DENSITIES AND MEDIA EFFECT ON TOMATO SEEDLING QUALITY

ZHOU RUI JUN, China

ABSTRACT

The quality of tomato seedlings raised in 4 seedling densities (1,100/m², 400/m², 200/m², 100/m²) and 2 kinds of media were compared. Decreasing seedling density markedly increased the seedling vigor, field survival rates and improved reproductive growth and fruit development. Vegetative vigor was evaluated according to an index based on relationships among seedling height, stem thickness, shoot and root dry weight. Seedlings in density 100/m² had the significantly highest vigor index while those from 200/m², 400/m² and 1,100/m² ranked the second, third and last, respectively. Significantly higher field survival rates were observed in densities 100/m² and 200/m² than those from density treatments 400/m² and 1,100/m². The number of individual flowers, infloresences and fruit/plant in early the stage significantly increased in density treatments 100/m² and 200/m². No significant difference was found between the media treatments.

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is one of the most popular vegetables in many countries. In the tropics, tomatoes, like most vegetable crops, are normally produced in mountain regions or in the low lands during the cool season. The unit yield per hectare has remained a below that of countries in the temperate zones. The lack of appropriate cultural practices during both the wet and dry season is one of the barriers to successful tropical tomato production (9). In tropics, tomatoes mostly are produced by transplanting. Good quality of seedling usually can lead to higher yield and earlier maturity. Tomatoes that mature early not only could receive higher price on fresh markets but also could reduce the risk of growing tomato in the tropics.

Adjusting the growth medium and seedling density for improving tomato seedling quality has long been accepted practice of tomato cultivation and production. Both the growth medium and density for tomato cultivation varied widely from country to country (1, 3, 8, 10). However, little is reported on the seedling-raising method for tropical tomato production which needs different cultural practice from that of temperate zone.

This research was conducted for the purpose of examining the effect of 4 seedling densities and 2 growth media on the quality of tomato seedlings, and their further development on the effect of tomato production. In this research both morphological characters of the seedlings and their field performance after transplanting were evaluated.

MATERIALS AND METHODS

Experiment was conducted in the TOP/AVRDC's experimental field in the Kasetsart University, Kamphaeng Saen Campus, Thailand, from November 1986 to January 1987.

The 4 density treatments were 100, 200, 400 and 1,100 seeds/m^2 and the 2 growth media treatments were consisted of soil, compost, sand and rice hull in the proportion of 5:3:1:1 and 5:2:2:2, respectively.

The first growth medium was devised by AVRDC and the second one was used routinely at TOP. In this study same amount of fertilizer was added to both media.

A split plot design with 3 replications was used and with medium treatment in mainplot and density treatments in subplot. Seedling beds of 10 m^2 with medium in depth of 20 cm were prepared 1 week before seeding.

Tomato seeds of AVRDC selection "CL 143-0-10-3-0-1-10" were precisely sown and evenly spaced at 10, 7, 5 and 3 cm apart on December 6^{th}, 1986. After seeding, the beds were mulched with rice straw and covered by plastic screen. Sprinkle irrigation was used as needed to promote rapid seed germination and seedling growth. Emergence rate was observe and mulching rice straw was removed after emergence.

Ten seedling were sampled randomizely from each subplot and the plant height, the stem thickness, the leaf number, the fresh and dry weight of shoot and root and the seedling vigor index were measured 23 days after sowing. The seedling vigor index was derived according to the formula:

Vigor index = (Stem thichness/Length + Root dry weight/Shoot dry weight) x (Shoot dry weight + Root dry weight) (4).

Meanwhile, the rest seedlings were transplanted to the field for the evaluation of their field survival rates and the early stage of growth development. In field evaluation, split plot design with 3 replications was used again with growth medium as the main treatment and the seedling density as the subtreatment.

Each subplot was 3 m in length and 1 m in width with 2 single line rows. There were 10 plants in each row, spaced 30 cm apart. Field survival rates were investigated 5 days after transplanting. Number of individual flower, infloresence and fruit/plant were observed on January 19th and 26th, 1987.

