

SPACING EXPERIMENTS WITH VEGETABLES

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SUMMARY

SPACING experiments with vegetables set down at the Vegetable Seed Stations at Matale and Tabbowa, in the *maha* season, 1940-41, are reported in this paper. On the basis of the results of these experiments, the following spacings are recommended to growers :—

- | | |
|----------------------------------------------|----------------|
| 1. Cucumber (<i>Cucumis sativus</i> L.) | 4 ft. by 1 ft. |
| 2. Luffa (<i>Luffa acutangula</i> Roxb.) | 6 ft. by 4 ft. |
| 3. Bandakka (<i>Hibiscus esculentus</i> L.) | 3 ft. by 3 ft. |
| 4. Brinjal (<i>Solanum Melongena</i> L.) | 3 ft. by 4 ft. |
| 5. Cowpea (<i>Vigna unguiculata</i> Walp.) | 4 ft. by 2 ft. |

In 1940, the Botanist assumed control of the Departmental Vegetable Seed Stations. A programme of vegetable selection with clearly defined objectives was outlined (Anon. 1940 *a* and *b*). The scantiness of information on cultural methods impeded the prosecution of this programme. Spacing information was the most pressing need. Trials set down at the Vegetable Seed Stations at Matale and Tabbowa, in the *maha* season, 1940-41, aimed at providing the desired data. The more important of these trials are reported herein.

The soils of the two stations differ markedly from one another. Matale is the more infertile, and the soil, of which the main component is ironstone gravel, is unsuitable for vegetables. Heavy dressings of organic manure are necessary if vegetable growing is to be at all possible. Tabbowa soils, on the other hand, are deep red loams, well supplied with replaceable bases, neutral to alkaline in reaction, and ideal for vegetable growing. They are, however, somewhat deficient in nitrogen and in organic matter, and their extremely good drainage may damage crops in periods of drought.

Matale and Tabbowa fall within the wet and dry zones respectively. At Matale, heavy and well distributed precipitation makes cultivation possible in both *yala* and *maha*. Insufficient rain prevents *yala* cultivation at Tabbowa. Rainfall data for the experimental season are given in Table 1.

TABLE 1

Monthly Rainfall at Matale and Tabbowa in the Maha Season, 1940-41

	Matale		Tabbowa	
	Rainfall in inches.	Number of Rainy Days.	Rainfall in inches.	Number of Rainy Days.
1940.				
September	.. 11.50	.. 13	.. 0.86	.. 5
October	.. 15.38	.. 20	.. 7.18	.. 22
November	.. 13.91	.. 22	.. 17.04	.. 25
December	.. 6.97	.. 15	.. 2.19	.. 16
1941.				
January	.. 7.55	.. 14	.. 2.14	.. 11
February	.. 3.23	.. 7	.. 0.22	.. 1
March	.. 2.12	.. 5	.. 0.11	.. 1
April	.. 4.79	.. 11	.. 3.49	.. 8

1. Cucumber (*Cucumis sativus* L.)

The following spacings were tested at Matale : 8 ft. by 4 ft., 4 ft. by 4 ft., 4 ft. by 2 ft. and 4 ft. by 1 ft. The spacings were replicated in four randomized blocks of 1/57 acre plots. Each plot had a nett harvested area of 1/170 acre. The Botanist's selected strain of the indigenous cucumber was grown. The experimental area, which consisted of newly cleared land, received an application of 10 tons compost per acre on November 16, 1940. Four seeds were dibbled per hill on November 21. Ninety per cent. of the seeds had germinated on November 24. Seedlings were thinned successively to three, two and one per hill on December 6, 11 and 19. Vegetative growth was most vigorous and flowering most prolific at the closest spacings. A record, made on December 19, of the incidence of flowering is given below :

Spacing.	Total Number of Plants in Flower.
4 ft. by 1 ft.	.. 30
4 ft. by 2 ft.	.. 19
4 ft. by 4 ft.	.. 2
4 ft. by 8 ft.	.. 0

Even after allowance is made for the greater number of plants at the closer spacings, plants at 4 ft. by 1 ft. and 4 ft. by 2 ft. will be seen to be earlier than those at 4 ft. by 4 ft. and 4 ft. by 8 ft.

Aulacophora beetles occurred in large numbers. Fruit-fly (*Dacus cucurbitae* Coq.) was first observed on December 31; the damage was not considerable. Fruits were harvested on January 9, 14 and 22, 1941.

The analysis of variance of weights of fruits harvested is given in Appendix I. The variance ratio for spacings reaches significance at the one per cent. point. The yield data are summarized below in Table 2.

