-35 days old seedlings are planted on raised beds. Tow lines of seedlings are planted in a 1m wide bed having 30 cm wide drains in between the beds. A spacing of 60 x 45 cm is recommended.

Irrigation

Irrgation is given according to the soil requirements and climatic conditions. A crop after transplanting may need irrigation twice a week and later once a week. Adequate moisture supply during flowering and seed development are necessary to obtain high yield.

Roguing

Careful roguing is essential for cauliflower seed production. Cauliflower varieties vary in their morphological characters, especially at the time of maturity. Therefore, off-type plants should be rogued out to bring uniformity in the variety. The characteristic of the curd, such as size, colour, compactness and uniformity are considered while roguing.

Curd Scooping

Scooping the central position of curd when it is fully formed helps in the easy emergence of the flower stalks. Chatterjee and Mukherjee (1962) suggested scooping in very compact varieties for easier bolting and early flowering, besides getting higher seed yields.

Isolation

The cauliflower seed producer must ensure sufficient isolation of this crop from fields of other cauliflower varieties as well as any other Brassicas. However, for the production of stock seed 1600m and for certified seed 1000m isolation is required.

Staking

The flower stalks should be supported with stakes of about 1m height to individual flowering plants.

Harvesting and Threshing

Harvesting can be done when pods are brown. Too ripe pods dehisce. Seed should not crush or split when rubbed between the hands. The harvesting may be done in two lots. Generally the early plants are harvested first, when the pod colour of about 60 to 70 percent of the pods turn brown and the rest of the crop changes to a yellowish brown. After harvesting it is piled up for curing. After 4 to 5 days it is turned up side down and allowed to cure for another four to five days in the same way. It is then threshed with sticks and sifted with hand sifters. After thorough drying of seed in partial sun (up to 7 percent moisture content) it is cleaned and stored.

Seed Yield

Average seed yield of cauliflower is about 200-600 kg/ha depending upon the variety, extent of pollination and management practices.

Disease-Pests and Their Control

Indiscriminate use of insecticides against insect pests of cauliflower seed crop during flowering seriously affects the insect-pollinators resulting in lower seed yield due to decreased population and activity of these pollinators. It is, therefore, essential to avoid indiscriminate use of insecticides.

Insects	Nature of Damage	Control Measures
Aphids	Swarms of insects attack leaves, flowers, pods and suck the ince.	Spraying of Malathion/ Diazinon 50 EC@ 2ml/ litre water
Prodenta catterpiller	Feed on leaves, some times make hole in stem	Spraying of Malathion/ Diazinon 50 EC@ 2ml/ litre water
Diamond back moth	Small caterpillar attack the inner surface of the leaves and suck on them	Malathion / Sumithion / Ripc-ord 50 EC@ 2ml/litre of water

Diseases	Nature of Damage	Control Measures
Alternania leaf spot	*Alternaria Brassicicola* forms small spots on leaves, stems and pods. The disease is transmitted through seed and soil	Seed treatment with Thiram (10 g/kg seed) Foliar spraying with Rubral (2ml/litre of water)
Cercospora leaf spot	Numerous tiny yellow spots appear on the leaves. The disease is transmitted through seed and soil	Seed treatment with Thiram 10 g/kg seed) Faliar spray of Bavistin or Knowin @1g/ litre of water
Black rot	Seed borne disease caused by Alternaria. Small brown to black circular spots appear on leaves, petioles and flower stalks. Causes damage to cabbage and cauliflower seed crop.	Seed treatment with Thiram (10 g/kg seed) (Faliar spraying with Rubral (2ml/litre of water)

Physiological Disorders

Buttoning : The general basis of buttoning may be explained that any check in the vegetative growth of the seedling may induce buttoning. The transformation from vegetative to curding in a cultivar of cauliflower is dependent on temperature. Late planting of tropical early varieties causes buttoning resulting very poor seed yield.

Riceyness : According to Wiebe (1975), a premature initiation of floral buds is characterized by riceyness in cauliflower. It has been found that such disorder may result from any temperature higher or lower than the optimum required for a particular cultivar.

Nutritional Disorders

Boron : Boron deficiency has been frequently reported in cauliflower. The symptom of boron deficiency is not very apparent till the curd development. The frist symptom is the appearance of small water soaked areas in the centre of the curd. In advanced stages, pinkish or rusty-brown areas develop on the surface of the curd. This may be controlled by applying borax or sodium borate at the rate of 20 kg per hectare (Datta, 1963). In case of acute deficiency spraying of 0.25 to 0.50 percent solution of borax would give a satisfactory control.

Molybdenum : Cauliflower responds severely to the deficiency of molybdenum and the damage may be considerable. Young cauliflower plants become chlorotic, cup-shaped and finally wither. Application of Mo 2 kg per hectare may correct the deficiency.

5.3. RADISH

Origin

Radish is probably originated in Western Asia, was cultivated in ancient Egypt, Greece and Rome. It is now spread throughout the world.

Botany/Taxonomy

Radish (*Raphanus sativus* L., n=9) is a member of cruciferae family. Depending upon flowering radishes may be classified as annual and biennial. The annuals are of mainly tropical origin and do not require chilling for flower induction while the biennials are of temperate origin and require chilling for flowering and seed production. Both types produce fleshy tap roots together with a rosette of leaves arising from a shortened stem.

The inflorescence is the typical terminal raceme of the crucifers, and the flowers are white, rose or liliac in colour. Radish is highly cross-pollinated crop, pollination occurs primarily by honeybees. Flowers open during the day time from 8:00 A. M. onward. Dehiscence generally takes place at warmer temperature condition.

Radish fruits differ from that of other crucifers in that it is not a siliqua but a true pod, about 2.5 to 7.5 cm with a pithy interior.

Varieties

Considering the factor of seed production, the radish varieties can broadly be divided into the following groups

Temperate varieties which produce seeds in the temperate areas by over wintering. They are biennials and include Japanese, European and American winter radishes. They require chilling for flower initiation. The popular Japanese varieties Miashige, Minowase and Minoearly are temperate biannials and are not capable of seed production in the tropical climate.

Tropical varieties which do not require chilling for seed production and produces seeds freely in the plains, e.g. Tasaki Mula, BARI Mula-2, BARI Mula-3 and Pusa Chetki (India).

The main features of BARI developed tropical radish varieties which produce seeds under Bangladesh condition are given below:

BARI Mula-1 (Tasaki Mula) : Cylindrical white roots, become harvestable after 45 days of sowing and remain edible upto 75 days without loss of quality. Root yield is 75 t/ha and seed yield about 1.2 t/ha. The variety was developed by BARI through mass selection and was released in 1983 (Rashid et al., 1985).

BARI Mula-2 (Pinky) : Attractive pink colour roots with white, crisp and slighttly pungent flesh. The roots are 30-40 cm long with semi blunt end, become harvestable after 50-55 days of sowing and remain edible upto 75 days. Average root yield is 60 t/ha. Produces seed abundantly in the northern districts of Bangladesh (Rangpur and Dinajpur), seed yield is about 1.0 t/ha. The variety was developed by BARI through mass selection and was released in 1996.

BARI Mula-3 (Druti) : White cylindrical roots, quick growing, takes 40-45 days for harvest. Average root yield is 55 t/ha and seed yield is 1.2 t/ha. The variety was developed and released by BARI in 1998.

Climatic Requirements

Radish is best suited to a cool moderate climate, especially in the vegetative stage. For seed production, a less humid climate is desirable. Long spells of hot dry periods are not suitable for seed production. Temperatures of 32°C or above can cause the stigma to dry and the pollen may fail to germinate. Considering the climatic requirements, the northern districts of Bangladesh are suitable for radish seed production. However, in Bangladesh condition the tropical annual type varieties are suitable for seed production, the temperate biannial varieties do not produce seed in Bangladesh.

Land Requirements

The land should be selected considering the fact that the same kind of crop was not grown within the previous two years to contain seed borne diseases beyond maximum permissible levels. Fertile loams are best suited, also grows well in light sandy soils with liberal application of organic manure. Heavy clays are not suitable. Slightly acidic reaction is favourable.

The soil for radish should be thoroughly prepared so that there is no clod to interfere with the root development. The soil should not contain any undecomposed organic matter, because they may result in forking or deformed roots.

Manures and Fertilizers

Radish is a short duration crop, hence judicious and proper use of manures and fertilizers are essential to get good seed yield. BARI recommended the following doses of manures and fertilizer :

Manures/compost	25-30 t/ha
Urea	300 kg/ha
TSP	200 kg/ha
MP	200 kg/ha
Borax	10-15 kg/ha
Sodium Molybdate	2.0 kg/ha
ZnO	4.0 kg/ha

The entire amount of compost, TSP, borax, sodium molybdate and half of the urea and MP are applied during final land preparation while rest of the urea and MP are applied in two equal instalments. The first top-dressing is given at root formation stage (2 weeks after sowing) and the second at flowering stage.

Radish seed crop often shows boron, molybdenum and Zn deficiency. Therefore, application of these micro-nutrients is very important.

Time and Method of Sowing

Radish seeds are sown in lines 30 cm apart in both ways (line to line and seed to seed). It is preferable to sow the seeds on beds. For seed crops seeds are sown during mid September to October. Two to three seeds are sown per hill. After germination one plant is kept in a hill. It is to be noted that there is sufficient soil moisture during seed sowing. In case of moisture deficiency irrigation should be given through the drain. About 4-6 kg seed is required per hectare of land.

Method of Seed Production

Both seed-to-seed and root-to-seed methods are employed for radish seed production. Seed-to-seed method is preferred for raising certified seed. The nucleus seed, however, is invariably produced by root to seed method. In this method the roots are uprooted and planted again before the onset of reproduction phase. In Bangladesh, radish seed is largely produced by root-to-seed method.

Root-to-Seed Method

In root-to-seed method, fully matured roots (before pith development) are harvested, true-to-type roots are selected and after giving proper root and shoot cuts they are transplanted in a well prepared field. Rashid et al. (1987) obtained highest seed yield in cv. Taski Mula from 1/4th root cut and 2/3rd shoot cut. The selection and roguing are done on the basis of foliage characters, root shape, size, colour, flesh colour, pithiness, pungency and bolting behavior. Small, deformed, diseased and other undesirable roots are discarded. Hairy, forked roots and early or late bolters are also removed. For high yield of good quality seeds, radish stecklings are planted at a spacing of 45 x 30cm. The field prepared for steckling planting should be fertilized with 200 kg urea and 150 kg MP/ha.

Seed-to-Seed Method

Usually commercial market seed is grown by this simpler method. The annual radish crop is sown in mid-September through October at a spacing of 45 x 45 cm in a well prepared land. Rashid et al. (1989) obtained highest seed yield in BARI Mula-1 (Tasaki Mula) from mid-October sowing in Bangladesh condition. The crop is allowed to grow and produce seed at their original position *(in situ)*. Rigorous roguing should be used to raise seed-to-seed crop.

Irrigation

Supply of moisture depends upon season, type of soil and amount of organic matter present. For rapid germination of seeds and production of tender and attractive roots, the soil should contain plenty of moisture. During flowering and seed development sufficient moisture should be provided.

Isolation Requirements

Radish is a cross-pollinated crop and honeybee is mainly responsible for pollination. Seed fields must be isolated from other variety of radish, and the same variety not conforming to varietal purity requirements by at least 1600 m for foundation seed and 1000 m for certified seed production.

Flowering and Fruit Setting

Honeybees are the chief pollinating agents. Kremer (1945) demonstrated that seed yield in radish is greatly influenced by the number of honeybees visiting the flowers. Those bee hives may be provided at the time of flowering field for higher seed yield.

Care After Bolting

Weeds, especially wild radish, wild turnip, wild mustard should be all removed from the radish field to avoid possible cross-pollination. One or two irrigation may be given after flowering which results in better seed yield. Sometimes staking is done to provide support to the seed stalk.

Harvesting, Threshing and Storage

The seed plants are allowed to mature fully before harvesting, since there is no natural dehiscence, and there is often considerable difficulty in threshing the seed from the pod. Plants are cut when most of the pods are brown. The crop is cut by sickle and brought to the threshing floor for thoroughly drying. The drier the pods, the more easily will they break open during threshing process. Threshing can be done by beating with sticks. The seed after sifting should be dried to 6-8 percent moisture content before storage.

Seed Yield

The average seed yield ranges from 500 to 1000 kg/ha; higher yields upto 1400 kg/ha can be obtained under favourable condition. Rashid et al. (1985) reported 1200 kg seed yield per hectare in BARI Mula-1 (Tasaki Mula) in Bangladesh condition.

Disease and Pest Management

Indiscriminate use of insecticides against insect pests of radish seed crop during flowering seriously affects the insect-pollinators resulting in lower seed yield due to decreased population and activity of these pollinators. It is, therefore, essential to avoid indiscriminate use of insecticides.

Insects	Nature of Damage	Control Measures
Aphids	Swarms of insects attack leaves, flowers, pods and suck the juice.	Spraying of Malathion/ Diazinon 50 EC @ 2ml/ litre water
Prodenta catterpiller	Feed on leaves, some times make hole in stem	Spraying of Malathion/ Diazinon 50 EC @ 2ml/ litre water
Diamond back moth	Small caterpillar attack the inner surface of the leaves and suck on them	Malathion / Sumithion / Rip-cord 50 EC @ 2ml/ litre of water

Diseases	Nature of Damage	Control Measures
Alternania leaf spot	Alternaria Brassicicola forms small spots on leaves, stems and pods. The disease is transmitted through seed and soil	Seed treatment with Thiram (10g/ kg seed) Faliar spraying with Rubral (2ml/litre of water)
Cercospora leaf spot	Numerous tiny yellow spots appear on the leaves. The disease is transmitted through seed and soil	Seed treatment with Thiram (10 g/kg seed) Faliar spray of Bavistinor Knowin (1 g/litre of water)

CHAPTER VI

SEED PRODUCTION IN CUCURBITS

The family cucurbitaceae consists of about 117 genera and 825 species out of which about 15 different species (Table 4) of cucurbitaceae are being cultivated in Bangladesh since long time. They have numerous resemblance in gourd development and similarities of root habit. They are also quite similar in their internal anatomy and development (Whitaker & Davis, 1962).

Experience has shown that good seed is essential for the production of a satisfactory crop of cucurbits, whether the producer is a backyard gardener or a large-scale farmer. Seed production methods including cultural practices of pumpkin, cucumber, bottle gourd and watermelon will be discussed in Part-I, II, III & IV respectively. The cultivation methods for the production of these crops for seed are similar as growing the crops for fresh market barring some important factors followed for seed production like roguing, isolation, to allow the crop to reach in full maturity, seed extraction, seed processing and storage etc.

Table 4. List of cultivated cucurbits in Bangladesh.

Sl. #	English name	Bengali name	Botanical species	Chromosome number (2n)
1.	Pumpkin	Misti kumra or misti lau or misti kadu	*Cucurbita moschata* (Duch) Poir	40
2.	Bottle gourd	Kadu, Lau	*Lagenaria siceraria* (Mol) Standl.	22
3.	Wax or ash gourd	Chal kumra	*Benincasa hispida* (Thunb.) Cogn.	24
4.	Cucumber	Shasha/Khira	*Cucumis sativus* L	14
5.	Snake gourd	Chichinga	*Trichosanthes anguina* L.	24
6.	Pointed gourd	Patal	*Trichosanthes dioica* Roxb.	24
7.	Teasle gourd	Kakrol	*Momordica dioica* Roxb.	28
8.	Bitter gourd	Karola	*Momordica charantia* L.	22
9.	Ridge gourd, Ribbed gourd	Jinga, Torai	*Luffa acutangula* L. (Roxb.)	26
10.	Sponge gourd	Dhundul, Torai	*Luffa cylindrica* L.	26
11.	Watermelon	Tarmuz, Tarbuz	*Citrullus lanatus* (Thunb.) Matsumura and Nakai	22
12.	Muskmelon/Snapmelon	Phuti, Bangi	*Cucumis melo* var. *momordica* L.	24

Botany

Roots : The root system of all the economic cucurbits is extensive but shallow. Upon germination of the seed, the plants soon develop a strong tap-root which may penetrate the soil to a depth of 3 or 4 to 6 ft. Numerous horizontal laterals develop rapidly and spread widely in the soil, although branching of the tap-root is not extensive below the 2 ft level.

Stems : All cucurbits are alike in their general stem morphology. The stems are branched (3 to 8), prostrate, trailing, hirsute to scabrous and usually angled in cross section. In most species, the stems grow to a length of several meters, and in a few species the stems may reach a length of 9 to 10 meters under abund andromonoecious, hermaphrodite, gynoecious forms are also met with, of which first 3 are stable form.

Fruits : The fruits of the cultivated cucurbits vary largely in size, shape and colour. Fruits are essentially a berry, even though called a pepo, because of hard and tough rind (when completely mature) as in bottle gourd. The fruit peduncle is 5 to 8 angular. The edible portion is placentae in cucumber and watermelon, pericarp with very little mesocarp in pumpkin, while the whole fruit in bottle gourd.

Seeds : The seeds of the cultivated cucurbits vary in size, shape, colour, the presence or absence of a margin and in the type of scar formed at the hilum. In general, each seed has a firm testa of several layers, a thin collapsed perisperm and endosperm and a large embryo. The embryo consists of two large, flat, leaf like cotyledons and a small redicle.