RESULTS

a) ON EMERGENCE

Table 1 shows the emergence of seeds in each medium and density treatments. However, no significant difference were found among all treatments.

b) ON SEEDLING VIGOR INDEX

Seedling density in both media significantly affected the seedling height, the stem thickness, the leaf number and the dry weight of shoot and root. The vigor index was calculated from each component parameter as shown in Table 2. Density treatment of $100/m^2$ had a significantly highest vigor index while density treatments of $200/m^2$, $400/m^2$ and $1,100/m^2$ ranked the second, third and last respectively. Vigor index increased significantly as the density decreased. Growth medium developed at TOP showed a higher average vigor index than that of AVRDC medium. However, this is not significant statistically (Table 4). The regression analysis between the vigor index and the seedling density was made. The regression equation used were as follows:

$YB1 = 0.101 + 0.075 \quad x \; Y=0.960^{**}$ (AVRDC medium)

$YB2 = 0.128 + 0.089 \quad x \; Y=0.989^{**}$ (TOP medium)

The results from both media treatments show that the seedling density has a significantly positive correlation with seedling vigor index (Figure 2).

c) ON THE FIELD SURVIVAL RATE

The seedling density had significant influence on the field survival rates of tomato plants. A consistant decrease of the field survival rates from 93.33 to 46.67% in AVRDC medium and from 88.33 to 76.67% in TOP medium treatments occured as the seedling density increased from $100/m^2$ to $1,100/m^2$ (Table 3). However, no significant difference was found in the medium treatments.

d) ON INDIVIDUAL FLOWER NUMBER

Individual flower number was counted 22 days after transplanting. There was significant difference ranged from 6.44 to 2.76/plant with increased densities. Density of $1,100/m^2$ gave the best flower number which significantly lower than densities $100/m^2$, $200/m^2$ and $400/m^2$. The difference in flower numbers between $200/m^2$ and $400/m^2$ was not significant. No significant difference was observed among medium treatments (Table 5).

e) ON INFLORESENCE NUMBER

Infloresence number/plant was counted 29 days after transplanting. A significant decline was observed as the seedling density increased. Seedlings from densities of $100/m^2$ and $200/m^2$ had 2.19 and 1.92 infloresences/plant respectively. These infloresence number were significantly higher than the 1.37 and 0.79 infloresences/plant obtained from densities of $400/m^2$ and $1,100/m^2$ (Table 5). However no significant difference was observed in medium treatments.

f) ON FRUIT NUMBER

Fruit number/plant was determined 29 days after transplanting. Seedlings from densities of $100/m^2$, $200/m^2$, $400/m^2$ and $1,100/m^2$ had 5.59, 4.93, 3.30 and 1.66 fruits/plant respectively. The densities of $100/m^2$ and $200/m^2$ gave significantly more fruits/plant than that of densities $400/m^2$ and $1,100/m^2$. In the meantime no significant difference was found between medium treatments (Table 5).

DISCUSSION

Raising good seedlings is the prerequisite to successful tomato growing. Good seedling quality could significantly improve vegetative and reproductive growth after transplanting. A number of research were reported for selecting the most suitable density for tomato growers and the density standard varied greatly from country to country. In Georgia, USA, seeding rate less than 63 seeds/m^2 was recommended becaused their research results indicated that greater than 63 seeds/m^2 usually increased only the cull transplants with no significant increase in the marketable transplants (10). The research results in UK showed that seedling density of 60 plants/m^2 ripened 5 days earlier when compared with that of 200 plants/m^2 and produced 50% more yield (2,3). In Poland densities of 133/m^2, 66/m^2 and 44/m^2 were compared, the best results in relation of earliness and higher yield were obtained from plants at 44/m^2 (8).

In northern China, the accepted seedling density is between 100/m^2 to 200/m^2. Because of the temperate climate and the indeterminate plant type, spacing in termperate zone is usually greater than the tropics. However, many research results showed that close spacing reduced seedling quality and delayed infloresence formation as compared with wider spacing. After planting in the field, tomato plants that were raised from the closer seedling spacings started the crop slowly and produced substantially lower yield (1,7). In the present study, the seedling density showed a significant effect on the quality of seedlings and subsequently influenced the field survival rates and delayed reproduction growth of the tomato plants. In the U.S.A., the stem thickness and the plant height were commonly accepted standards for the evaluating of tomato seedling quality (10). In Hungary, a quality index which was developed from the relationship among plant height, leaf number, stem thickness and weight was suggested as a yardstick for the evaluation of tomato seedling quality (5). In northern China, the Hungarian method was used to evaluated seedling vigor with a slight modification in calculating the formula by emphasizing more on the dry weight ratios of shoot/root (4). This modified formula was used in the current study. Results of the field observation confirmed that the vigor index used in this work is reasonable and had a good representation of tomato seedling quality.