TABLE 2
Yields of Cucumber Fruits in lb. per Acre

Spacing :	8 ft. by 4 ft.	4 ft. by 4 ft.	4 ft. by 2 ft.	4 ft. by 1 ft.	Significant Difference.
Yield (lb./acre) ..	1890 ..	3734 ..	4284 ..	6061 ..	1898

Yields were highest at the closest spacing, and declined *pari passu* with width of spacing. The 4 ft. by 1 ft. spacing was significantly superior to both 4 ft. by 4 ft. and 4 ft. by 8 ft. The superiority of 4 ft. by 2 ft. to 4 ft. by 8 ft. was also significant.

A somewhat different series of spacings was investigated at Tabbowa, viz., 8 ft. by 8 ft., 8 ft. by 4 ft., 4 ft. by 4 ft. and 4 ft. by 1 ft. The spacings were replicated in four randomized blocks of 1/38 acre plots. The nett harvested area was the same as in the Matale trial, viz. 1/170 acre. The variety grown was also identical. Seed was dibbled on November 13, 1940. Germination was evident in nearly 75 per cent. of the hills on November 19. Damage to seed by rats caused numerous vacancies; these were filled on November 23. *Aulacophora* sp. made its first appearance on December 10; the beetles were collected in hand nets and destroyed. Fruit-fly was first recorded on December 30; the damage was inappreciable. The first and main harvest was made on January 15, 1941. A second and much smaller pick was taken on January 24. All the vines were dead by February 2.

Appendix 2 gives the analysis of variance of total weights of fruits harvested. The variance ratio for spacings is significant at the five per cent. point. A summary of the yield data is presented in Table 3. As in the Matale trial, increase in yield runs parallel to increase in plant number per unit area. The closest spacing, 4 ft. by 1 ft., is significantly superior to every one of the other spacings. There are no other significant differences.

TABLE 3
Yields of Cucumber Fruits in lb. per Acre

Spacing :	8 ft. by 8 ft.	8 ft. by 4 ft.	4 ft. by 4 ft.	4 ft. by 1 ft.	Significant Difference.
Yield (lb./acre) ..	489 ..	1768 ..	2261 ..	4905 ..	2263

Comparable results have been obtained at the dry and wet zone stations. The closest spacing tested, viz. 4 ft. by 1 ft. has given the highest yields, in spite of the apparent overcrowding that occurs at this spacing.

2. *Luffa* (*Luffa acutangula* Roxb.)

At Tabbowa, the following spacings were tested in a randomized block design : 6 ft. by 6 ft., 6 ft. by 4 ft., 4 ft. by 4 ft. and 3 ft. by 3 ft. There were four blocks of 1/38 acre plots. A nett area of 1/100 acre was harvested in each plot. Seeds of the Botanist's selected strain of ribbed luffa were dibbled on November 13, 1940. Approximately 90 per cent. of the seeds had germinated within a week. Blanks were filled on November 23. Vines had commenced trailing on December 10, and were thinned to one per hill and trained to stakes on December 18. The area was weeded on December 17, 1940, and January 18, 1941. Fruits were harvested on January 16, 22, 28 and 31, and February 3 and 8.

The analysis of variance of total weights of fruits harvested is presented in Appendix 3. The variance ratio exceeds the 0.1 per cent. point, and indicates a very high degree of significance. Yield data are recorded in Table 4. The widest spacing, 6 ft. by 6 ft. is significantly inferior to the other three. These three spacings do not differ significantly from one another. The growers' obvious choice is the 6 ft. by 4 ft. spacing.

TABLE 4
Yields of *Luffa* Fruits in lb. per Acre

Spacing :	6 ft. by 6 ft.	6 ft. by 4 ft.	4 ft. by 4 ft.	3 ft. by 3 ft.	Significant Difference.
Yield (lb./acre) ..	17425	29770	28023	34590	5057.5

3. *Bandakka* (*Hibiscus esculentus* L.)

At Tabbowa, the performance of the Botanist's single-plant selection, H. 10 was compared with that of the variety NWD. There was little difference in type between the two strains. Both possessed unbranched stems and pigmented petioles, and produced large, ridged, pubescent fruits. The two varieties were tested at the following spacings : 3 ft. by 3 ft., 3 ft. by 2 ft. and 3 ft. by 1 ft. The layout consisted of four randomized blocks of six 1/34 acre plot. Each plot possessed a nett harvested area of 1/48 acre.

Seeds were dibbled on November 14, 1940. Nearly 85 per cent. of the seed in both strains had germinated on November 19. Vacancies were supplied on November 24. The area received one weeding on December 15. Seedlings were thinned to one per hill on December 19. Flowering in the strain NWD was slightly earlier than in H. 10 ; in the former, five per cent. of the plants were in flower on December 26. Harvesting was spread over the period January 16—February 15, 1941; there were eleven picks at approximately three-day intervals.