Taxonomy

Muller & Pax (1894) have divided the Cucurbitaceae into five sub-families:

1. Fevilleae
2. Melothrieae
3. Cucurbiteae
4. Sicyoideae and
5. Cyclanthereae

The important cultivated genera are found only in the sub-families Cucurbiteae and Sicyoideae. The Cucurbiteae includes the genera are (i) Citrullus, (ii) Cucumis, (iii) Luffa, (iv) Lagenaria and (v) Cucurbita and the Sicyoideae include the genus (vi) Sechium.

Flowering

Flowering in cucurbits normally starts in about 40-45 days after sowing depending upon the weather condition. The sequence of flowering follows a set of pattern, namely (i) male phase: First few nodes bear only the staminate flowers, (ii) Mixed phase: both pistillate and staminate flowers appear in few nodes in the main axis and secondary branches in cycles and (iii) female phase: few nodes produce mostly the pistillate flowers. In a typical monoecious sex form of cucurbits the ratio of staminate and pistillate flowers may range from 25 to 30:1 to 15:1, the later condition is advantageous and economical, because consequently it results higher fruit set and yield. Generally high nitrogen, long days and high temperature promote greater number of staminate flowers.

Sex Expression

Cucurbits exhibit a wide range of sex form such as (i) monoecious (ii) dioecious, (iii) hermaphrodite, (iv) gynomonoecious (v) andromonoecious and (vi) trimonoecious.

In sex forms, although a species character, a wide range of exceptions have been reported in cucurbits. Though the sex of *C. sativus, Citrullus vulgaris, C. moschata* typically monoecious exhibit exceptional sex forms such as andromonoecious in the first two cases and hermaphrodite in the later cases in their respective varieties of 'Lemon Banana'. 'Siberian sweet", 'new winter' and 'Japanese Chirimen'. Sex of *Lagenaria vulgaris* has been reported to be typically monoecious (Whitaker, 1931). Kalia and Dhillon (1964) however, observed trimonoecious forms in *Lagenaria siceraria* grown during the extreme cool season. Apart from it sex ratio of each species, varied from the characteristic type (Whitaker, 1931). Phatak (1959) found variations in the quantitative ratios of different sexes in different varieties of *C. sativus*.

Pollination and Fruit Set

Anthesis, pollen dehiscence and fruit set in cucurbits are influenced by environmental factors. Usually fruit set takes place early in the morning between 6:00 A. M. to 8:00 A. M. in crops like cucumber, pumpkin and watermelon etc. Optimum temperature during this period would range between 12.8°C to 18.3°C (Bose et al., 1986). There are other cucurbits which flower later in the day and fruits set at higher temperature of mid day as in bottle gourd etc.

Monoecious condition in cucurbits imposes a situation conducive to cross-pollination, however, a limited percentage (20-40%) of natural self-pollination takes place within the same plant. The andromonoecious condition favours a higher degree of natural self-pollination than in the monoecious condition.

For maximum fruit set and seed yield, two bee colony per hectare would be required. As a single fruit of a cucurbit contains a large number of seeds, hand pollination should be followed for quality seed production in cucurbits. By hand pollination fruit set can be increased in cucurbits resulting increased seed production. For example, Musiiko (1941) observed about 30 to 35 percent increase in the fruit set of cucumber with hand pollination as compared to natural pollination. In case of hand pollination male and female flower should be bagged before the day of anthesis. Afterwards, when anthesis take place, butter paper bags are opened and petals of male flower are removed and anther are gently rubbed on the stigma, then again female flowers are to be bagged for 2-3 days to avoid contamination by foreign pollen. After 3 to 4 days of pollination, bags can be removed.

6.1. PUMPKIN

Climate : The areas having long period (at least 160 days) with warm, abundance sunshine and low humidity are ideal for successful production of seeds of this crop. It grows best at 18-200°C but can't withstand at minimum 15°C and maximum 45°C.

Soil

Soil containing an abundance of humus, or an abundant supply of organic matter, are considered the most desirable for the culture of pumpkin. The best results being obtained on soils which are near neutral or slightly alkaline. However, loamy soil rich in organic matter with a pH value of 5.5-6.8 is the best for successful production of pumpkin.

Varieties

There is no released variety of pumpkin in the country. A land race named 'Baromashi' improved by BADC is popularly cultivated. However, Vegetable Division of BARI is working on a good number of germplasm with a view to develop variety (s) with good quality.

Sowing Time and Seed Rate

Seeds may be sown from October to December for winter crop and February to May for summer crop. For seed production mid November is the best time for seed sowing. Five to seven kg of seeds may be required to plant one hectare of land.

Seed Treatment

Seeds need to be treated with Vitavax or Captan at the rate of 2 g/kg before sowing to avoid seed borne diseases.

Seedling Raising and Transplanting

Seedlings are needed to be grown in a nursery. Two seeds are sown in polybags of 6 x 8 cm size. The growth medium is prepared by mixing compost and soil in 50:50 proportion. Intensive care is necessary during seedling production. Sixteen to twenty days old seedlings are transplanted in the prepared pit. These are watered immediately after transplanting and it continued every afternoon till seedling establishment. Finally vigorous seedling is allowed to grow in the field.

Land Selection and Preparation

The well drained land should be selected with irrigation facilities and sufficient sunshine. The land should not be used in previous year for growing such type of crop. Land is prepared by 4 to 5 cm deep with cross ploughing and harrowing followed by laddering.

Preparation of Pits and Planting Methods

20 cm raised and 2 m width beds are to be prepared as convenient depending upon the land size. Pits of 45 x 45 x 40 cm size are to be prepared 2 m apart in a single row along the bed. The top of pit is to be kept little bit above the bed level. Centre of the pits are to be kept 50 cm apart from the bottom side along the irrigation channel and 1m from the top/bottom side of the bed. For commercial fruit production pits are to be prepared in double lines. In this case, width of the bed will be 2.5 m and centre of the pits will be 40 cm apart from both of the bed sides keeping 1m in one line and 2m in another line from the top/bottom side of the bed. Between the beds 50 cm drains are to be prepared. In case of single line planting, drains are used for irrigation/drainage alternatively and double line planting all drains are used for irrigation and drainage simultaneously. Main irrigation and drainage channel should be 70-75 cm wide.

Fertilizer Dose and Methods of Application

Sufficient nutrient supplies are essential for its successful production for fresh market as well as seed. The kind and quantity of fertilizer needed depend on the soil type and the amount of nutrients already available in the soil. As it is difficult to attempt specific recommendation for every area of pumpkin production, the general recommendations as suggested in Table 5, based on experimental evidence, may prove beneficial in those areas where more specific information is not available.

Table 5. Manures and fertilizers recommended for pumpkin per hectare

Manure/ Fertilizer	Dose (Kg/ha)	During land preparation (kg)	5-6 days prior to seedling transplanting in pit (kg)	20-25 days after transplan-ting (kg)	During flowering (kg)	During fruit setting (kg)
Cowdung	1600	800	800	-	-	-
Urea	175	-	50	50	30	45
TSP	175	75	100	-	-	-
MP	150	25	50	25	25	25
Gypsum	100	100	-	-	-	-
Zinc	12	12	-	-	-	-
Borax	10	10	-	-	-	-

Irrigation

In dry weather, pumpkin should be irrigated at every 5-6 days interval. The crop when sown during rainy season should be irrigated as and when necessary. Excessive water during ripening causes rotting and reduces sugar content of fruits of pumpkin, watermelon etc.

Weed Control

The field should be kept free from weeds until harvesting. Certain weeds act as harbour of some virus diseases and insect pests by which the crop may be infected. Hand-hoeing is recommended for weed control. Early hoeing may be fairly close to the plants, and at a shallow (2-4 inch) depths. Subsequent hoeing should be relatively shallow and not immediately adjacent to the plants. After the vines cover the ground in case of pumpkin and watermelon, hoeing is stopped, but it is necessary during that time to go through the field and pull out the weeds.

Other Cultural Practices

After each irrigation mulching should be done to break the crust of the soil and to keep granular surrounding the base of the pit. The first 2-3 side branches near the base of the plant should be removed. Earthen plate may be put turning upside down under each fruit of those crops which grow on the ground like pumpkin, watermelon etc to avoid fruit rotting. Plastic mulch also can be used under the fruits.

Isolation

To maintain genetic purity of the seed, the recommended isolation distance between seed crops of different cultivars of the same species is 800 m for foundation seed and 400m for certified seed. Crops for basic seed production should be isolated by at least 1500 m (George, 1985). If adequate isolation distance could not be provided, hand pollination must be followed.

Roguing

Roguing is done at 4 stages in pumpkin as follows :

Early Vegetative Stage : The plants whose vegetative characters (e.g. bush or trailing type), foliage and vigour and resistance to specific pathogens are not in accordance with the cultivar description, should be removed.

Before First Flower Open : Plants having under developed fruit or female flower buds, whose characters are not true to type, should be removed.

First Fruit Setting : Developing fruits of such a plant which are not typical of the cultivar should be removed alongwith the whole plant itself.

Harvesting of Fruit for Seed Extraction

For seed extraction fruits should be harvested at full maturity. Several factors are taken into consideration to judge the maturity in pumpkin which are: (i) When fruit colour changes to yellow or yellow orange or straw colour, (ii) when the peduncle becomes straw coloured and (iii) when the vines start drying. Any delormed fruit should be removed earlier.

Seed Extraction and Washing

Before seed extraction fruits should be stored in room temperature for 4 to 7 weeks spreading in one single layer with a space between the fruits preferably in a cooler dry place. Afterward, the fruits are cut into half and scoop out the seed by hand. Some placenta may remain with the seeds which are to be separated by rolling and raking simultaneously. Then the seeds are to be washed with water in troughs.

Seed Drying

The washed seeds should be dried quickly. For this, trays with screen wire or burlap bottoms may be used. The seeds are spread on trays and placed in the shade and gradually to sun to dry and continued upto a moisture level of 7 percent. Frequent turning of seeds will ensure uniform drying.

Seeds may be dried more rapidly in a drier or dehydrator employing artificial heat and forced air circulation for large quantity. Seed should be dried carefully at a temperature not exceeding 38-42°C.

Seed Storage

For safe storage, moisture content of the seeds should be 7 percent (Harrington, 1959). Moisture determinations should be made on properly drawn samples of seed at the temperatures prevailing in the seed storage facility. The well dried seeds are placed in containers and stored in a cool, well-ventilated room, preferably provided with some means of dehumidification, and with protection from rats and other pests. For retail sale, tin can with moisture resistant polytheylene or aluminium foil as wrap or liner can be used.

Seed Yield

The average seed yield is about 500-1000 kg per hectare depending upon the cultivar, pollination and cultural managements.

Disease and Insect and Their Control

Described in Table-9.

6.2. CUCUMBER

Climate

The plants prefer a warm climate and do well in areas with 30°C temperature during day and 18-24°C at night. Below 15°C and above 35°C temperature do harm to the natural plant growth and thereby reduce the yield.

Soil

Silty-loam and clay-loam soil with a pH value of 6.5 or slightly above containing sufficient organic matter are most suitable for its successful production though it can be grown also in sandy or sandy-loam soil.

Varieties

There is no released variety of cucumber yet in Bangladesh but research is going on at BARI on this aspect. BADC is producing seeds of two local cultivars named 'Baromashi' and 'Patia Giant'.

Sowing Time and Seed Rate

Seeds are to be sown from February to March. About 2.5 to 3.5 kg of seed is required for one hectare.

Land Selection and Preparation

As described for pumpkin

Fertilizer Dose and Methods of Application

The areas where specific recommendations for cucumber are not available the general recommendations mentioned in Table-6 will be beneficial.

Table 6. Fertilizer dose and methods of application for cucumber per hectare

Manure/ Fertilizer	Dose (Kg/ha)	During land preparation (kg)	5-6 days prior to seedling transplanting in pit (kg)	15 days after transplan-ting (kg)	During flowering (kg)	During setting/ har vesting (2 splits at 15 days interval) (kg)
Cow-dung	1500	700	800	-	-	-
Urea	175	-	50	50	25	25 + 25
MP	150	25	50	25	25	25 + 0
TSP	175	75	100	-	-	-
Gypsum	100	100	-	-	-	-
Zinc	12	12	-	-	-	-
Borax	10	10	-	-	-	-

Seedling Raising and Transplanting : As described for pumpkin

Preparation of Pits and Planting Methods

20 cm raised and 1m width beds are to be prepared as convenient depending upon the land size. Pits of 40 x 40 x 30 cm size are to be prepared 1m apart for fresh fruit production and 1.5 m apart for seed production in a single line along the bed. The top of the pit is to be kept little bit above the bed level. Centre of pits are to be kept 40 cm apart from the bottom side along the irrigation/drainage channel and 50 cm and 75 cm from the top bottom side of the bed for fresh and seed production respectively. Between beds 50 cm distance is kept for irrigation/drainage and 30 cm for drainage alternatively. Main irrigation and drainage channel should be 70 cm wide.

Irrigation, Weed Control, Other Cultural Practices : As described for pumpkin.

Support

Support is necessary for fresh fruit as well as seed production in cucumber. For this, net-wire or thin rope of jute and bamboo may be used as trellis for climbing the vines.

Isolation : As described for pumpkin

Roguing

Roguing is done at 4 stages in cucumber as follows :

Before 1st Flowers Open : At this stage roguing should be done considering growth habit, vigour and foliage typical of the cultivar.

Early Flowering : Roguing is done on the basis of observable characters of underdeveloped fruit, especially colour of spines and whether any specific seed-borne diseases are present.

Fruit Setting : Off-types are rogued out considering the following factors such as (a) satisfactory level of productivity, (b) fruit characters, including size, shape and colour.

Ripe Fruit : Off-types are rogued out considering the colour of ripe fruits in accordance with cultivar description, e.g. fruits either green, yellow, white and orange.

Fruit Harvest for Seeds

Any malformed or deformed fruits should be removed earlier and only healthy fruits are selected for seeds. The fruits are allowed to ripen fully. The factors are taken into consideration to judge full maturity in cucumber as follows : (i) Yellow or brown or brownish-yellow or rusetting skin colour of fruit, (ii) Carpel separation in transverse section of fruit, (iii) fruit stalk adjácent to the fruit withers, (iv) mature seeds separate easily from the interior flesh. After full maturity fruits are harvested and kept 5-7 days for post-harvest maturity spreading in one single layer with a space between the fruits in a shade dry place under ordinary condition.

Seed Treatment, Seed Drying and Seed Storage : As described for pumpkin

Seed Yield

The average seed yield is about 400-700 kg per hectare depending upon cultivar, extent of pollination and cultural management.

Disease and Insects Including Their Control Measures : As described in Table-9.

6.3. BOTTLE GOURD

Climate

Bottle gourd can withstand at minimum 10°C and maximum 40°C, but prefers the climate which is dry and neither very cold nor very hot. Winter season of Bangladesh is favourable for its successful production.

Soil

As described for pumpkin

Varieties

BARI has developed one high yielding variety of bottle gourd namly BARI Lau-1 which can be grown successfully in winter. The fruits are long, light green and narrow. Besides this, BADC produces seeds of two cultivars namely 'Khet lau' and 'Hazari'.

Sowing Time and Seed Rate

Suitable seed sowing time for edible fruit production is August to October. Late October sowing is best for seed production. Five to seven kg of seeds is required for one hectare.

Land Selection and Preparation

As described for pumpkin

Fertilizer Dose and Application Methods

The areas where specific recommendations for bottle gourd are not available the general recommendations mentioned in the following Table may be beneficial.

Table 7. Fertilizer dose and application stages for bottle gourd per hectare

Manure/ Fertilizer	Dose (Kg/ha)	During land preparation (kg)	5-6 days prior to seedling transplanting in pit (kg)	20-25 days after transplan-ting (kg)	During flowering (kg)	During fruit setting/harvesting (2 splits at 20 days interval (kg)
Cow-dung	1600	800	800	-	-	-
TSP	175	75	100	-	-	-
MP	150	25	50	25	25	25 + 0
Urea	175	-	50	50	25	25 + 25

Seed Treatment

As described for pumpkin

Seedling Raising and Transplanting

As described for pumpkin. It is useful to soak the seeds of bottle gourd in water for 15-20 hours before sowing for easy and early germination.

Preparation of Pits and Planting Methods

As described for pumpkin. The trellis needs to be provided for this crop. Bamboo or net wire or any other likewise materials can be used for this purpose.

Irrigation

As described for pumpkin.

Weeding

As described for pumpkin.

Other Cultural Practices

As described for pumpkin.

Isolation

As described for pumpkin

Roguing

As described for pumpkin

Fruit Harvest for Seed

Any deformed or malformed fruits should be removed earlier. The rest of the fruits are allowed in the plant to ripen fully to dry. When fruits become dry and seeds rattle inside the shell, the fruits are harvested for seed extraction.

Seed Extraction

Usually extracted by breaking open the dry and mature fruits.

Seed Drying and Cleaning

Seeds are washed in clean running water and dried upto 7% moisture level.

Seed Storage

As described for pumpkin

Seed Yield

It may be more than 500 kg per hectare depending upon cultivar, successful pollination and management practices.