Though the seedling density of $100/m^2$ showed the highest vigor index and had the best field result, it is not significantly different from the density of $200/m^2$ in almost all categories. From the point of economy, density $200/m^2$ should be recommended. With the density, grower can double his seedling production on same area of seed bed and also with acceptable seedling quality.

The seedling density of 300 plants/m^2 or 5.5 x 6.0 cm spacing was applied by AVRDC for raising tomato seedlings and the transplanting was usually conducted when the seedling reached 3 to 5 true leaf stage (6). At TOP, a density of 220 plants/m^2 or 6.5 x 7 cm spacing was used and the seedling were transplanted at 5-6 true leaf stage. It needs earlier transplanting with smaller seedings. This density is as rational as the density used by TOP. Both of these two densîties are in agreement with the results obtained by the present research which suggest that a density of $200/m^2$ or 7 x 7 cm spacing with the transplantation at 5 to 6 true leaf stage are most suitable. The TOP modified medium gave higher permeability which lead to a higher value on the seedling height the stem thickness, the leaf number, the dry shoot & root weight and the vigor index, though the difference between these and the AVRDC is not significant (Table 4).

CONCLUSION

Seedling quality of tomato was significantly effected by seedling density. As the density increased, the corresponding value of quality decreased.

Seedlings raised in densities of $100/m^2$ and $200/m^2$ had significantly vigor index, field survival rates and early reproductive growth than the seedling densities of $400/m^2$ and $1,100/m^2$. No significantly difference was found between the densities of $100/m^2$ and $200/m^2$.

No significant difference in the effectiveness of tomato seedling raising was found between the AVRDC medium and the TOP medium.

In Thailand, the seedling density of $200/m^2$ or 7 x 7 cm. spacing is suggested for raising tomato seedlings and they should be transplanted at 5-6 true leaf stage to the field.

ACKNOWLEDGMENTS

I would like to express my sincere gratitude to Dr. Charles Y. Yang, Director/Resident Scientist for giving me the opportunity to participate the training/study in the programs of TOP/AVRDC and his valuable guidance on my experiment and writings.

I am indebted to the International Development and Research Center (IDRC) for funding my training and making it possible for me to carry out the present study.

I am grateful to Dr. Peerasak Srinives and Mr. Krung Sitathani for giving the guidances and good suggestion on my experiment.

I wish also to thank all training officers and of the field staff of TOP/AVRDC for the generous assistance during the course.

Table 1. Effect of growth media on the emergence of tomato seeds. (11 Dec. 1986)

Sub Density	Main (AVRDC) Seeds emerge	(%)	Main (TOP) Seeds emerged	(%)	Sub total Number	survival (%)
1,100/m2	144.00	96.00	147.00	98.00	291.00	97.00
400/m2	143.00	95.33	145.00	96.67	288.00	96.00
200/m2	145.00	96.67	145.00	96.67	290.00	96.67
100/m2	144.00	96.00	146.00	97.33	290.00	96.67
Total	576.00	96.00	583.00	97.17	1159.00	

Table 2 Effect of densities and media on seedling growth and vigor of tomato. (29 Dec. 1986)

entry density medium		height (cm)	stem thickness (cm)	rate (thickness per high)	number of leaves	Dry weight(g) (10 seedling) shoot (S)	root (R)	rate (R:S)	Total	Index vigor
Main	Subplot									
AVRDC	1,100/m2	12.40	0.281	0.022	4.50	1.47	0.196	0.133	1.666	0.260
medium	400/m2	16.30	0.373	0.023	5.43	3.00	0.393	0.133	3.393	0.561
	200/m2	16.27	0.414	0.026	5.83	4.07	0.474	0.116	4.544	0.647
	100/m2	13.27	0.443	0.033	6.33	4.27	0.582	0.137	4.852	0.824
Main	Subplot									
TOP	1,100/m2	17.03	0.335	0.020	5.03	2.37	0.274	0.116	2.644	0.359
medium	400/m2	17.33	0.420	0.024	5.93	4.20	0.463	0.110	4.663	0.628
	200/m2	16.00	0.446	0.028	6.50	4.67	0.541	0.116	5.211	0.752
	100/m2	13.63	0.485	0.036	6.50	5.80	0.697	0.120	6.497	1.014

Table 3 Effect of seedling density and growth on the field survival rate of tomato.