Disease and Insect and Their Control

As described in Table-9.

6.4. WATERMELON

Climate

The crop requires a long growing season with warm, dry and abundant sunshine for its best growth and quality. The average temperature of 25°C during crop period and 28-30°C during fruit ripening is needed. Its growth and fruit set is hampered below 25°C.

Soil

It grows best in fertile, well-drained and sandy loam soils with a pH value of 5-6.8.

Varieties

There is no released variety of watermelon in the country. BARI developed a F1 variety namely 'Padma'. The seeds of some hybrid varieties such as Top Yield, Glory, Big Top from Japan; Champion form South Korea; Empire, Giant Red, World Queen from Taiwan; World King, Island Star, Crown, Sugar Empire and Field Master from China are being imported for their fruit production in the country. There are also some famous open pollinated varieties developed by USA such as Charleston Gray, Dixie Queen, Klondike, Jubilee, New Hampshire Midget, Dessert King and Congo etc which can be grown in the country. There is another famous open pollinated vareity, Sugar Baby, is being grown successfully in South-East Asia which can be recommended for its production in the country. It yields small fruits of 2-3 kg.

Sowing Time and Seed Rate

Due to temperature variation in the North and South of the country, the seeds can be sown in the North in the late January or 1st week of February and 1st week of January in the South. For the early crop, seed can be sown in the 1st fortnight of December in Chittagong, Comilla, Noakhali, Jessore and Natore. About 1.5 to 2 kg of seeds is required to plant one hectare of land.

Land Selection and Preparation

As described for pumpkin.

Fertilizer Dose and Methods of Application

The areas where specific recommendations for watermelon are not available the general recommendations mentioned in the following Table may be beneficial.

Table 8. Fertilizer dose and application methods for watermelon

Manure/ Fertilizer	Dose (Kg/ha)	During land preparation (kg)	5-6 days prior to seedling transplanting in pit (kg)	10-15 days after transplan-ting (kg)	During flowering (kg)	During fruit setting/harvesting (2 splits at 15 days interval (kg)
Compost/ Cow-dung	10000	5000	5000	-	-	-
Urea	200	-	40	60	30	35 + 35
TSP	175	75	100	-	-	-
MP	250	25	50	50	50	40 + 35
Gypsum	100	100	-	-	-	-
Zinc	12	12	-	-	-	-
Borax	10	10	-	-	-	-

Seed Treatment

As described for pumpkin.

Method of Sowing/ Transplanting

Direct Seeding : Direct sowing saves times and labour. But if the seeds are sown in the field after harvesting rice, the harvesting of watermelon will be late which forces the fruits to hailstorm damage. In this method 2-4 sprouted seed should be planted in each pit. When seedlings will attain 3-4 true leaf stage, thinning should be done keeping two healthy seedlings in each pit.

Transplanting Method : Transplanting method provides some advantage of watermelon cultivation. (i) Needs less quantity of seeds, (ii) Easy management of seedlings, (iii) Possibility of raising seedlings in advance. Sprouted seeds (one seed/pot) are sown in 8 cm dia poly bags. The seedlings may be covered with polythene sheets to protect them from cold injury during winter season. Thirty days old (4-5 leaf stages) seedlings are good for transplanting in the field.

Irrigation

Watermelon crop growth hampers when soil moisture falls below 40-50% of the field capacity, even though the plant may still be green & healthy. Therefore, irrigation should be given based on the crop and soil condition. Furrow irrigation is the best method of irrigation in watermelon.

Mulching

When the vines have grown to a certain extent, the plants should be mulched by rice straw, wheat straw, water hyacinth or tree branches. The effects of mulching are-

- Keeping the soil moist.
- Keeping the soil warm.

- Protecting the plants from soil dust, disease and insects.
- Controlling of the overgrowth of weeds.
- Preventing the fruit injury from soil.

Pollination

Watermelon is monoecious in nature and its fertilization is entomophillous. Sometimes, problem of fruit setting occurs in some part of our country due to the non-availability of insects in early morning during winter season. In this case, hand pollination showed some good result in fruit setting. Hand pollination is accomplished by transferring pollen of a new staminate flower to the stigma of a pistillate flower which blossoms on the same day.

Pruning

Pruning and training followed by hand-pollination is a good practice for increasing yield of watermelon. When all the vines of watermelon are allowed to grow, they overlap each other and reduce fruit production. Densely growing vines disturb the entomophillous fertilization and excessive vegetative growth also impairs the reproductive stage of the plant. Main vine and three lateral vines growing vigorously at the base of plant are kept and other lateral vines are pruned out. Pruning should not be done after fruit setting and one fruit should be allowed to develop on each vine in order to get good quality of fruits.

Isolation

As described for pumpkin.

Roguing

Roguing is done at 4 stages in watermelon as follows :

Early Vegetative Stage : The plants whose vine growth, leaf shape and colour and resistance to specific pathogens are not in accordance with the cultivar description, should be removed.

At early Flowering : Plants, having underdeveloped fruit on female flower buds whose characters are not true to type, should be removed earlier to prevent the out crossing of surrounding plants by the off-type pollen.

Fruit Developing : Developing fruits of such a plant which are not typical of the cultivar, should be removed earlier alongwith the whole plant.

Marketable Fruit : Fruits, whose skin, colour, size, shape and quality (TSS, flesh colour etc.) are not in accordance with cultivar description, should be removed.

Fruit Harvest for Seed

Well matured fruits are harvested for seed extraction. Seed maturity in watermelon coincides with edible maturity and so there is no difference in picking stage. However, it is useful to harvest fruits for seed at least one week later than the optimum stage for marketing. For seed collection, fruits need to be verified for flesh colour and percent TSS content. The fruits scoring less than 9% TSS should be rejected.

Seed Extraction and Washing

As described for cucubmer.

Seed Drying

As described for pumpkin.

Seed Storage

As described for pumpkin.

Seed Yield

The average seed yield of most watermelon cultivars under good conditions is bout 400 kg/ha.

Table 9. Insect-pests of cucurbits and their control

Disease Symptoms and Control

Diseases	Susceptible crops	Symptoms	Control measures
Powdery mildew	Pumpkin, cucumber, bottle gourd, watermelon (in some cases) and some other cucurbits	• Nearly white or fluffy symptoms, some white circular patches or spots appear first on the undersurface of the leaves. • In severe cases, these spread, coalesce and cover both the surfaces of the leaves and spread also to the petioles, stem etc. • Severely attacked leaves become brown and shriveled and defoliation may occur.	• Crop rotation and clean cultivation are to be followed • Thiovit @2 g or Bavistin @1 g per litre of water is to be sprayed at an interval of 5-6 days till the control of the disease.
Downy mildew	Cucumber, bottle gourd and some other cucurbits	• Yellow angular spots appear first on the lower surface of the leaves, while purplish spores appear on the upper surface of the leaves. • Spreads rapidly and causes defoliation and kills the plant. sprayed at an interval of 5 to 6 days till the control of the disease.	• Seed treatment • Crop rotation and clean cultivation to be followed. • Dithane M-45@ 2 g per litre of water is to be

Diseases	Susceptible crops	Symptoms	Control measures
Anthracnose	Watermelon, bottle gourd, cucumber and some other cucurbits	• In case of cucumber radish brown dry leaf spots are formed which often coalesce and cause shrivelling and death of leaf. • In case of watermelon, leaf spots are black and foliage presents a scorched appearance. • Under moist conditions, the lesions are dotted with pink conidia. • Lesions on petioles and stems are water soaked and yellowish. • It spreads to fruits of watermelon and bottle gourd in severe cases of incidence.	• Seed treatment • Crop rotation and clean cultivation to be followed. • Dithane M-45 @ 2.0 gm per litre of water is to be sprayed at an interval of 5 to 6 days till the control of the disease.
Fusarium wilt	Watermelon, cucumber, pumpkin and bottle gourd (minor disease) and some other cucurbits	• It is a soil borne disease. • In young seedlings cotyledons drop and wither. • In older plants, leaves wilt suddenly and vascular bundles in the collar region become yellow or brown.	• Can be controlled raising 32-33°C in watermelon using plastic mulch. • Can be checked to some extent by drenching with Captan@ 2g per litre of water. • Grafting of watermelon on resistant rootstocks (bottle gourd and many pumpkin) is used in countires of control this disease.
Mosaic	Pumpkin, cucumber, bottle gourd, watermelon and almost all other cucurbits	• Vectors : aphid, whitefly etc. • The leaves show mottling mosaic, crinkling and twisting and shortened internodes and flowering is adversely affected.	• Infected plants should be removed and burried immediately after expression of disease symptom. • Seeds should not be collected from virus infected plants. • Can be checked by controlling vectors. • Aphid can be controlled by spraying Nogos @ 2 ml and Chess @ 1 ml per litre of water at 7 days and 15 days interval, respectively.

Insect infestation and their control

Insects	Susceptible crops	Nature of damage	Control measure
Red pumpkin beetle	Severe in pumpkin, cucurber, bottle gourd, watermelon	• Attack mostly at seedling stage, especially at cotyledonary leaf stage, although they attack the vines in the grown up stage also. • It makes holes in cotyledonary leaves.	Sevin @ 2g per litre of water at 6-7 days interval to be sprayed till controll.
Aphids	Pumpkin, bottle gourd, cucumber, watermelon and almost all cucurbits	• Damage the plants by sucking the leaf sap. • In young stage, cotyledonary leaves crinkle and in severe cases the plants wither. • In grown up vines, the leaves turn yellow and plants loss its vigour and yield.	• Nogos @2 ml and Ches @ 1 ml per litre of water to be sprayed at 7 days and 15 days interval respectively immediate after attack.
Fruit fly	Severe in cucumber, watermelon, pumpkin and most of the other cucurbits. Minor in bottle gourd	• The adult fly lays eggs below the skin of the young ovaries. The eggs hatch into maggots which feed inside the fruits and cause rotting.	• The adult flies can be controlled by using poison baits.
Mite	Serious in watermelon and minor in most of the other cucurbits	• Found on the undersurface of the leaves.	• Nogos, Neoron, Denitol, kalthen etc @ 1 ml per litre of water to be sprayed at 7 days interval till to control.

CHAPTER VII

SEED PRODUCTION IN OTHER VEGETABLES

7.1. OKRA

Origin

West Africa (Joshi et al., 1974)

Botany/Taxonomy

Okra is known by many local names in different parts of the World. For example it is called Lady's finger in England, Gumbo in USA, bhindi in India and Dherosh in Bangladesh. Okra (*Abelmochus esculentus* L. 2n=130) belongs to the family Malvaceae. Okra plant is an erect, herbaceous annual, 1-2 meter tall and forms fairly heavy tap root.

Floral Biology

A flower bud appears in the axil of each leaf above 6th to 8th leaf depending upon the cultivar. Flowers solitary, axillary with about 2 cm long peduncle; epicalyx up to 10, narrow hairy bracteoles which fall before the fruit reaches maturity; calyx split longitudinally as flower opens; petals 5, yellow with crimson spot on claw; 5-7 cm long; staminal column united to the base of petals with numerous stamens; ovary superior, stigma 5-7mm, deep red. A flower bud takes about 22-26 days from initiation to full bloom. The time of anthesis varies with the cultivar, temperature and humidity and it ranges from 8 to 10 A. M. (Purewal and Randhawa, 1947, Srivastava, 1964; Ramu, 1976). The dehiscence of anther occurs 15 to 20 minutes after anthesis. The dehiscence is complete in 5-10 hours for fertilization after pollination. The flowers remain open for a short time and they wither late in the afternoon. The stigma is receptive at the time of opening of flowers.

Varieties

BARI Dherosh-1: This variety was developed and released by BARI in 1996. Plants are intermediate, erect having 2-3 branches. Fruits are green with 5 marked ridges and 14-18 cm long. Each plant produces 24-28 fruits. Fresh edible yield is 14-17 t/ha. The variety is highly tolerant to Yellow Vein Mosaic Virus.

Pusa Sawani : This is an Indian variety developed by IARI, but widely cultivated hitherto in Bangladesh too. The fruits are dark green, smooth with 5 ridges and about 10-12 cm long at the marketable stage.

There are few more varieties like Pusa A-4, Arka Anamika, Parbhani Kranti from India which are resistant to YVMV. Hybrids of several seed companies are also available in the market.

Soil and Climate

Well drained sandy to clay soils supplied with enough organic matter are good for okra cultivation. However, loose, friable and well-manured loam soils having the pH range between 6.0 to 6.8 are the best.

Being a warm season crop it is susceptible to cold and frost. It thrives well during warm, moist season although it grows fairly well in the hottest summer. The seeds do not germinate below 17°C. Okra flowers drop at 42°C day temperature (Chauhan, 1972). Uniform day and night temperature levels is preferred by okra, wide difference between day and night temperature reduces the seed yield considerably.

Land Preparation, Manure and Fertilizer

Land should be thoroughly prepared by deep ploughing, harrowing, laddering etc. Manures and fertilizers are applied at the rate of 15 ton compost, 150 kg Urea, 100 kg TSP and 100 kg MP per hectare. The entire amount of compost, TSP and half of both urea and MP are applied during land preparation while the rest of the urea and MP are applied at three equal installments at 30, 45 and 60 days of sowing.

Seed Sowing

Seed should be sown during (a) mid June-Mid July and (b) Mid February-mid March. Soil temperatures between 27-30°C help in quick and better seedling emergence. Seeds will not germinate below soil temperatures of 17°C. Seeds should be soaked in clean water for 24 hours before sowing. Seeds which will not absorb water during imbibition should be discarded. Seeds to be sown in lines and in small hills. Spacings of 60 cm. between lines and 30 cms between plants are to be maintained. 2/3 seeds should be sown per hill.

After Care

- Only one healthy plant should be allowed per hill.
- Land should be kept clean by weeding and mulching.
- Irrigation is to be provided in dry season crop as and when required.
- In wet season crop, however, irrigation should only be given if there is no rain for a longer period.
- Earthing up along the lines to be provided at the time of top-dressing urea.
- Roguing is very important and should start as early as possible. All off types and plants affected by virus must be removed as soon as they are observed. The crop will normally require several roguings.

Isolation

A minimum isolation of 500 m is desirable (George, 1985)

Harvesting, Threshing, Cleaning and Drying

Pods of okra are angular in shape and have the tendency to open along structures when dry. This will cause shattering loss and the seeds may be damaged due to entry of rain water inside if there is rain. Pods, therefore, must be harvested as soon as they have become mature and before shattering.

Pods are best harvested by hand individually and there after dried. Threshing is also done by hand after the pods are sufficiently dry. Light seed are then removed by cleaning and winnowing. Collected seeds are sun dried to moisture level not exceeding 12% for open storage and upto 9% for sealed container storage.

Seed Yield : 1.0 - 1.5 t/ha

Insect, Diseases and Their Control

The Following Insect and Diseases are reported in onion in Bangladesh

Insects	Control Measures
Shoot borer	Bidrin or Dimecron 100 EC@ 1ml/1 litre of water or Diazinon 50 EC@ 2ml/litre
Shoot and fruit borer	Spraying of Bidrin or Carbicron 100 EC@ 1ml/1 litre of water
Leaf hopper	Diazionon or Malathion@ 2ml/litre of water is to be sprayed.
Aphid	Malathion @ 2ml/litre of water is to be sprayed.

Diseases	Control Measures
Yellow vein mosaic virus	At present no defined control measures are known. Protection of the crop from white fly, the vector by spraying Ripcord 50 EC@ 2ml/litre of water.
Powdery mildew	Spraying of Bavistin @ 2g/litre of water
Damping off	Seed treatment with 3g Captan or Thiram per kg of seed before sowing.

7.2. SPINACH-BEET

Origin

Indo-Chinese region, especially Bengal region of Indian subcontinent.

Botany

Spinach beet also known as Palak or Palong and is closely related to beet root and Swisschard. Botanically it is known as *Beta vulgaris* var. *bengalensis* Hort. (2n = 18) and belongs to the family Chenopodiaceae. Plant of spinach is a herbaceous annual for the edible leaf production while it is a biennial for seed production. Leaves are long with entire margin and long petioles. Flowers are small, sessile, bisexual, perfect and are borne in the axil of leaf in a group of 2-3, with 5 stamens, flowers produce abundant, small and light pollen grains which are carried by wind. Hence the crop is highly cross-pollinated (a wind pollinated crop).

Varieties

The following varieties are grown for seed production in Bangladesh.

Kopi Palong : Green tender leaves, bushy, late bolting, high yielding.

Pusa Jyoti : Thick leaves, dark green, fleshy. Wavy margin, late bolting, high yielder.

Climate and Soil

Spinach-beet is generally a crop of cool climate. However, the crop is adjustable to an wide range of climate. Seed production of the above varieties can easily be undertaken during winter in our climate.

The optimum soil conditions for spinach seed production is well drained fertile sandy loam soil, deeply worked and sufficient humus added. It is susceptible to excessive soil moisture. Hence, water logging should be avoided. Successive cropping on the same land should be avoided. Soil pH should be in the range of 6-7. The crop may be rotated with paddy.

Land Preparation, Manures and Fetilizer

Land should be well prepared by deep and good tilth and well levelled.

Farmyard manure 10 ton, Urea 120 kg, TSP 150 kg and MP 100 kg/ha may be applied. Entire farmyard manure is to be applied during land preparation. Entire TSP and MP to be applied at last ploughing during land preparation. The urea should be applied as top-dressing in two equal installments, the first 12-15 days after germination and the second before bolting.

Sowing

Sowing of seeds is to be done in lines. Line to line distance may be 35-40 cm, keeping seeds at 2 cm apart and at a depth of about 2 cm. About 25-30 kg seeds will be needed per hectare. Pretreatment of seeds in the following manner will ensure uniform quick germination.

Seeds are to be soaked over night in water and kept spread between the wet gunny bags in order to keep moderately moist and to accelerate germination. The seeds are ready for planting when visible sprouting spots/cracks of rooting are observed. If delayed, the roots will become entangled causing it difficult to handle and susceptible to injury.

After Care

Thinning and roguing is to be done for several times. Thinning will start as the leaves of seedlings start touching each other and continue till the plant to plant distances stands at about 15-20 cms. Before bolting, thinning and roguing for off types will include plants in terms of colour of plants, shape of leaves, stoutness in establishment etc. Early bolters should be removed as soon as observed.

- Land should be kept clean through weeding and mulching.
- Plants of *Chenopodium album* must not be allowed to grow in and around the field.
- Irrigation is to be provided as and when required.

Harvesting, Threshing, Drying etc

Spinach-beet seeds mature in sequence even in the same plant. First opened/formed inflorescence seeds mature first. Seeds after maturation may get discoloured/damaged due to foggy weather/rain. As such sequential harvesting should be done. When the seed stalks and seeds turn yellow and dry, harvesting is to be done by cutting the branch. About 2/3 harvests will be necessary before leaving the crop for seed production. Harvested branches should not be kept heaped which may cause damage to seed due to fermentation. Harvested branches to be dried in the sun over drying floor/canvas. Threshing is done by hand beating with a stick after being properly dried. Seeds are cleaned by winnowing and dried to 9% seed moisture content for temparary open storage.

Seed Yield

Seed yield is about 600 kg/ha (Bose et al., 1986)

7.3. INDIAN SPINACH

Origin

Asia, more particularly the Indian sub-continent

Botany/Taxonomy

Besella commonly known as Pui, Malabar Nightshade or Indian spinach is a popular summer leafy vegetable. It belongs to the family Besellaceae and genus Basella. There is only one species *B. rubra* (2n=24). *Basella alba*, the green stemmed white flowered one is considered as form of B. rubra. Basella is a fleshy annual or biennial, branched herb with alternate broadly entire leaves. Flowers are pink or white, small sessile in clusters on elongated thickened peduncles.

Variety

There are two distinct types, one with reddish petiole and stems, and the other with green leaves, petioles and stems. The green leaved cultivar (*Basella rubra* var. *alba*) is commercially cultivated in Bangladesh.

Climate and Soil

Hot humid climate is best suited for vegetative growth and crop production of Indian spinach. However, mildly cool temperature and short day is essential for flowering and fruit set. Flowering and fruit set starts during the start of November in our climate and matures in February-March.

High lands of loam, sandy loam or clay with drainage facility and ample sunshine are desirable for pui cultivation.

Land Preparation, Manure and Fertilizer

Land should be prepared thoroughly. The compost 10 tons, urea 100 kg, TSP 150 kg and MP 100 kg are to be applied during land preparation. Half of the urea is to be top dressed after 25 days of sowing and the rest before flowering starts.

Land, after preparation should be arranged into raised beds of one meter wide and 6 cm high. About 30 cm wide drain is to be provided between two beds.

Planting and After Care

For seed production planting is to be done through August. Seedlings raised in the seed bed are to be planted at a spacing of 30 x 30 or 45 x 30 cm on raised beds. Adequate drainage facilities are to be provided.

Irrigation

Sufficient moisture is needed to produce rapid and succulent growth. Inadequate moisture may lead to their wiry stems and small leaves. The frequency of irrigation depends on the soil type.

Isolation

Proper isolation distance should be maintained between two cultivars for producing nucleus and foundation seeds.

Harvesting, Threshing and Cleaning

Seeds are ready for harvest when they are fully matured. Vines start dying and their colour turns brown/yellowish. Seeds are picked manually from the vines and dried on the threshing floor/over canvas in the sun. The seeds are cleaned and separated from plant parts by winnowing and are dried well in the gentle sun light and stored.

Seed Yield

Seed yield is about 700-800 kg/ha (Rashid, 1999).

7.4. YARD LONG BEAN

Origin : Africa and Asia

Variety

Yard long bean or string bean (*Vigna unguiculata* var. *sesquipedalis)* belongs to Leguminosae family. Though it is a popular vegetable crop in Bangladesh, there is no recommended variety of the crop. However, a variety named "KAGORNATOKI" introduced from Thailand and maintained by BADC is popularly cultivated in this country.

Climate and Soil

The crop can be grown under a wide range of climatic conditions. The crop is generally grown in our hot climate of summer. For seed production, timings are to be adjusted to avoid excessive rainfall during maturation of pods.

It can be grown successfully on a great variety of soils, provided, they are well drained. However, loam to sandy loam soils are best suited. Soil pH should be between 5.3 to 6.0.

Land Preparation, Fertilizer and Manure

Land should be well prepared by ploughing and harrowing, 15 cm raised beds of 120 cm wide is to be prepared keeping a 40 cm wide drain between beds.

Ten ton farmyard manure, 50 kg urea, 120 kg TSP and 50 kg MP should be applied per hectare. All fertilizers and manures should be applied during land preparation prior to planting, but depending upon the crop condition, urea and MP may be top dressed.

Sowing

Seeds are sown by hand on the beds. Two lines are drawn on a bed at a spacing of 80 cm keeping 20 cm from each edge of the bed. Seeds are sown in rows 2-3 cm deep and about 20-25 cms apart. For seed production sowing is done i) during February - March and (ii) during August-Mid September. For line sowing 5 - 8 kg seed is required for an hectare.

After Care

About 150-175 cm high trellis are to be provided for every two lines of a bed, trellis to be created in such a way that the tops of sticks are bounded together to form a triangular structure with the bed. Sufficient sticks to be provided to help the plants to climb up.

- Land should be kept clean and free from weeds.
- Sufficient irrigation should be provided when flowering starts. Previous irrigations should be light and as per requirements.

Roguing

Constant roguing for off type plants and plants affected by mosaic or other diseases should be done right from the beginning. Affected plants should be removed as a whole immediately on sight.

Isolation

Since yardlong bean is a self-pollinated crop, relatively short isolation distance has been recommended. It is important that adjacent cultivars should be at least 20 m apart with distance increased to at least 100 m for stock seed production.

Seed Harvesting, Threshing and Drying

Pods are harvested when they have turned yellow but have not been completely dry and seed in the pods are firm and well developed and have just begun to break free from the inside of the pod. Harvesting should be done as soon as the pods are ready to avoid any damage due to sudden rain. Two-three harvestings will be necessary. Harvested pods are dried in the sun and threshed by hand with care to avoid loss due to breaking injuries. Seeds are cleaned and dried soon after threshing. Drying seed to a moisture level below 15% will be necessary for temporary storage in ventilated sheds. For long storage, moisture content should be around 11%.

Seed Yield

Under appropriate care and management, seed yield should be about 1000-1200 kg/ha

7.5. FRENCH BEAN OR DWARF BEAN

Origin

Central and South America, China.

Varieties

BARI Jhar Seem-1 : The variety has been developed by BARI. Plants are determinate, bushy and of medium growth. Pods are slightly curved. Fresh pod yield is about 13-14 t/ha.

Contender : An introduction from U. S. A. It takes 50-55 days for vegetable pods. Bush type with pink flowers, pods green, large with slightly curved tip, stringless, meaty, tolerant to mosaic and powdery mildew. Seed light brown.

Climate and Soil

French bean production is possible in the tropics provided that the maximum day temperature does not exceed 30°C at the time of flowering and the temperature is not lower then 10°C at the time of seedling emergence. Flowers drop down at temperatures above 30°C. It can not tolerate frosts and dislikes wet, cold, overcast conditions. Excessive rain causes flowers to drop and increases the incidence of diseases. Dry weather is required for harvesting the mature pods. However, relative humidity above 50% is necessary to obtain a good seed set.

To have the best results, beans should be grown under decreasing temperature conditions, so that it has the benefit of warm weather for germination and still reaches flowering when cooler condition prevails.

In view of the above conditions, french bean is to be sown in Bangladesh during October-November when the monsoon stops and the temperature starts decreasing and ultimately harvesting can be done during drier period.

Fertile and heavier loam soil is best suited. But can be grown in most soil types with adequate drainage facility and good tilth. It prefers slightly acid to almost neutral soils (pH 6.0-7.5). Seed crop should be grown only every 3-4 years on the same land to control most soil borne disease. It can be rotated with cereals and root crops.

Land Preparation, Manure and Fertilizer

Land should have a good tilth and be free from clods and lumps of soil. It is necessary for maximum field germination. The land should also be well levelled and well drained so that water does not stand. Standing water causes damage to root system and plants die. Twenty tons of farmyard manure, 100 kg urea, 150 kg TSP and 50 kg MP should be applied per hectare. All fertilizers and manures should be applied during land preparation prior to sowing.

Sowing

Seeds are sown by hand in uniformly light soil moisture conditions. Lines are drawn at 45-60 cm apart, and seeds are sown 2-3 cm deep and about 15-20 cm apart. About 50-75 kg seeds are required for one hectare of land (Bose et al., 1986).

After Care

Crop should be kept clean through weeding and hoeing between lines.

- Earthing up of the lines should be done simultaneously with weeding.
- The above intercultural operations should be avoided when the plants are wet with dew or after rains, because disease organisms are then more easily spread.
- After seedlings have emerged, light irrigation should be given till flowering stage.
- Heavier irrigations should be given once flowering starts, till pods are fully developed to avoid any stress conditon.

Roguing

Constant roguing for off type plants and plants affected by diseases like anthracnose, bacterial blights and mosaic must be done right from the beginning. Affected plants should be removed as a whole immediately on sight.

Isolation

A distance of 50 m between French bean cultivars or commercial seeds but a minimum of 150 m is recommended for basic seed production.

Seed Harvesting, Threshing and Drying

Pods are harvested when they have turned yellow but have not been completely dry and seeds in the pods are firm, well developed and have just began to break free from the inside of the pod.

Harvesting should be done as soon as the pods are ready to avoid any damage due to sudden/early rain. Two harvesting operations may be necessary before leaving the crop for seed production. Harvesting is best done in the morning to avoid shattering loss.

Harvested pods should be dried in the sun and kept stacked under cover for 1-2 weeks for curing. Pods are then threshed by hand. Seeds with a low moisture content are extremely liable to injuries during threshing. It may result in bald headed seedlings which are very less productive. If splitting of seed occurs, it fails to germinate at all.

Soon after threshing seed should be cleaned and dried. Drying to seed moisture content below 11% will be necessary for temporary storage in ventilated sheds within the RH of 75%. For storing in moisture proof containers seed moisture content should be reduced to 9%. Reduction of seed moisture content below this level is not required. If done, it will

cause high percentage of hard seeds especially in white seeded varieties and increases susceptibility to cracking.

Seed Yield : Under appropriate management seed yield should be more than 1000 - 1200 kg/ha.

Insect and Diseases and Their Control

The following insects and diseases are observed in Bangladesh.

Insects	Control Measures
Pea aphid	Malathion/Sumithion 50 EC@ 2ml/litre of water is to be sprayed.
Pod borer *(Heliothes sp.)*	Ripcord/Sumithion 50 EC@ 2 ml/litre of water is to be sprayed
Leaf miner	Chlordane 5% dust is effective against the pest.

Diseases	Control Measures
Powdery mildew *(Erysiphe polygoni)*	Bavistin @ of 2 g/litre of water to be sprayed
Fusarium wilt *(Fusarium oxysporum)*	Use of resistant varieties
Root rots *(Rhizoctonia, Fusarium and Pythium)*	*Seed treatment with fungicides like* Ceresan, Arasan and soil drenching with Captan.

7.6. PEA

Botany/Taxonomy

The genus *Pisum* includes 6-7 species out of which only *Pisum sativum* (2n=14) is cultivated. The plant is a short lived, herbaceous annual and climber. The cultivars may be dwarf, semi-dwarf or tall. The flowers are solitary, axillary or up to 3 flowers per raceme, bracts very small, calyx oblique, corolla white, pink or purple; stamens diadelphous, filaments broad, anthers uniform, style falcate, flattened, stigma minute terminal. Pods swollen or compressed, straight or curved on short stalk. Seeds are angular or globose, smooth or wrinkled. Pea is a self-pollinated crop.

Varieties

BARI Motor Shuti-1 : BARI developed this variety in 1996. Plants are short with white flowers. Each plant produces 20-25 pods, dry seeds are wrinkled. Green pod yield is 10-12 t/ha. Moderately resistant to powdery and downy mildews.

BARI Motor Shuti-2 : Developed by BARI in 1996. The pods are edible at green stage. Pods are light green, fibreless flat type unlike garden pea. The average number of pod per plant is 25. Green pod yield is 12-14 t/ha.

Arkel : Exotic variety but popularly grown in Bangladesh. Plants are dwarf but the growth is vigorous. Pods are attractive, green-deep green and about 8 cm long.

Climate and Soil

Peas prefer a cool moist climate and favourable temperature ranges from 10-20°C. Pea does not grow well in hot weather.

The crop is best adapted to well drained clay loam soils well supplied with calcium. Soil pH should be in the range of 6.0-7.7.

Peas should not be grown consecutively even for two years in the same land as it will favour seedling diseases, blight and also pea nematodes. It is best rotated with cereals.

Land Preparation, Manures & Fertilizer

Thorough preparation of soil is essential for pea because it is an exhaustive and short duration crop. It helps the rapid and free spread of roots.

Organic manures and phosphorous application are most important for peas. Farm yard manures 7000 kg, urea 50 kg, TSP 150 kg and MP 50 kg should be applied per hectare. All the fertilizers and manures should be applied at the time of land preparation at least a week before sowing.

Seed Sowing

Sowing is done through October. For tall cultivars seeds are sown in rows 45-60 cm apart and for dwarf cultivars 25-30 cm apart. In both cases 5-10 cm distance is maintained in between plants. About 25-30 kg seed is required for one hectare.

After Care

- Land should be kept clean by weeding and mulching.
- Irrigation should be provided as and when needed. Abundant water supply during flowering should be ensured.
- Late irrigation during warm weather should be avoided which may cause sun-scalding of plants as also plants may tend to lodge and some rotting of vines may occur if the soil is kept too wet.
- Careful roguing at flowering and after pod formation need to be done. Off types and plants affected by blight and pea mosaic must be removed as soon as observed.

Roguing and Isolation

The off-type and diseased plants affected by pea mosaic, foot-rot and blight should be rogued out from the seed field. Pea flowers are almost self - pollinated. Hence, the isolation distance for peas is relatively short and aims mainly to avoid mechanical mixtures. However, the isolation distance may be at least 20 meter from one variety to another.

Seed Harvesting, Threshing and Drying

Maturity of seed crops take about 130-140 days. To test the maturity a common practice is to squeeze the seed between fingers. If the cotyledons break away from each other and free moisture is not visible, the crop may be considered mature enough for harvest.

Vines along with the pods are harvested from the field and dried in the threshing floor under sunshine. Threshing is done by beating with stick when sufficiently dry. Care should be taken during threshing so that the seed coats are not injured.

Threshed seeds are cleaned by winnowing, dried to reduce seed moisture content to 12% for temporary storage. For longer storage pea seed should be stored in sealed containers at 10% moisture content and in air cooled rooms.

Seed Yield

Seed yield is about 1000-1200 kg/ha.

Insects and Diseases and Their Control

The following insects and diseases are observed in Bangladesh.

Insects	Control Measures
Pea aphid	Malathion/Sumithion 50 EC@ 2ml/litre of water is to be sprayed.
Pod borer (*Heliothes* sp.)	Ripcord/Sumithion 50 EC@ 2 ml/litre of water is to be sprayed
Leaf miner	Chlordane 5% dust is effective against the pest.

Diseases	Control Measures
Powdery mildew *(Erysiphe polygoni)*	Bavistin @ of 2 g/litre of water to be sprayed
Fusarium wilt *(Fusarium oxysporum)*	Use of resistant varieties
Root rots (*Rhizoctonia, Fusarium* and *Pythium*)	Seed treatment with fungicides like Ceresan, Arasan and soil drenching with Captan.

7.7. GIMA KALMI

Origin : South-East Asia, Africa

Botany/Toxonamy

Gimakalmi (*Ipomoea aquatica* Forsk. Syn : *Ipomoea reptans* Poir) belongs to the family convolvulaceae. It is called Swamp Cabbage or water spinach in english. In South-East Asia it is known as Kangkong. The plant is dwarf, erect, leaves are long, narrow, light green stem and white flowers. Unlike water kalmi, Gimakalmi grows on soil.

Variety

BARI developed one kalmi variety named "Gimakalmi" (Rashid et al., 1985) which is now popularly grown in Bangladesh. This is an erect type variety grown on land, both leaves and stems are edible. First harvest starts 30 days after sowing and subsequent harvests at 15 days interval.