Sub density	Main (AVRDC) survival seeds	survival (%)	Main (TOP) survival seeds	survival (%)	Subtotal survival average	(%)
1,100/m2	28.00	46.67	46	76.67	74	61.67
400/m2	52.00	86.67	45	75.00	97	80.83
200/m2	58.00	96.67	47	78.33	105	87.50
100/m2	56.00	93.33	53	88.33	109	90.83
Total	194.00	80.83	191	79.58	385	80.21

Table 4. Variance analysis of emergence vigor index, survival rate, individual flower number, infloresence number, fruit number fruit number of tomato.

SOV	entries	DF	SS	MS	F-Value
Total	emergence	23	32.957		
	Vigor index	23	1.355		
	Field survival rate	23	292.959		
	Individual flower No.	23	92.764		
	Infloresence No.	23	8.566		
	Fruit No.	23	65.144		
Block	emergence	2	6.082	3.041	0.336 NS
	Vigor index	2	0.022	0.011	1.030 Ns
	Field survival rate	2	9.334	4.667	1.037 NS
	Individual flower No.	2	6.310	3.155	0.487 NS
	Infloresence No.	2	0.247	0.124	4.565 NS
	Fruit No.	2	0.565	0.283	0.290 NS
Main	emergence	1	2.039	2.039	0.225 NS
	Vigor index	1	0.080	0.080	7.480 NS
	Field survival rate	1	0.375	0.375	0.083 NS
	Individual flower No.	1	7.797	7.797	1.203 NS
	Infloresence No.	1	0.133	0.133	4.930 NS
	Fruit No.	1	0.081	0.081	0.083 NS
ERR(A)	emergence	2	18.086	9.043	
	Vigor index	2	0.021	0.011	
	Field survival rate	2	9.000	4.500	
	Individual flower No.	2	12.961	6.481	
	Infloresence No.	2	0.054	0.027	
	Fruit No.	2	1.948	0.974	
Trt.	emergence	3	0.789	0.263	0.611
	Vigor index	3	1.154	0.384	69.874 **
	Field survival rate	3	122.458	40.820	7.168 **
	Individual flower No.	3	40.891	13.630	6.891 **
	Infloresence No.	3	6.937	2.312	29.913 **
	Fruit No.	3	55.810	18.604	50.949 **
Main trt.*	emergence	3	0.797	0.266	0.617 NS
	Vigor index	3	0.124	0.004	0.752 NS
	Field survival rate	3	83.459	27.820	4.885 *
	Individual flower No.	3	1.069	0.356	0.180 NS
	Infloresence No.	3	0.266	0.089	1.149 NS
	Fruit No.	3	2.328	0.776	2.125 NS
Trt. ERR(B)	emergence	12	5.164	0.430	
	Vigor index	12	0.066	0.005	
	Field survival rate	12	68.333	5.694	
	Individual flower No.	12	23.735	1.978	
	Infloresence No.	12	0.928	0.077	
	Fruit No.	12	4.382	0.365	

* significant at 0.05 level
** significant at 0.01 level
NS non significant

Table 5. LSD test of emergence of seed number, vigor index of seedling, field survival rate, individual flower number, infloresence number and fruit number of tomato.

Densities	Emergence of seeds number	Vigor index	Field survival rate	Individual survival number	Infloresence number	Fruit number
100/m2	290	5.51 aA	109 aA	38.65 aA	13.11 aA	33.51 aA
200/m2	290	4.20 bB	105 aA	28.76 aAB	11.52 aA	29.56 aA
400/m2	288	3.56 cB	97 aAB	27.85 aAB	8.23 bB	19.81 bB
1,100/m2	291	1.86 dc	74 bB	16.54 bB	4.71 CC	9.91 cC