Climate and Soil

The growth of kalmi is favoured by hot and humid climate. It is a short day plant and therefore, requires short day length condition for its flower induction. In Bangladesh, as the day becomes shorter and average temperature gradually goes down from October, the plants enter into reproductive phase and starts flowering.

Well drained sandy loam soil with a clay sub soil is best suited for its growth, pH around 5.0-6.5 is favourable.

Land Preparation, Manure and Fertilizer

Land must be well prepared, the following manures and fertilizers should be applied per hectare

Cowdung	4000 kg
Urea	100 kg
TSP	80 kg
MP	50 kg

The entire quantity of cowdung, TSP, MP and half of urea should be applied at land preparation. The rest of urea should be applied in two equal installments at 3 weeks interval after planting.

Sowing

Seed should be sown in the early August for seed production. Distance between rows should be 30 cm and that between hills within a row should be 15 cm. About 2-3 seeds should be sown per hill.

Intercultural Operations/After Care

Irrigation as and when needed should be given without delay. Crop should be kept clean by weeding and mulching.

Roguing

Roguing of off-types should be done as and when observed, runners and those producing flowers other than white colours should be rogued out.

Isolation

Sufficient isolation distance should be maintained from wild kalmi.

Flowering and Seed Set

Flowering generally starts in late November and seed sets in December. Seed can be harvested in early February.

Harvesting, Threshing and Drying

Seeds are harvested when the capsules turn brown. Hand picking is generally done. Capsules are dried and seeds extracted by beating lightly with stick. Seeds are than cleaned and dried properly for storage.

Seed Yield

Seed yield varies from 1000-1200 kg/ha.

7.8. AMARANTHUS

Origin : The leafy amaranthus is said to be the native of India (Nath, 1976)

Botany/Taxonomy

Amaranthus belongs to the genus Amaranthus and the family Amaranthaceae. The genus Amaranthus includes 50 to 60 species, the leaves and stems of which are edible. These are the most important leafy vegetables of the tropical countries in South Aisa, South-East Asia, East Africa, Central Africa, West Africa, Ethiopia, the Pacific and Far East. Amaranthus is an annual herb, erect or trailing, scarce to profuse branched, shallow to deep tap-rooted, stem green to purple, leaf simple, alternate or opposite, colour green to purple. Inflorescence terminal and axillary, branched spikes, flower small, regular, mostly unisexual, monoecious. In general the cultivated species are monoecious.

Soil and Climate

The crop can be grown in almost all types of soil. However, loam and sandy loam soils with good drainage facility is best suited. Vegetative growth of stem amaranth is favoured in the hot humid climates of summer in Bangladesh and flowering is generally encouraged when summer temperature starts falling. Lalsak is best grown in winter in Bangladesh both for vegetable and seed purpose.

Land Preparation, Manure and Fertilizer

Land should be well prepared by several ploughing and harrowing. Sufficient compost, urea 80 kg, TSP 100 kg and MP 80 kg per hectare is needed. Entire quantity of compost, TSP and half of MP should be applied at the time of land preparation before sowing. Urea and the remaining MP should be applied in two splits at 20 and 15 days after sowing.

Sowing and After Care

Sowing is done in lines on raised beds of 120 cm width. Three lines are sown on one bed at a distance of 45 cm keeping 15 cm away from the edge of the beds. A 45 cm wide drain is kept in between two beds.

Seeds are mixed with ash or fine soil before sowing and sown by hand along the lines at one cm depth. Sowing is done in July-August for stem amaranth and October-November for Lalsak (leafy amaranth).

As seedlings start growing, thinning is to be done. Final spacing of 30 cm between plants is to be established after 2-3 thinnings of weak and off type plants. The field should be kept clean and free from all weeds including "Katanate" (*Amaranthus spinosus*). About 3-5 kg seed will be needed for one hectare of land.

Isolation : Since it is a wind cross-pollinated crop, an isolation distance of about 400 m has been recommended (Agrawal, 1980).

Seed Harvesting, Threshing and Cleaning

Seeds are ready for harvest when they are fully matured and come out when rubbed by hand and the plants start dying. Plants are cut (either whole plant or the seed bearing branches) and dried on canvas or concrete floor. Seeds are extracted by beating with stick when plants dry up. Cleaning is done manually by winnowing and dried in the sun.

Seed Yield

The seed yield is about 800-1000 kg/ha (Rashid, 1999)

7.9. ONION

Origin

Onion is one of the oldest cultivated plant species. It probably originated in Middle Asia and the regions around the Mediterranean sea.

Botany

The common onion bulb (*Allium cepa* L., 2n = 16) is generally a biennial plant, but grown as an annual. The genus Allium contains about 300 widely distributed species.

Onion forms the bulb in the first year and the seed in the second year. The leaves arise from a shortened crown stem. The sheaths of the older or outermost leaves enclose the younger ones. The basal portion of the leaves encircles the stem, and thickens to form the bulb. The stem elongates during the second year forming the flower stalk. The onion has a fibrous root system extending to a depth of over one meter, but most of them are found in upper surface about one-half meter area.

Floral Biology and Nature of Pollination

Flowers are borne in simple umbels at the apex of a floral stem which is hollow and round in cross section and somewhat swollen at the middle or near the base. Most onion varieties produce seed stalks over one meter height. The number of seed stalks per plant may vary from 1 to 20 or more depending on the variety, size of mother bulb and time of plating. Before expanding, the umbel is enclosed within a papery spathe consisting of 2 or 3 bracts which are split open by the pressure of the developing flower buds. The number of flowers per umbel varies considerably, from 50 to over 2000. The differentiation of the flower begins in the late winter. Temperatures around 20-22°C favour the vegetative growth while temperatures around 12-13°C are conducive to seedstalk formation. Also short day conditions are favourable to seed production.

White or bluish flowers have an outer and an inner whorl of stamens of three each. The anthers of inner stamens dehisce first. The pistil has a three-celled ovary with two ovules in each. The style is about one mm in length when the flowers open first. It is not receptive until it elongates to a length of about 5 mm, which requires 1 or 2 days after all the anthers have dehisced. Opening of flowers usually continues for a period of two weeks or more and onion plant may be in bloom for over 30 days.

The fruit is a three-lobed, three-celled capsule, each locule containing 1 or 2 black seeds at maturity.

Varieties : The following varieties are popularly grown in Bangladesh.

BARI Piaj-1 : This variety has been developed by selection by BARI from a local strain commonly grown in Bangladesh. It produces red coloured medium sized single bulb. The variety is resistant to foot rot, damping off and also tolerant to Purple Blotch and Stem phyllium diseases. Yield is 12-16 t/ha while seed yield in 800-1000 kg/ha. Suitable for long storability and seed production under Bangladesh climate.

Taherpuri : Single bulbed variety. Medium sized, flatish round, red coloured bulbs, pungent and good keeping quality. Matures in 150 days.

Faridpuri : Multiple bulbed, generally two bulbs remain together. Bulb is semi-spherical, red coloured, pungent and good keeping quality. Matures in about 150 days.

Climatic Requirements

Onion is a biennial crop and takes two seasons to produce seeds. In the first year bulbs are formed and in the second year stalks develop and seed is produced. It requires cool weather during its early development and during the early growth of the seed stalk (Hawthorn and Pollard, 1954), varieties bolt readily between 10 to 15°C. A moderately high temperature and a dry atmosphere favours the bulb maturity as well as seed production.

Land Requirements

Sandy loam, silty loam and deep friable soils retaining adequate amount of moisture are most suitable for onion cultivation. Low lying, marshy and heavy clay soil is not desirable.

Method of Seed Production

There are two methods of seed production. Most commonly used method of seed production is the bulb-to-seed method. Another method is seed-to-seed.

Bulb-to-Seed Method

Production and Storage of Mother Bulbs

Seedling Raising : For raising a crop for bulb production onion seeds are sown in nursery beds to raise seedlings for transplanting in the field. Seeds are sown on well prepared beds in lines at a spacing of 5-7 cm and are covered with soil. Before sowing seeds are treated with Thiram 2-3 g per kg of seeds. Thiram is also applied in seed bed soil for drenching to protect the seedlings against damping off. Seed sowing is done in October-November. Since the medium sized onion bulbs have been found to be satisfactory, many seed growers use higher seed rates, about 8-10 kg/ha then commonly used for the production of market crop (2.5-4.5 kg/ha).

Fertilization of the Field : Urea 250 kg, TSP 200 kg, MP 150 kg and 20 tons farmyard manure are applied for bulb production. The whole amount of manure, TSP and half of MP is applied during final land preparation. The urea and rest of the MP is applied at two splits during growing season. Application of micro-nutrients e.g. Gypsum 100 kg, ZnO 5 kg, Boric acid 5 kg/ha increases the bulb yield.

Transplanting and Spacing : Eight to ten weeks old seedlings are planted in small beds in well-prepared fields. December-January is the best period. Onion seedlings are transplanted at a distance of 15 x 10 cm.

Irrigation : The field is irrigated immediately after transplanting. Fortnightly irrigation during winter and weekly irrigation during hot dry weather is recommended. At bulb maturity irrigation should not be given as it would cause delay in harvest and the bulbs may get soiled up.

Interculture : Frequent weeding and mulching is essential for good bulb development.

Harvesting and Curing of Bulbs : Well-matured bulbs should be harvested. Maturity is indicated by the tops droping just above the bulb, while the leaves are still green. After harvesting, the bulbs should be trampled leaving a half inch neck. Before storage a thorough selection and curing of bulbs should be done. The time required for curing depends largely on weather conditions and may take three to four weeks.

Storage of Bulbs : The storage should be well ventilated. The bulbs should be well matured, dried and cured before storage. The roots of the bulbs should be left intact after harvest. The storage temperature influence seed yield. Temperature ranging from 4.5°C to 14°C with an optimum of about 12°C is the best for storage of mother bulbs. Plants from such bulbs produce early and heavy yield than those grown from the bulbs which have been stored at higher or lower temperature.

Planting of Mother Bulbs

Time of Planting : Planting of bulbs for seed production is done in October-November. In Bangladesh condition higher seed yield is obtained from planting in the first fortnight of October.

Preparation of Land : The land should be prepared to good tilth. One deep ploughing followed by three to four harrowings and land levelling is desirable.

Seed and Seed Rate : Bulbs selected for replanting should be free from disease infection. Doubles and long thick-necked bulbs are discarded and only true-to-type bulbs are selected. The seed yield is affected by the size of the bulb, the bigger is the bulb size, the higher is the seed yield. Although the increase in weight and size of bulbs result in higher seed yield. Very large size bulbs if used will need a very high seed rate. A bulb size of 2.5-3 cm diameter needs about 1500 kg to plant one hectare of land. Therefore, for commercial seed production medium sized bulbs (2.5-3 cm dia.) may be used economically.

Fertilization

Same as described for bulb production

Method of Plating

The selected bulbs are planted in well prepared field. The growing portion of the bulb is cut to the extend of 1/4 to 1/3 for easy and quick sprouting of more growing buds. The lower portion of disc-like stem and roots is used for planting. To avoid rotting due to fungal infection of bulbs in the field, Bavistin @ 20 g in 10 litres of water is used for dipping the bulbs before plating. Bulbs are planted 2 to 3 cm deep in the soil at a distance of 30 x 30 cm.

Intercultural Operation

A light irrigation is applied immediately after planting; the subsequent irrigation may be given at 7-10 days interval. Weeding and mulching should be done frequently to have a good crop. Discontinuing irrigation when the seeds reached the milk stage give high yields of good quality seeds (Globerson et al., 1987).

Roguing

In order to detect and eliminate different plant types, roguing should be started before the bulbs are harvested. It is easier to remove late maturing bulbs at this stage. After the bulbs are harvested they may carefully be rogued for colour and off-types.

Isolation

The minimum isolation distance recommended between different varieties is 1000m. Some authorities stipulate shorter distances than this for cultivars with the same bulb colour. In some countries there are declared zones in which only varieties of a specific bulb colour can be grown for seed.

Harvesting and Threshing

The seed is harvested when the fruit opens and exposes the black seed. According to Hawthorn and Pollard (1954), a field is considered ready to harvest when about 10 percent of the heads have black seeds exposed. At this stage practically all the seed is well matured to give a good germination. Two to three pickings may be necessary to harvest the heads. The seed heads with a small portion of the stalk attached are cut with sharp knife. When cutting the umbel are supported in the palm of the hand and held between fingers to avoid seed loss. Seed heads after harvest are thoroughly dried on canvas. Heads can be threshed when seeds separate easily from them. Much of seeds fall from capsules during drying. The remaining seed is removed by flailing. Under the humid conditions, seeds may be dried in sheds with air circulation. Frequent stirring may be needed when the seed is dried in shed. Since natural seed drying often requires 2 to 3 weeks, some growers prefer to dry seeds quickly using artificial dryers or dehydrators. Before storage, the seed must be dried to six to eight percent moisture.

Seed Yield

The average seed yield varies from 850 to 1000 kg per hectare.

Pests and Diseases and Their Control

The following insects and diseases are reported in onion

Insect	Control Measures
Onion thrips *(Thrips tabaci)*	Malathion/Sumithion/Nogos @ 1ml/litre of water should be sprayed
Onion Maggot *(Hylemia antiqua)*	Application of Thimet is beneficial; crop rotation should be followed
Head borer *(Heliothis armigera)*	Zolon @2ml/litre of water should be sprayed.

Diseases	Control Measures
Purple Blotch *(Alternaria sps)*	Rubral and Ridomil/@ 2g each in 1 litre of water should be sprayed at an interval of 7-10 days.
Basal rot *(Fusarium sps)*	Bavistin @ 2g/litre of water should be sprayed.
Downy mildew *(Peronospora sps)*	Zineb @ 2g/litre should be sprayed.

CHAPTER VIII

HYBRID SEED PRODUCTION IN VEGETABLES

Hybrid varieties have been evolved in those high valued vegetable crops which exhibit marked heterosis such as solanaceous vegetables (tomato, eggplant, sweet pepper), cucurbits (melons, watermelon, cucumber, squash, pumpkin and gourds), cole crops (cabbage and cauliflower), root and bulb crops (onion, radish, carrot) and fruit vegetable like okra. Techniques of hybrid seed production in some major vegetables are discussed below:

8.1 SOLANACEOUS CROPS

8.1.1. Tomato

Manifestation of Heterosis : Hybrid vigour in tomato is manifested in the from of earliness, total yield, uniformity of produce, greater plant vigour and better adaptability to unfavourable environment. In general heterosis for yield in hybrids ranged from 30-50 percent.

Hybridization Techniques : For commercial hybrid seed production the emasculation of female flowers and pollination by hand is still considered economical and efficient. Most of the seed companies do hybridization this way.

Indeterminate tomato varieties are staked and trained with either single stem or double stem, whereas, the determinate tomato varieties are trained with 3 stems. Usually 1st to 4th cluster on each branch are selected for emasculation. Buds where the corolla leaves have just opened and form an angle upto 45° in respect to the flower axis (a day prior to anthesis) are selected for emasculation. The emasculation operation involves in holding the corolla at the base and with a single upward pull pick off the corolla along with all the stamens. Usually the anthers are picked off a day before anthesis with the help of forceps leaving the petals intact. Such petals turn yellow on the day of anthesis. Fresh pollen collection on the day of anthesis by a vibrator has the highest viability, because only ripe pollen are shed by vibrating the flowers. Pollens are collected in a glass tube or on a glass plate from the male line and are transferred to the stigma by finger or by inserting the stigma into a glass tube containing the pollen grains. Left over pollen grains in the glass tube are not used on the next day because its viability is reduced considerably. Half of the calyx of pollinated flowers is removed to distinguish it from unpollinated flowers.

Pollen grains can be stored for a longer period (2 months) of time when its moisture content is reduced using a descicator and the temperature is kept around 0°C.

Physiological Parameters Affecting Tomato Seed Yield and Vigour

Growth of tomato plant is satisfactory upto 25°C. In tropical regions, prolonged high temperatures (35-42°C) adversely affect pollen fertility and physiology of fertilization, leading to poor seed set. Age of pollen and stigma, abundant or scarce pollination, height of inflorescence, different altitude and latitude and fertilizer application exert an influence on the vigour of the plant.

Improvement in Methods of Hybrid seed Production

Nearly 40 percent of the total labour expenditure is on flower emasculation during the course of hybrid seed production, which can be reduced by using male sterile lines. Male sterility controlled by recessive genes (totaling 42 in number now) and stamenless mutant controlled by recessive gene (s1) having normal corolla and free stigma, are quite accessible for pollen application. Limited success has also been obtained in phenotypical restoration of sterility in 'ms' forms with silver nitrate treatment. Partial success has been achieved in restoration of (ms) sterility using GA 3 or GA 4/7. Such restoration will result in the production of 100% fertile plants from male sterile forms.

Seed extraction and Drying

Tomato seeds are extracted mainly by fermentation method. Under warm conditions, the fermentation process is complete in 24 hours. At 25°C, it requires 2 days for the completion of fermentation process. The pulp is stirred several times in a day to maintain a uniform rate of fermentation and to avoid discolouration of the seed. Seeds are than washed with clean water. Fermentation method of seed extraction also controls bacterial canker disease which is seed born. Tomato seed is also extracted using acid (HCl) or alkali (NaOH), 10 cc or 36 percent HCl or 30 percent NaOH is added in 4 kg of tomato pulp. The treatment is given for a period of 15 minutes, which separates the jelly from tomato seeds. The seeds are than washed thoroughtly and then dried.

Seed Yield

One kg of tomato fruit will produce 3-4g of seed yield (1000-1200 seed). Av. seed yield : 60-70 kg/ha depending upon the performance of parental lines.

8.1.2. Eggplant and Sweet Pepper

Manifestation of Heterosis

In general heterosis in sweet pepper ranged from 35-40 percent whereas, in eggplant it ranges from 50-150 percent. Rashid et al. (1988) reported 50% heterosis in eggplant in Bangladesh. Heterosis in eggplant is manifested in earliness, fruit number per plant and fruit weight. In case of sweet pepper, heterosis is manifested for plant height, days to flower, fruit weight, number of fruits per plant, early and total yield.

Hybridization Techniques

Emasculation and hand pollination is the useful production techniques. Stigma is receptive a day prior to anthesis in eggplant. Hence bud pollination is possible giving good fruit set and seed yield. In sweet pepper, emasculation is done a day prior to anthesis, whereas, pollination is done in the morning on the day of anthesis. Natural cross pollination ranged from 0.2-46.8% in eggplant flowers. Emasculated flowers are never visited by pollinators. Pepper flowers are visited by honey bees occasionally. Fresh pollen grains are collected on the day of anthesis by a vibrator and can be stored for a period of 1 to 2 months at 0°C, using silica gel for proper drying of the pollen grains.

In order to obtain optimum yield and good quality seed, it is essential to train the eggplant as well as sweet pepper plants. The first and 2nd flowers are harvested at the initial stages. This will boost plant growth as well as the number of seeds formed in subsequent fruits. The training of eggplant involves to allow two lateral branches below the first flower and the remaining lateral branches are removed. This technique is aimed to attain sound growth of plant.

Physiological Parameters Affecting Seed Yield and Vigour in Eggplant and Sweet Pepper.

The eggplant is photoinsensitive but requires an optimum day temperature of 25-30°C and 20-27°C night temperature for its growth. In case of pepper effect of low temperature (8-10°C) on seed set is greater before anthesis than afterwards. Plant growth is satisfactory at day temperature ranging from 20-25°C. Pepper plant prefers high humidity for its proper growth. Providing partial shade prior to flowering boost its vegetative growth. Capsicum flowering and fruit set require bright sunlight.

Use of Male Sterility in Hybrid Seed Production in Eggplant and Sweet Pepper.

Male sterile lines are available in eggplant (genic male sterility) and sweet pepper (genic and cms) but are not successful at commercial seed production. Seed set on male sterile lines ranged from 46-67% in capsicum. Use of functional male sterility in hybrid seed production, sweet pepper has a bright future. Cytoplasmic male sterility is being used now in case of chilli pepper to produce F1 hybrid commercially by several seed companies.

Seed Extraction

Eggplant fruits are harvested 50-55 days after anthesis and are stored for a period of 10 days for postharvest repening. Sweet pepper fruits are harvested 60-65 days after anthesis. The ripe fruits are crushed and seeds are separated by washing with excess of water without fermentation. The seeds are dried using dry air at 28-30°C.

Seed Yield

A satisfactory seed yield in eggplant is 150-200 kg/ha with a thousand seed weight ranging from 4-5g. In peppers the seed yield varies from 100 to 200 kg/ha. One kg of sweet pepper will yield 5-7g of seed with the thousand seed weight equals to 5g.

8.2. CUCURBITACEOUS CROPS

Sex Expression and Sex Forms in Cucurbits : Cucurbitaceous plants produce three types flowers depending on species and variety. One plant my contain more than one type of flowers, and more than one sex forms may be available in a species. According to the sex forms, cucurbitaceous plants can be grouped as follows :

Hermaphrodite : All flowers of a plant are bisexual (available in some varieties of Luffa, Cucumis and Benincasa spp.)

Monoecious : Male and female sexes are in different flowers of the same plant (the most common sex form).

Andromonoecious : Male and hermaphrodite flowers are in the same plant.

Gynomonoecious : Female and hermophrodite flowers are in the same plant.

Trimonoecious or Androgynomonoecious : Male, female and hermaphrodite flowers are in the same plant.

Dioecious : Male and female flowers are in different plants. Plants bearing male flowers called androecious and those bearing female flowers called gynoecious plants.

Gynodioecious : In dioecious species some plants of a variety bear only female flowers and others bear hermaphrodite flowers.

Sub-gynoecious : When gynoecious plants of dioecious species produce some male or hermaphrodite flowers.

Monoecious sex form is the most common one in this family. Hermaphroditism is the original sex form from which monoecious and dioecious sex forms have been evolved.

Control of Sex Expression

In cucurbitaceous plants, sex expression such as time of flowering, sex type of flowers, number of flowers of different sexes, sex ratio, etc. are determined by gene as well as environment. Sex expression can be controlled by changing the environment and by using different growth regulators. Commonly available hormones found in plant body are auxins, gibbrellins, cytokinins, ethylene, abscicic acid which are responsible for flowering. Some growth regulators promote femaleness, while some others promote maleness.

The growth regulators responsible for promoting femaleness are :

Auxin, Etylene (ethephon or ethrel), Maleic hydrazide (MH), Tri-iodobenzoic acid (TIBA), Cytokinin, Boron at low concentration, etc.

Growth regulators responsible for promoting maleness are :

Gibbrellin, Silver compounds like AgNo3, Silver thiosulfate [Ag (S_2O_3)], Aminoethoxyvinylglycine (AVG), etc.

Moreover, high temperature, bright sunlight and long day length encourage male flowering. High potashic fertilizer also favors male flowering, while nitrogen has antagonistic action.

Pollination and Fruit Set

Dioecious and monoecious plants are cross pollinated. Hermaphrodite flowers also fail to set seed by self-pollination some times as the pollen grains are sticky. However, self-pollination between two sexes of the same plant is also common in cucurbits.

Poor fruit setting in cucurbits is primarily assumed as the failure of pollination. However, this situation may be improved by hand pollination. Fruit setting is largely dependent on varietal characteristics, nutrition, disease status and environment. It also depends on the number of fruits already present in a plant. Therefore, harvesting of edible-mature fruits encourages new fruit setting.

Methods of Hybrid Seed Production in Cucurbitaceous Vegetables

Most of the cucurbits are cross-pollinated because of their monoecious flowering behavior. However, inbreeding may take place without any barrier as both the sexes are present in the monoecious sex form. Experimental results have demonstrated that cucurbits as a whole exhibit no inbreeding depression. It should be pointed out that there are twopopular cucurbitaceous vegetables-Kakrol and pointed gourd (potal), which are of dioecious flowering habit leading to 100% cross-pollination. These crops may have tremendous inbreeding depression, especially in Kokrol even after one generation of selfing. Inbreeding in dioecious species is not possible in conventional methods as the male and female sexes are in different plants. Moreover, time of anthesis, time and duration of stigma receptivity and pollen availability are different in different cucurbits. Therefore, hybrid seed production technique for each of the cucurbits has been discussed separately.

Different steps of hybrid seed production are :

- Production of inbred lines by inbreeding for 3 to 5 generations.
- Selection of inbred parents through combining ability tests and potential hybrid production ability.
- Production of hybrid seeds (preferably single cross hybrids and pistilate parent preparation is relatively easy, and single fruit produces quite a large number of seeds), and
- Maintenance of inbred parents.

8.2.1. Watermelon

Inbreeding and Selection

Inbreeding may be defined as any system of mating that will lead to an increase in homozygosity. In watermelon, inbreeding is usually practiced by controlled self-pollination. This provides the most effective approach to obtain homozygosity. Inbreeding in watermelon does not cause loss of vigour, self-sterility, decrease in the number of fruits or total yield per plant (Porter, 1930; Porter, 1933 and Walker, 1944). Porter (1933) stated that inbreeding tends to isolate strains which produce either larger or smaller fruits than the commercial variety. It was also reported by Porter (1930) that in Klondike variety, inbred for four successive generations have been isolated which produce fruits equal in weight to those of the parent variety but excel the latter in fruit uniformity, flesh color, texture and quality. Single plant selection and compositing the seeds of selected plant after five successive generation will lead the inbred development in watermelon.

Technique of Hybrid Seed Production

Hybrid seed production in watermelon entails little difficulty because of the monoecious nature of the flowers and the large numbers of the seeds contained in a fruit.

Selection of Parental Line : For hybrid seed production, it is very important to choose the parental line for cross combination. The selection of parent should be based on combining ability, cross compabality study and hybrid vigour manifested in F_1 generation. At BARI two parental combination viz. WM0024 x WM0045 and WM0053 x WM0045 were evaluated based on heterotic performance and cross compatibility and one of the combination was released as F_1 PADMA for its light green colour, oblong shape, high sugar percentage and better overall performance.

Maintenance of Parental Line : When a new superior combination of parent lines for an hybrid variety is identified, the first step should be taken on the process of seed production of parent lines by selfing. For the production of seeds of inbreds the following points should be avoided - i) to produce seeds of parent lines every year and ii) to improve the genetical characters of the parent lines by means of producing their seeds early.

Hybrid seeds of watermelon can be produced by two ways.

1. *Through artificial pollination.*

2. *Removal of male flower and use of insect pollination.*

Artificial Pollination

Field Lay-out : Seedlings at 3-4 true leaf stage should be transplanted at 1.5 m apart in 2.5 m wide beds. At transplanting time, male parent line should be transplanted in the separate rows, so that they never get mixed with female parent lines.

Selection of Female Flowers : Since watermelon plant bears a number of ineffective female flowers which may fail in fruit set, therefore, effective female flowers have to be selected in order to make successful pollination. Strong and stout female flowers having large ovary with long peduncle are best for effective pollination. The female flower bud which will open next day should be selected for bagging.

Bagging of Female and Male Flowers : The process of bagging are as follows.

- Find out adequate female flowers
- Put the bag covering on the bud
- Insert the bud with vine upto the end of bag and
- Fix the bag on the vine by means of twisting 2-3 times the cut ends of the bag at opposite of the vine

Collection of Male Flowers : There are two methods of collection of male flowers. One is that considering convenience of pollination, male flower buds can be collected in the late afternoon of previous day, keeping their peduncles as long as possible and store them upto the next morning. Another method is to collect the male flowers in early morning before dehiscence of anthers.

Period of Pollination : Main pollination period is usually 7 days, 2 days for beginning, 2 days for the peak and another 2-3 days for the last. The peak period of flowering occurs almost in the same dates, therefore, if needed to widen the pollination period, the design of planting date must be adjusted at 15 days interval.

Correlation Between Pollination Hours and Fruit Set : From the mid February to the end of March, flower buds of watermelon starts to open from 6:00 A. M, fully blooms by 7:00 A. M and completely closes by 11:30 A. M. On the other hand during the end of June to the begining of July, flower bud open from 4:30 A. M, fully blooms by 5:30 A. M and completely closes by 10 A. M.

Pollination

- Collect the male flowers in the box or petri dish.
- Pick the male flower from the box and break the petal, then hold it by the mouth at its peduncle.
- Remove the bag carefully from the opened flower.
- Pick the male flower, hold it at its peduncle and put its anther mass on the pistil tapping all the divided 3-4 stigmas evenly and wholly to pollinate completely.
- Hold the male flower again by the mouth, then put bag on the pollinated flower.
- Put the mark-tag on the vine at the female flowers internode.

In the case of rainy days, the pollinated flowers should have to be protected from rain. Watermelon pollens are very susceptible to water and if touched with water drop the pollens are destroyed immediately.

Seed Fruit Management During Growth Period

When the fruits become the size of baby's head, spread the straws under the fruits in order to avoid phytophthora rots.

Harvesting : Fruits of 30-35 days old from the date of pollination, become ready for harvesting. After harvesting, keep the fruits in well ventilated room for the post-harvest ripening in order to improve the seed colour and for the convenience of seed extraction. When the fruits become over ripe, the seed extraction becomes very easy due to softening of flesh.

Extraction, Washing and Drying of Seeds : It is wise to complete the seed extraction and drying on the same day, therefore, referring the weather forecast and choosing fine day the work is to be started from early morning. The process is as follows.

Seeds are mixed with pulp or placenta in cucumber, watermelon etc. Fruits are cut longitudinally into half and scraped out the seed and collected in a barrel. Some placenta remains with the seeds which is to be removed by rubbing with sand or ash followed by washing in water. Otherwise, the pulp surrounding the seeds can be allowed to ferment for 48 hours, when the pulp can be easily separated and then seeds are washed in fresh water. A rapid method of separating the seed from pulp is by acid treatment. Twenty five to thirty ml of hydrocloric acid or about 8 to 10 ml of commercial sulfuric acid can be used for 5 kg of pulp containing seeds. The seeds can be washed free from the pulp in about 20 to 30 minutes. Then the seeds have to be washed thoroughly to remove excess acid and undeveloped floating seeds are discarded.

Seed yield per hectare varies from 150 kg to 300 kg which may vary based on varieties , extent of pollination and field condition.

Removal of male flowers and Use of Insect Pollination

The technique is applicable to monoecious species of the cucurbits, in which male and female parental line should be planted in alternate rows. The male flowers of female plant should be completely removed before their opening. The fruits from the female parent are harvested as crossed fruits and those of the other variety as self fruit of the male variety. This technique has been used in commercial hybrid seed production. According to Wal Kof and Nuttal (1955), in Canada hybrid seeds of muskmelon, cucumber, squash etc. are produced by planting one row of male parent plant and two rows of female parent plants alternately. This methods is referred to as crossing block method. According to Nishi (1955), in Japan three workers are required for 0.245 acres to carry out their operation.

8.2.2. Pumpkin

Floral biology

Anthesis, stigma receptivity and pollen dehiscence are at early morning. However, stigma receptivity persists till mid day.

Methods of Hybrid Seed Production

Production of Inbred Lines

- Seed sowing of diversified genotypes in November to January for winter ecotypes giving 10.6 m distance within and between lines. For summer ecotypes, seed sowing preferably after the 1st monsoon. Allow the plants to climb on narrow bamboo trellis or vertical net-trellis giving 1.0 m interval between plants.
- Bagging of male and female flowers one day before anthesis, and also after pollination of the pistilate flowers for another two days.
- Select the vigorous inbreds after 4-5 generations of inbreeding.

Selection of inbred parents for the most desired hybrids for winter and summer production considering the hybrid performance, general combining ability (GCA) and specific combining ability (SCA).

Production of Hybrid Seeds

- Planting of female and male inbred parents in 4 : 1 ratio,
- Spray 50 to 100 ml of ethephon per litre of water at 2-3 leaf stage on pistilate parent to increase female flowers at lower nodes.
- Allow the plants to climb on narrow or vertical net-trellis.
- Bagging of male and female flowers every afternoon before anthesis. Rebag the female flowers after pollination for another two days.
- Harvest fruits after about 60 days of pollination.
- Remove seeds from the fruits, wash and dry at low temperature (<30°C) for 3-4 days and then sun dry for another 3-4 days.
- Preserve the seeds in sealed polyethylene bags at low temperature (4-5°C).

Maintenance of the Inbred Parents

Inbreeding of parents to produce seeds provided the parental stock is depleted. Produce large quantity of seeds to maintain genotypic and phenotypic integrity of the hybrid.

Seed Extraction : As in watermelon.

8.2.3. Bottle gourd

In cucurbits, bottle gourd (2n = 22) is second to the pumpkin by area (7300 ha) of cultivation and total production (60,000 t/year) in Bangladesh. Probable centre of origin is Africa.

Objectives

- High fruit yield or high vine yield with succulent growth.
- Short vine type which can grow without trellis.
- Genotype having summer production potential.

Floral Biology

- Anthesis time is from 5:00 P.M. to 8:00 P.M.
- Maximum stigma receptivity at anthesis and it remain so for 24 hours.
- Pollens of a particular flower remain effective for about 18-24 hr. However, fresh pollen is the best for pollination.

Method of Hybrid Seed Production

Production of Inbred Lines of Diverse Genetic Background

- Bagging of male and female flowers before anthesis
- Inbreeding at anthesis through following morning and rebagging of the female flowers for another 2 to 3 days.
- Inbreeding should be done for 4-5 generations and select the better types by discarding the poor performers.

Selection of Male and Female Inbred Parents on the Basis of Their Hybrid Performances, SCA and GCA Value.

Production of Hybrid Seeds

- Planting of female and pollinator inbreds in 4:1 ratio.
- Bagging of female and male flowers before anthesis, and only female flowers after pollination for another 2 days.
- Harvesting of mature fruits after senescence of the plant, remove seeds, wash and dry them. Store in sealed polyethylene bags at low temperature.

Maintenance of The Inbred Parents

Inbreeding of parents to produce seeds should be done when the parental stock is depleted. Produce large quantity of seeds to maintain genotypic and phenotypic integrity of the hybrid.

8.2.4. White gourd

Area of white gourd (2n =22) cultivation in Bangladesh is 3,600 ha and total production is 22,000 t/year. Probable centre of origin is Java, Indonesia. Av. yield = 6.11 t/ha.