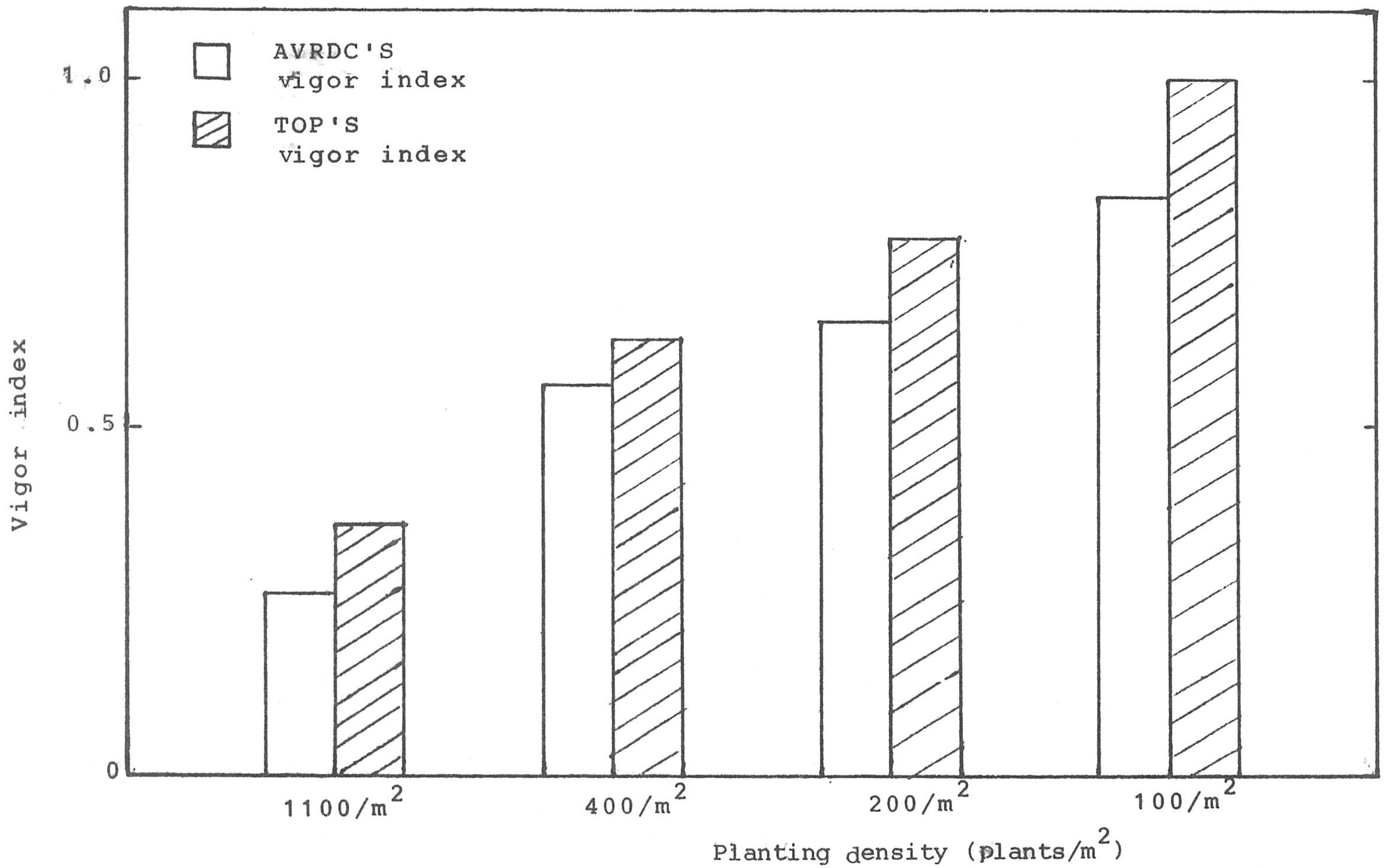

Fig. 1 Vigor index of 4 seeding densities and 2 growth media of tomato planting density (plants/m^2)