Objectives

- High fruit yield along with fruiting from early nodes.
- Dwarf vine types which can grow on a short single stick or on a narrow trellis.
- Short life cycle of the crop with multiple planting potential.
- Resistance against CMV and aphid.

Floral Biology

- Anthesis time is very early morning (3-5 A. M.)
- Stigma becomes receptive at anthesis and remains so up to 24 hr.
- Pollens become viable even 2-3 hr before anthesis and remain viable for about 12 hr after anthesis.

Method of Hybrid Seed Production

Production of Inbred Lines of Diversified Genetic Background : As in bottle gourd

Selection of male and female inbred parents on the basis of SCA, GCA and hybrid performances.

Production of Hybrid Seeds

- Planting of female and pollinator inbreds in 4: 1 ratio.
- Vertical net-trellis should be allowed for climbing.
- Bag the female and male flower buds before anthesis and rebag the female flowers after pollination for another 2 days.
- Harest mature fruits after 70 to 90 days depending on inbreds. Remove seeds, wash, clean and dry them. Store in sealed polyethylene bag at low temperature.

Maintenance of The Inbred Parents : As in bottle gourd

8.2.5. Ribbed gourd

Total area under ribbed gourd (2n=26) cultivation is 4000 ha and total production is 17,000 t/year in Bangladesh. Indian subcontinent is the centre of origin. Av. yield is 4.25 t/ha.

Objectives

- High yield having non-bitter taste of fruit.
- Delayed fibre formation in the fruit.
- CMV, powdery mildew and mite resistance.

Floral Biology

- Anthesis at sunset (5-6 P. M.).
- Pollen dehiscence at anthesis.
- Stigma becomes receptive 5-6 h before anthesis and remains so for another 24 h with maximum receptivity at anthesis.

Methods of Hybrid Seed Production

Production of Gynoecious and Monoecious and Moecious/Harmaphrodite Inbred Lines Having Distant Genetic Background

- Gynoecious plants should be treated with 300-400 ppm GA3/AgNo3 to induce male sex for selfing to produce gynoecious inbred.
- Bagging of male and female flowers in monoecious plants before anthesis.
- Pollination in the afternoon and rebagging of the female flowers for another 2 days.
- Inbreeding should be done for 4-5 generations and select the better types by discarding the poor performers.

Selection of male and female inbred parents on the basis of their hybrid performances and considering their SCA and GCA value.

Production of Hybrid Seeds

- Planting of gynoecious/gynoedioecious/monoecious inbred as female, and monoecious/hermaphrodite/andromonoecious as male in 4:1 ratio.
- Remove hermaphrodite plants from gynodioecious female inbred parent retaining the gynoecious plants only, OR in case of monoecious parents, bag the male and female flowers before pollination and rebag female flowers for another 2 days after pollination.
- Harvest mature fruits and dry them before seed removal. Seeds should not be stored at low temperature.

Maintenance of The Inbreds

- Gynoecious line should be maintained by inducing male sex using 300 - 400 ppm GA3 or AgNo3.
- Hermaphrodite inbreds can be maintained by simple selfing, and for other sex forms inbred can be maintained in the similar way mentioned for other monoecious species.

8.2.6. Sponge gourd

Area of cultivation and total production of sponge gourd (2n=26) in Bangladesh are not known. However, it becomes available in lean period of vegetable supply. Centre of origin is India.

Objectives

- High fruit yield having non-bitter taste
- Early fruiting habit having late fibre formation in fruit
- Resistance against CMV, mites, powdery mildew and downy mildew.

Floral Biology

- Anthesis at late night
- Anther dehiscence in the morning with the rise of temperature.
- Stigma becomes receptive at anthesis and remains so until noon.

Method of Hybrid Seed Production

Production of Inbred Lines of Diversified Genetic Background : As in bottle gourd

Selection of male and female inbred parents on the basis of SCA, GCA and hybrid performances.

Production of Hybrid Seeds : As in bottle gourd.

Maintenance of The Inbred Parents : As in bottle gourd

8.2.7. Snake gourd

Area of snake gourd (2n = 22) cultivation is 2000 ha and total production is 9000 t/year in Bangladesh. Centre of origin is India.

Objectives

- High yield with thick mesocarp of the fruits.
- Free from bitterness.
- Variety with early and late seeding potential.

Floral Biology

- Anthesis at or after sunset.
- Stigma becomes receptive at anthesis and remains so far at least another 12 hours.
- Pollination can be done in the following morning of anthesis.

Method of Hybrid Seed Production

Production of Inbred Lines of Diversified Genetic Background : As in bottle gourd

Selection of male and female inbred parents on the basis of SCA, GCA and hybrid performances.

Production of Hybrid Seeds : As in bottle gourd.

Maintenance of The Inbred Parents : As in bottle gourd

8.2.8. Bitter gourd

Area of bitter gourd (2n = 22) production is 4000 ha and total yield is 15,000 t/year in Bangladesh. Centre of origin may be Aisa, Africa or tropical America. Av. yield = 3.75 t/ha.

Objectives

- High yield with at least moderate size of fruit in winter months and long fruits in summer season.
- Less bitter taste with thick mesocarp having poor number of small seeds.

Floral Biology

- Anthesis at early morning.
- Stigma becomes receptive at enthesis and it remains so for another 5-6 hr.
- Pollen dehiscence starts at anthesis and it increases with the rise of temperature.

Method of Hybrid Seed Production

Production of Inbred Lines of Diversified Genetic Background : As in bottle gourd

Selection of male and female inbred parents on the basis of SCA, GCA and hybrid performances.

Production of Hybrid Seeds : As in bottle gourd.

Maintenance of The Inbred Parents : As in bottle gourd

8.2.9. Kakrol or Teasle gourd

Exact area of cultivation and total yield is not known. However, large area of cultivation is seen in Brahmanbaria, Akhaura, Rangpur and some other areas. Kakrol (2n = 56) has export potential to Middle East and U. K. Centre of origin probably is Indo-Burma region. It is generally a vegetatively propagated dioecious crop.

Objective

- High yield with big size of fruits.
- Reduced seed number in fruits, and poor root tuberization.
- Elimination of cumbersome hand pollination practice.

Floral Biology

- Anthesis at early morning.
- Stigma becomes receptive at anthesis and receptivity remains until mid day.
- Pollen becomes viable with the rise of temperature, at about 6:00 to 7:00 A. M.

Method of Hybrid Seed Production

(i) Production of Inbreds of Different Clones on The Basis of Fruit Characteristics

- Grow different fruit morphotypes from tubers on vertical trellis of net giving 0.8 m distance between plants in a row.
- Treat some of the twigs of each clone with 400 ppm AgNo3 before flower bud organogenesis to induce male sex in female plants. Treatment should be given by spraying the solution on top 7-8 leaves of the twigs.
- Cover the flowers of treated and untreated vines one day before anthesis.
- Pollinate the stigma of untreated vines with induced pollen of the same plant or different plants of the same clone. Rebag the pollinated flowers for 3 days to avoid genetic contamination.
- Collect ripe fruits and dry the seeds for storing at low temperature.
- Deshelled seeds, without any injury in the embryo, should be sown in moist sterile medium (sand, soil, vermiculite, etc.) maintaining at least 30°C for about 10 days. Seedlings should be established in February every year.
- Inbreeding should be done for 3-4 generations in selected morphotypes following the above procedure.

Selection of Inbred Parents

Select two genetically female inbreds, as male and female parents of the hybrid, on the basis of their hybrid performances, SCA and GCA value. Male sex must be induced while producing their hybrids.

Production of Hybrid Seeds

- Transplant tuber-originated inbred parents side by side, and allow them to grow on vertical trellis so that pollination can be done conveniently.
- Induce male sex in at least one of the parents (pollen parent) by spraying AgNo3 (400 ppm) in twigs before flower bud organogenesis.
- Bag the flowers of seed and pollen parents 1 day before anthesis.
- Pollinate the flowers by induced pollen and rebag the pistilate flowers for 3 days.
- Harvest the hybrid seeds at full maturity and dry them for storing at low temperature.
- Distribute the hybrid seeds directly or establish the hybrid tubers from F1 seeds and distribute them for commercial production with natural male in 10:1 ratio (female : male) provided there is no parthenocarpy.

(ii) Maintenance of The Inbred Parents

Just maintain the seed-originated tubers of the inbred lines and multiply according to necessity.

- Inbreeding depression may be very high in kakrol.
- Chance hybrids, though relatively low, from ordinary crosses of male and female genotypes may also be selected and multiplied as variety.

Similar methods of hybrid seed production may be applicable in pointed gourd. However, seed-originated plants take several years for fruit production. Therefore, generation advancement may take time during inbred production.

8.3. ONION

Heterosis in Onion

Heterosis in yield of onion hybrids ranged from 14 to 67 percent when compared with commercially grown onion varieties. Heterosis is manifested in uniform bulb size, bulb weight and an efficient source sink ratio.

Male Sterility in Onion

Male sterility in onion is controlled by the combination of a cytoplasmic factor 'S' together with a recessive nucleus gene in its homozygous form (ms). These male sterile lines are maintained by pollination with a maintainer line of construction 'N ms ms'.

Hybrid Seed Production Techniques

For the production of hybrid seed in onion, the male and cytoplasmic female lines are planted in the ratio of 2:8. The success of hybrid seed production depends upon the pollen distribution pattern from fertile to sterile plants in the crossing block.

Factors Affecting Hybrid Seeds in Onion

The following factors are responsible for reduced hybrid seed yield in onion.

- Weak inbred lines
- Abnormal florets where ovary started to develop but failed to produce seed.
- Aborted ovule
- Asynchrony of flowering of parental lines
- Excessive heat damaging the flowers.

Seed Yield in Onion can be Improved as Follows

- Better synchrony of flowering of parental inbreds is achieved by adjusting either storage temperature of the mother bulb (9-14°C) or by planting dates.
- Keeping bee colonies in the hybrid seed production plots @ 3-5 dully developed bee colonies/ha.
- A single application of GA at 50 ppm at the time of first seed stalk emergence reduces the times of 80% of floral stem emergence by half and improve the uniformity of seed stalk height.
- Harvesting seed having 60-70% dry matter content while still in capsule attached to the stalk.
- Avoid shattering of seeds by spraying antishattering materials such as polyvinyl acetate.
- Spray desiccants (diquats) to facilitate uniform drying and mechanical harvesting.

Seed Yield

Hybrid seed yield in onion ranges from 300-350 kg per hectare.

8.4. COLE CROPS

Manifestation of Heterosis

Heterosis in cabbage (25-61%), cauliflower (20-60%) and Broccoli (26-58%) is manifested in head/curd size, early maturity, head/curd weight, and plant weight.

Incompatibility and Hybrid Seed Production in Cole Crops

Mild winters (0-5°C) with spring temperature at bloom (15-20°C) are very suitable for cole crop seed production. In cole crops it is the sporophytic incompatibility system which is most prevalent.

The self-and sib-incompatible but cross-compatible lines are set in the field with a planting ratio of one row of pollinator to four rows of seed parent. The lines A (S_{11}) and B (S_{22}) are each propagated by bud pollination or through tissue culture. The hybrid seeds (S1 S2) are harvested from both parents. Such hybrids are the most uniform ones but usually the production cost of the parental lines is prohibitive. Main problems in hybrid seed production using incompatibility system are (i) depression by continuous inbreeding of parental lines (ii) pseudo compatibility (iii) reduction of incompatibility by environmental conditions (iv) restriction of pollination within parental lines and (v) matroliny.

Male Sterility and Hybrid Seed Production

Cytoplasmic male sterile lines and their maintainers have been developed in cauliflower, cabbage and broccoli using radish cytoplasm for male sterility. Cytosterile plants of broccoli, cabbage and cauliflower are petaloid with large necteries responsible for bee attraction and good female fertility.

Seed Yield

It varies from 500 - 800 kg/ha.

CHPATER IX

POST-HARVEST PROCESSING OF VEGETABLE SEEDS

Introduction

Harvesting, drying, storage and processing operations markedly influence the seed quality, especially its viability or germination capacity as well as the yield. Salunkhe and Desai (1984) and Salunkhe et al. (1984) have described harvesting, handling, storage, and other related aspects of post-harvest conservation of quality of vegetable and flower seeds in great details. Most of these information can be used to reduce post-harvest losses in the vegetable seed production.

Harvesting

In general, the later the crop is harvested, the greater will be the seed yield. In several crops, including vegetables, before the bulk of the crop is ready to harvest, the earlier ripened seed may be lost. Delayed harvesting in such cases may cause heavy losses. The optimum time of harvest for a given seed crop is the point beyond which losses will be greater than the potential seed yield which requires further ripening. Hot dry weather conditions greatly accelerate the rate of natural seed drying on the plant. Seed moisture can form the most important indication of a crop's fitness for harvesting (Thomson, 1979). George (1980) divided vegetable seed crops into three broad groups, depending on the state of seed at harvest time.

Dry Seed

The seed is usually dried on the plant before harvesting; e.g. brassicas, lettuce, peas, beans, beet and onion.

Fleshy Fruits

The ripened fruits are picked from the plants and dried first. The dried fruits are then opened later to remove the dried seeds, e.g. chillies, okra, gourds, pumpkins and eggplant.

Wet Fleshy Fruits

In fruits containing a high level of moisture, the seed has a gelatinous or mucilaginous coating adhering to it. This has to be removed after seed extraction by a fermentation process or treatment with dilute acids. Such fruits are harvested when they mature and ripen e. g. tomato and cucumbers.

Method of Harvesting

The harvesting of seed or fruits containing the seed may be carried out manually or mechanically, depending upon the scale of production, cost and availability of skilled labour and or of suitable harvesting machines.

Hand Picking

Seeds of some crops such as solanaceous fruits (eggplant, pepper, tomato), cucurbits and sweet corn are conveniently harvested by picking fruits by hand. The small seeded fruits or seed heads of vegetable crops like onion, carrot, okra or chilli can be cut with a knife or secateurs. Often it is preferable to cut off the whole plant with a matchet or sickle, as in the case of lettuce, chicory, brassicas, radish and sometimes in peas. The legumes are, however, usually harvested by pulling up the whole plant and then threshing it to recover the seed (e. g. peas and beans).

Although hand harvesting methods are labour intensive, they allow plants to be harvested individually or even at several stages of crop growth. Manual harvesting provides more protection and the maximum potential seed yield per unit area, when compared with the mechanical harvesting. According to George (1980) generally the larger the plant part cut and removed with the ripening seed, the greater will be the ultimate seed yield resulting from the after ripening process, e.g. the small seeded vegetable crops like lettuce and brassicas.

Mechanical Harvesting

Vegetable seed crop may be harvested by employing a suitable mechanical harvester, especially in the large-scale commercial seed producing farms where the manual labour is costly. In the mechanical harvesting, cutting and threshing operations may be carried out by two separate machines or both the operations may be performed by a single combined machine. The cutting operation can be mechanised, using mowing-wind-rowing machines, which are most conveniently used for crops like peas, beans, spinach, carrot and brassicas.

Threshing, Winnowing, Cleaning and Grading

Threshing involves beating or rubbing the plant material to detach the seed from its pod or fruit. The detached seed is then winnowed to remove chaff, straw and other light material from the seed. The seed may be cleaned by removing heavier material like soil, stones, etc. and graded into different sizes by sieving.

Traditional Threshing Methods : Seed has to be extracted from dry seed heads (e.g. onion, lettuce, brassicas), dried fruits (chilli, pepper and gourds) or from fleshy fruits like tomato, cucumbers and melons in which the seeds are wet at the time of extraction. Threshing may be carried out by flailing, beating or rolling the seed containing material to separate it from other plant debris or 'straw'. It may be performed manually, with animals or mechanically. Head threshing is simplest and can be a cheaper method if sufficient labour is available. Seeds may be hand-rubbed (legumes), beaten against a solid wall (lettuce) or on the ground with sick or flail (dried fruits). Thickness or depth or the plant material being threshed should be sufficient to avoid damage to the seeds.

Mechanical Threshing : Various types of threshing machines with adjustable cylinder speeds are available for extraction of vegetable seeds. The cylinder clearance, concave mesh size, airflow rate and screen size greatly influence the efficiency of these machines.

Every care must be taken to avoid damage to the seed during mechanical threshing, by properly adjusting the speed of the beaters, the width of the gap between the beaters and the concave, the airflow and the sieve sizes.

Wet Seed Extraction : Wet seed extraction is followed in certain vegetable crops which bear ripe seeds in fleshy fruits, e.g. tomato and cucumbers. Such seeds have a gelatinous layer around them. The seeds along with this gelatinous materials and the pulp are squeezed or spooned from the cut fruits into containers. The fruit skin and other cell debris are discarded. The pulp containing the seed is allowed to ferment for 1 to 5 days depending up on the stage of fruit-ripening and fermenting temperature. Completion of the fermentation process leading to break down of gelatinous coating can be determined by daily inspection. The mixture must be stirred daily to allow uniform fermentation and avoid seed discoloration. An attack by insects such as fruit flies can be avoided by covering the container with muslin cloth. Use of iron vessels for fermentation can also lead to seed discoloration.

After the completion of the fermentation process, the seed is washed repeatedly by directing a jet of water into the vessel. The light seed and other debris floating on the surface should be discarded. The remaining good seed is finally poured into a retaining sieve, and subsequently spread out to dry on a suitable matting.

Dilute inorganic acids such as hydrochloric acid may also be used to separate gelatinous material from the seed. About 5 to 8 litres of commercial grade HCl are required for 100 kg of tomato pulp. The mixture is stirred for about one-half hour and seed is washed out as described above.

Seed of some fleshy fruits like melons, sweet peppers, etc, which are also extracted wet, do not require fermentation. They are simply macerated and rubbed in water.

Seed Drying

Seeds contain natural moisture, which at harvest time is often higher than the optimum required for the maximum potential life and best germination. The amount of moisture in the seed is probably the most important factor influencing the longevity and germination capacity of the seed.

After the seed is detached from the mother plant, its moisture content is a function of relative humidity (RH), and it is at equilibrium with that of the surrounding air. Seeds of fleshy fruits such as tomato, cucumber and melons, have a much higher moisture content at harvest, and may absorb more water during their wet extraction process. On the contrary, seeds formed in fruits which become descicated during the ripening process are relatively dry at the time of harvest, e.g. onion, Amaranthus, brassicas, etc. The approximate moisture content of some vegetable seeds in equilibrium with air at different relative humidities at 250C is presented in Table 10. Different kinds of seeds vary greatly in their moisture content at a given relative humidity.

Table10. Approximate Moisture Content of Some Vegetable Seeds in Equilibrium with Air at Different Relative Humidity at 25°C

Seeds	Relative Humidity %				
	15	30	45	60	75
	Moisture content, percent on wet basis				
Maize	6.5	8.5	10.5	12.5	15.0
Mustard	4.0	5.0	6.0	7.0	9.0
French bean	5.0	6.5	8.5	11.0	14.0
Beet root	5.0	6.0	7.5	9.5	12.5
Okra	7.5	8.0	9.5	11.0	13.0
Egg plant	4.7	7.0	-	-	-
Cabbage and cauliflower	3.5	4.5	6.0	7.0	9.0
Capsicum (Chilli)	6.0	7.0	8.0	9.0	11.0
Carrot	5.0	6.0	7.0	9.0	11.5
Cucumber	6.0	7.0	7.5	8.0	9.5
Lettuce	4.0	5.0	6.0	7.0	9.0
Onion	6.0	7.0	8.5	10.0	12.0
Pea	5.0	7.0	8.5	11.0	14.0
Spinach	7.0	8.0	9.5	11.0	13.0
Tomato	6.0	7.0	8.0	9.0	11.0
Watermelon	6.0	7.0	8.0	9.0	10.5

From : Harrington J F and Douglas, J E, (1970) Seed Storage and Packaging : Applications for India, National Seeds Corporation Ltd., and The Rockefeller Foundation, New Delhi.

However, an excessive drying of large seeded legumes may cause cracking of hypocotyls, seed coats or whole seeds. Under humid tropical conditions, the freshly harvested vegetable and flower seeds may have a moisture content ranging from 18 to 35%, which must be reduced to a 'safe level'. According to George (1980), the safe moisture level for open storage of starchy seeds is 12%, for open storage of oily seeds is 9%, and for seeds to be stored under seal is 6 to 8%.

The Temperature, Duration and Rate of Seed Drying

The temperature and duration of seed drying play an important role in the retention of seed viability. According to Thomson (1979), temperatures upto 45°C are generally safe but higher temperatures may be used in continuous flow driers than in batch driers because the time of exposure is shorter. The time or duration of seed drying will depend on the crop species as well as on the method of storage employed.

Although it is not possible to accurately judge the maximum drying temperatures, which can be guaranteed to be safe, the following temperatures for some vegetable seeds can serve as a guideline.

Maize (sweet corn)	40 to 45°C
Pea	30 to 50°C
Beet	45°C
Brassicas	27 to 40°C
Onion	21 to 33°C

Methods of Seed Drying

Natural Drying

The seed is dried under the sun, spreading it on a suitable surface such as mats, hessian or concrete floors. Natural sun drying is generally employed in the areas with prolonged arid conditions with brighter sunlight. Traditional methods utilize solar and wide energy to dry smaller quantities of seed most effectively. Threshed seeds are spread out in a thin layer on a smooth earthen floor or straw matting. Ventilation is improved by stretching the matting on a horizontal framework supported on stake above ground level to allow the wind to blow through the seeds. Also the unthreshed inflorescences may be hung on frames or placed in cribs with open sides. Direct exposure to sunlight may affect germination capacity, particularly when the seeds containing high moisture are exposed to prolonged solar radiation with high temperatures and ultraviolet radiation.

Artificial Drying

Artificial drying using heated air is required to be followed in the temperate and humid tropical regions where natural drying can not be adopted with efficiency.

Geroge (1980) divided artificial drying into following two types :

Batch Drying Systems

In batch driers relatively dry air is blown through a layer of seed until drying is completed. The dried seed is then replaced by another batch. The method is simple, suitable to handle smaller quantities of seed and allows easy cleaning. Batch drying systems can be of the following types:

Rotary driers - These are suitable for seed with relatively low moisture content, but require a high level of technical operation skill. They are also not very suitable for small seed lots of different moisture contents.

Fluidisation driers - These have a relative high energy consumption and are not suitable for seed lots of varying size.

Vertical driers- These are low in their energy requirements and drying capacity.

Belt driers - These are suitable for seeds with poor flowering properties.

Continuous Drying Systems

In continuous-flow driers, the seed moves horizontally or vertically through a stream of hot air and then into a cooling chamber. Since it is a continuous process on a factory scale, continuous flow driers are suitable to handle large quantities of seed. It is, however, difficult to clean the seed when there is a change of cultivar. In this process, the seed is heated comparatively for a much shorter time, the air temperature, therefore, can be higher than in 'batch' driers. These are of four types:

Horizontal tray drier

Vertical single-layer drier

Vertical double layer drier, and

Cylindrical drying bin with central duct.

All these systems dry a layer of seed. The horizontal tray drier is particularly suitable for small batches of different seeds, since it can be designed or adapted to take seed trays or containers.

Seed Storage

Seed is required to be conserved through proper storage for a short or long period of several months. The reasons for this include:

- It may be uneconomic to multiply each seed stock annually.
- It is not always possible to estimate seed yields.
- Demands for seed may fluctuate and
- Good seed stocks are valuable and can be difficult or costly to produce.

A small quantity of seed may be stored on the farm using traditional methods, but conservation of large quantities of certified seed requiring storage periods of 18 months or more need appropriate storage methods to overcome the deterioration effects of temperature and relative humidity of the storage environment. Vegetable and flower seeds are sold in relatively small quantities. It may be advantageous not to produce seed every year and to carry over stocks by proper storage, if there are difficulties in producing seed, e.g. special requirement of pollination.

Method of Storage

Traditional Methods : Based on local climate and needs various traditional methods are employed by the farmers in tropical, sub-tropical and humid temperature regions. In the drier tropics and sub-tropics, for example, seeds are stored in woven socks or in heaps on the ground, usually under shade and protecting against animals and rodents. Some

protection against rain and condensation from dew (in the form of a cover) may be necessary. In the temperate regions, seed is often stored in woven socks or on barn floors but always covered. More care is needed in the humid tropical regions, where seed is usually stored in earthenware bins or in gourds sealed with clay and well protected from rodent. Smaller quantities of seed stored in baskets may be hung in the kitchen out of reach of rodents in a dry smoky atmospher. Seed may be drawn from the large quantity of grain stored for food in special huts built of wood, bamboo or straw. These huts are usually constructed above the ground level and have a thatched roof to protect the seed from rain. Grain may also be stored in ground pits, if there is no danger of excessive rain and the soil is impermeable.

Improved Storage Structures : Larger quantities of seed may be stored in bins, boxes or bags by specially constructing purpose-built stores. These builders should provide protection against rodents and birds. Floors should be smooth (preferably in cement concrete), above ground level of walls should have smooth internal surfaces without ledges. Fans or blowers used for ventilation should have covers (to protect the seed from birds and rodents) when they are not in use. Ventilation ports should be insect-proof and single door should be tight-fitting and kept closed. Double roofs, heat insulating materials as well as moisture vapour proofing may be necessary.

Cylindrically-shaped storage bins of maximum 100 tonnes capacity are recommended for seed. Air blown through a perforated floor keeps the seed mass well ventilated. This can also be employed for initial seed drying after harvest. Such aeration cools the seed or evaporates water which has condensed under roof, when the temperature and relative humidity of the ambient air are low. According to Thomson (1979), aeration can be used to introduce a fumigant.

Large open-topped boxes made of wood, each with a capacity of several tonnes are also used to store seed. These boxes are convenient to handle numerous smaller seed lots. They can be placed one above the other to the roof of the store. Fork-lift trucks can easily stack or unstack them.

Bagged seed should be stored on pallets, each carrying about one tonne seed. These can also be stacked and moved from place to place by fork-lift trucks. Use of pallets encourages an orderly arrangement of bags, space economy, adequate aeration and easy access to seed lots. An individual stack can easily be enclosed by a plastic or other suitable sheet for fumigation.

In the humid tropics, refrigeration and dehumidification are necessary to be provided in store rooms. However, their use is prohibitively expensive for long-term storage of large quantities of seed. On a medium scale, insulated rooms fitted with a domestic air-conditioner may be used. They are universally available and replaceable in case of breakdown. Stores with a 100 tonnes capacity in bags, fitted with such air-conditioner, have successfully been operated at 22°C and 50 percent RH. The refrigeration unit used in the store should be powerful enough to counteract the heat generated by dehumidification.

Seed can also be stored in sealed plastic bags. Densest and thickest (High Density Polyethylene) films impermeable to water are suitable, they can be easily heat-sealed to

make the bags airtight. The seed to be stored in airtight bags, however, must be drier than when it is stored in open. Respiring seeds produce water which cannot escape and raises the humidity within the package. Seed must, therefore, be dried down to a low moisture content, in equilibrium with 30 to 50 percent RH, depending on the temperature expected and the length of storage desired. Slight rise in humidity during storage is not enough to allow mould development. The extra cost of drying under such storage can be set against the reduced loss of valuable seed through deterioration.

Seed Processing

Seed processing aims at cleaning of seeds to remove plant debris (chaff, straw, flower heads, stem, leaf etc.), non-seed materials (soil, sand or stone particles), seeds of other crops, seeds of common and noxious weeds, and seed appendages (which may interfere with free running of the seed in future operations, including sowing). Seed processing up-grades or concentrates seed by removal of seed of undesirable quality such as damaged, diseased, insect affected, partly germinated, discolored, lighter, larger or smaller than the optimum. Processing of seeds thus reduces the total weight of a seed lot and increases its value per unit weight or volume.

Processing, however, does not normally increase genetical quality of seed. It also does not separate the seeds of different varieties of the same crop or improve seed germination, with the possible exception of a process which breaks dormancy.

A good seed is separated from its valueless or even harmful contaminants, based on differences in certain physical properties of these materials such as size, length, shape, relative weight, surface texture, colour, affinity for liquids, and relative conductivity. Wide range of seed processing equipment used to upgrade the value of seed of different species. Raymond and George (1980) classified seed cleaning operations into the following four processes:

A. Winnowing
B. Pre-cleaning or Conditioning ('Scalping')
C. Basic Cleaning, and
D. Separation and Upgrading

A. Winnowing

Dry seed which has been extracted by hand or with a thresher can be further separated from the lower density plant debris by winnowing. This operation is performed by hand, using the natural breeze or by blowing to remove plant debris. Sophisticated winnowing machines having hand and mechanically operated blowers are also used to process the seed on commercial scale.

B. Pre-cleaning or Conditioning

Pre-cleaning, also called 'scalping' is usually practised to pre-clean or condition the seed material before further processing. This operation normally removes the bulk of the plant debris and other undesirable material. The most commonly used machine for

pre-cleaning is the 'scalper'. Seed clusters may be required to be broken during the pre-cleaning process. The 'scalper' scalps off the larger pieces of plant debris (stem, haulm, pod, dried flower and other foreign materials, such as stone, clod, etc.). Smaller seeds fall through a vibration or rotating sieve. Some scalper machines have an air flow to remove dust, chaff and other lighter materials from the seed. Certain operations known as 'hulling' and 'shelling' are required in specific crops. 'Hulling' is carried out by feeding the seed into a cylinder containing revolving arms which rubs the seed against the internal concave surface of the cylinder. The machine has to be adjusted to avoid seed damage. In shelling maize, the ears are pressed against revolving cylinders with projecting lugs which with a thumb-like action detach the caryopes from the tough fibrous axis. Damage is minimized by delaying this operation until after drying. However, in most other cases, it is always desirable to preclean the seed before drying it in bulk.

C. Basic Cleaning

This is the generalised cleaning operation used to remove all but the contaminants requiring special processes to separate them. 'Screning' and 'air separation' are the two main basic cleaning operations performed with the help of various machines. Many basic cleaning machines combine both these features.

Packaging

The processed seed is required to be packaged properly in uniformly sized bags and closed. Seed is usually supplied to the farmers in bags. During its transfer from the processing plant to the field, seed is subjected to rough handling. Its journey by rail, road or sea may be interrupted by periods of storage in country merchants' or village traders' premises and in the farmers' houses. A package must ensure :

- A convenient unit for handling transport and storage,
- Protection against contamination, mechanical damage and seed loss,
- A suitable environment for storage
- A barrier against loss of seed and escape of pesticides, and
- A safe promoter.

Bags manufactured from cloth, paper or plastic film are normally used to package seed. Cloth bags woven from jute or cotton or from synthetic fibres such as nylon or other polymers may be used. These bags, however, are not suitable for seed treated with a highly poisonous pesticide. Paper bags built up of several thick layers are more suitable for humid conditions. Polyethylene plastic bags are being increasingly used for packaging, owing to their strength and impermeability to moisture. Denser and thicker grade plastic bags provide good protection against rough handling and are resistant to rodent damage. Packaging in sealed bags requires additional drying, the cost of which may not be justified in temperate climate. Thomson (1979), therefore, recommends provision of small holes in the bags to permit diffusion of water vapour. These bags cannot be left exposed to rain.

Bags may be closed by tying them with a string or machine stitching. Polyethylene bags are usually heat-sealed. Paper and polyethylene bags can be closed by a valve, which is shut automatically by the seed weight when the bag is turned after filling. For certified seed, an official sealing device is employed. Information about the species, the cultivar, the grade, a lot reference number and any other details as specified by the law must accompany each bag in the form of a label or tag firmly attached as a part of stitching or sealing operation. The packaging size should be adaptable to local conditions, taking into consideration the upper weight limit that a man can carry during loading and unloading operations.

E. Seed Process Management

Management of seed processing requires a good planning of all the operations to save time, labour, money and energy. It is important to choose processes and their proper sequence for each seed lot so that work is carried out efficiently taking into account the available resources and ultimate value of the seed.

Labelled seed lots, bearing reference number should be stored in spillage and leak-proof containers, only one seed lot being processed at a time and each fraction properly labelled. Maintenance of a stock book, showing origin, processing and treatment of each seed lot, and disposal of the debris is necessary.

The sequence of all events during seed processing (processing line) consisting of machines, apparatus, etc. must be arranged efficiently. George (1980) recommended the following sequence for efficient management of vegetable seed processing :

- Receiving
- Pre-cleaning (or conditioning)
- Cleaning and/or separation
- Blending
- Treatment (control of diseases and pests)
- Packaging, and
- Dispatching

Drying and storage operations may be necessary to be included in the processing of certain kinds of seed. A seed may remain within the processing plant for weeks or months, only a fraction of this time being spent in actual moving of seed through the machines. Seed may be stored in bulk or in bags as received, in bins or large boxes between operations or in bags after packaging. Also seed may be required to dry at different stages in sequence and need not be completed in one operation. It may be partially dried on the farm and if its moisture is still more than 3 percent above the level considered safe for storage, it should be dried immediately. Seed which is close to the safe moisture content may be cleaned wholly or partially before a second drying. Seed is normally less susceptible to mechanical damage before it is completely dried. Seed destined for sealed polyethylene bag should be given a final drying in as short a time as

possible before packaging. Since a wide range of vegetable and flower seed types are encountered, the processing lines must be flexible to suit the condition of each type of seed lot.

Machines and equipment required for seed processing must be maintained clean and in order. A regular maintenance unit with a ready stock of the needed spare parts has been recommended. Overhauling of machines and replacing working parts such as drive belts, etc during the quiet season are advisable.

Duties and functions of the seed processing staff should be specified. All staff must understand and obey safety regulation regarding fire hazards, use of machines, electricity, crop protection, chemicals, dust and other potential hazards.

A good management of seed processing is characterized by orderliness and cleanliness. The work load of a processing establishment is not uniform throughout the year. Active periods start at harvest time and end when the packaged seed is dispatched. There may be more than one such period in a year, distinct and overlapping. All the operation of processing, therefore, should be planned well in advance. The plan must, however, be flexible to accommodate unexpected contingencies such as unusually early harvest or high moisture content of seed lots.

Laboratory tests should be carried out on seed samples drawn before and after processing and at intermediate stages, to supplement the observations of experienced operators. Initial tests carried out to determine moisture content of seed and the presence of impurities are most important. A separate identity of the seed lot should be maintained throughout the processing with clear labelling and appropriate separation.

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