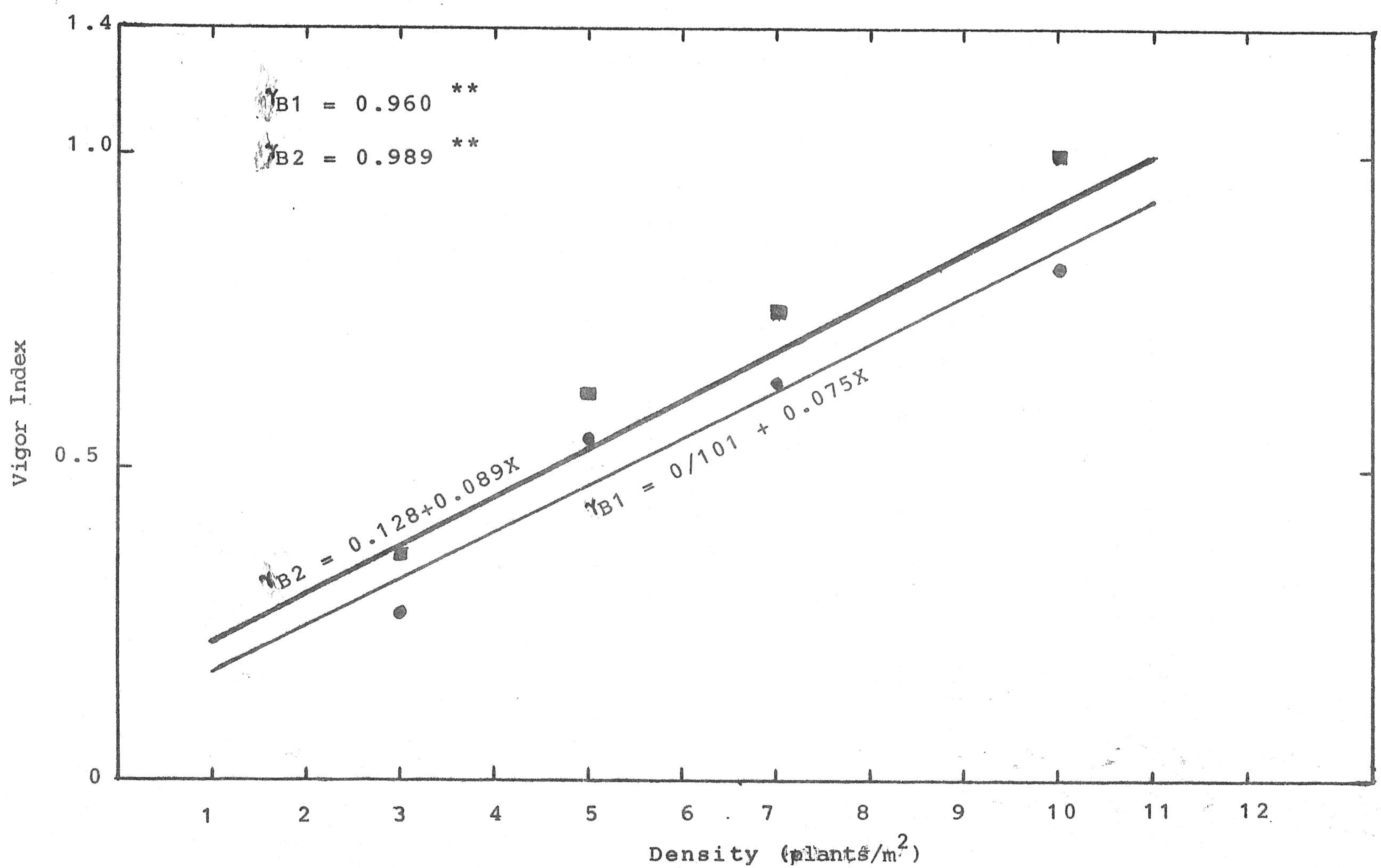

Fig 2. Regression analysis between vigor index and seedling densities, of tomato

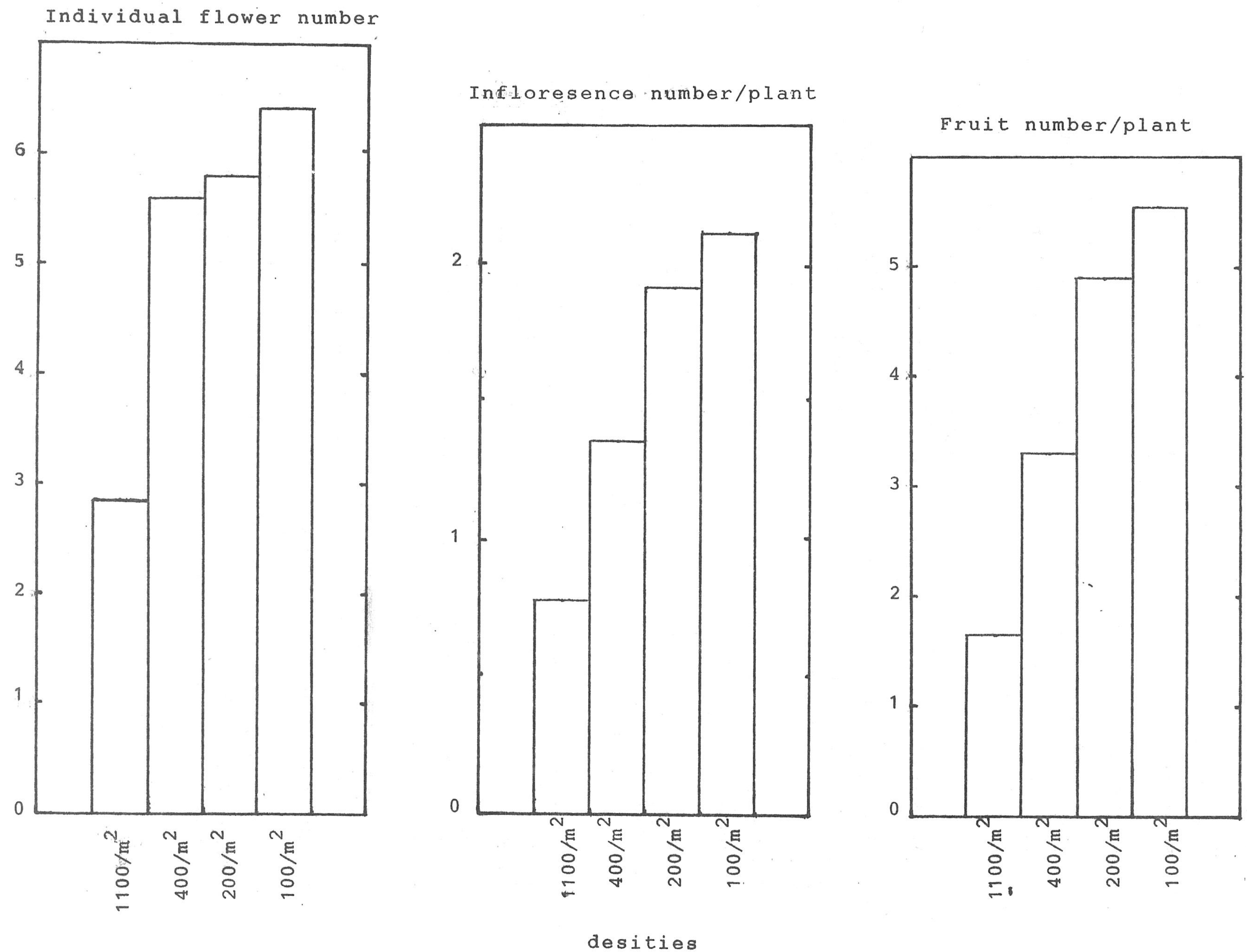

Fig.3 Individual flower number, infloresence number of 4 seedling densities of tomato.

REFERENCES

1. Gnatov, B. 1915. The Effect of the Pricking out Density of Seedlings on the Yield, Earliness and Quality of Some Tomato Cultivars for Early Field Production. Hort. Abstracts, 1978.

2. Gray, D., Steckel, J.R.A., and J.A.A. Ward. 1980. A Comparison of Methods of Growing Tomato Transplants. Hort. Sci. 12(2): 125-133.

3. Gray, D. 1981. Outdoor Tomatoes. Right Choice for Early Cropping. <<Grower>> 1981. 95: (19) 17-18.

4. Guo Xiao Quang. 1983. Raising Vegetable Seedlings in Nutrient Solution. Transactions of Shen Yang Agricultural University, Shenyang, China.

5. Hamar, N. 1915. Evaluation of Tomato Seedlings. Hort. Abstracts. 48(2): 1485.

6. Kuo, C. G. and S.H. Lai. 1979. Suggested Cultural Practices for Tomato. AVRDC International Cooperators Guide. Shanhua, Taiwan, China.

7. Masaki, T. and H. Ohno. 1979. Study on the Growth of Vegetable Seedling in Pots. Bulletin of Vegetable and Ornamental Crop Research Station. 5: 81-93. Japan.

8. Skapski, H. 1975. The Influence of Transplants Spacing on Earliness of Tomato. Acta Horticulturae. 52: 127 - 129.

9. Villareal, R. L. 1978. Tomato Production in the Tropics-Problem and Progress. 1^{st} International Symposium on Tropical Tomato. AVRDC. Shanhua, Taiwan, China.

10. Williamson, R. E. and C. A. Jaworsk. 1979. Effect of Seeding Rates Patten Row Position and Clipping on Size Uniformity of Field-Grown Tomato Transplants. J. Amer. Soc. Hort. Sci. 104(3): 368-371.