In the analysis of variance of total weights of fruits, none of the variance ratios reach significance even at the five per cent. point. There is no significant difference in yield between the two varieties. As there is no evidence of an increase in yield with closer spacing, 3 ft. by 3 ft. appears to be the most economic planting distance. Yield data are summarized below in Table 5.

TABLE 5

Yields of Bandakka Fruits in lb.

(Yields per acre are given in brackets below plot totals)

Varieties.	Spacings.			Total.
	3 ft. by 3 ft.	3 ft. by 2 ft.	3 ft. by 1 ft.	
H. 10	549·6 (6595·2)	370·8 (4449·6)	637·3 (7647·6)	1557·7 (6230·8)
N.W.D.	604·8 (7257·6)	469·8 (5637·6)	562·2 (6746·4)	1636·8 (6547·2)
	1154·4 (6926·4)	840·6 (5043·6)	1199·5 (7197·0)	3194·5 (6389·0)

4. Brinjal (*Solanum Melongena* L.)

Two spacings were tested at Matale, viz. 3 ft. by 4 ft. and 3 ft. by 2 ft. Two varieties were grown, viz. (a) Matale Wilt-Resistant, the Botanist's selection for resistance to bacterial wilt (*Bacillus solanacearum* E.F.Sm), and (b) Valuthalai, a strain obtained from the Experiment Station, Anuradhapura. The former produces purple fruits and the latter green fruits. The variety Valuthalai branches higher. The high-branching habit is valuable in the control of soil-borne, fruit-rotting fungi, *i.e.* *Phytophthora* spp. A factorial design consisting of five blocks of four 1/67 acre plots was adopted. Each plot had a nett harvested area of 1/130 acre.

Seeds of the two varieties were drilled in nurseries on October 4, 1940. Damping-off (*Rhizoctonia solani* Kühn) caused some damage to the Valuthalai beds. Seedlings were transplanted on November 11. The area had carried luffas and bitter-gourds in the previous *yala* and received an application of 10 tons compost per acre in the experimental season. The soil of the station has always been heavily infested with the wilt bacterium. Wilt caused 16 casualties in the Matale Wilt-Resistant strain and 107 in Valuthalai. Red ants (*Dorylus orientalis* Westw.) too proved troublesome; casualties numbered seven in the Matale Wilt-Resistant strain, and 22 in Valuthalai. The filling of vacancies was continued till December 28. Harvesting was spread over the period February 7—April 20, 1941; eleven picks were taken at approximately weekly intervals.

The analysis of variance of total weights of fruit harvested is presented in Appendix 4. The variance ratio for varieties is greatly in excess of even the 0·1 per cent. point. The variance ratios for spacing and for the interaction between varieties and spacing do not reach significance. The Matale Wilt-Resistant strain is significantly and overwhelmingly superior; the yield is roughly five times that of Valuthalai (Table 6). The greater susceptibility of Valuthalai to wilt would have contributed to the relatively low yields in that strain. The 3 ft. by 4 ft. spacing is recommended as it is not significantly inferior to 3 ft. by 2 ft.

TABLE 6
Yields of Brinjal Fruits in lb.

(Yields per acre are given in brackets below plot totals.)

Varieties.	Spacings.		Total.
	3 ft. by 4 ft.	3 ft. by 2 ft.	
Matale Wilt-Resistant	.. 178·0 (4628·0)	.. 204·3 (5311·8)	.. 382·3 (4969·9)
Valuthalai 35·3 (917·8)	.. 41·3 (1073·8)	.. 76·6 (995·8)
Total	.. 213·3 (2772·9)	245·6 (3192·8)	458·9 (2982·9)

5. Cowpea (*Vigna unguiculata* Walp.)

Two spacings were investigated at Tabbowa, viz. 4 ft. by 3 ft. and 4 ft. by 1 ft. The strains whose performance was investigated included:

(a) *V. 4*.—The Botanist's single-plant selection of *polon-mé*. Plants in this strain possess a low, half-bushy habit, violet flowers, short, straw-coloured, purple-blotched pods which are closely packed with black, subreniform seeds.

(b) *Trinidad*.—An erect, white-flowered, white-seeded, short-podded strain of the *catjang* type.

(c) *C. D.*—The Botanist's selected strain of *murunga-mé*. The strain is characterized by its very short age (two months) and the possession of very long, attractive pods of the *sesquipedalis* type. The flowers are violet and the seeds brown.

The strain *C. D.* is usually staked as it is claimed that plants that are allowed to trail on the ground produce a high proportion of malformed pods.

The four varietal treatments, viz. *V. 4* (unstaked) *Trinidad* (unstaked), *C. D.* (unstaked) and *C. D.* (staked), at the two spacings, viz. 4 ft. by 3 ft. and 4 ft. by 1 ft. were tested in a factorial design of four blocks of eight 1/76 acre plots. The nett harvested area in each plot was 1/151 acre.

Seeds were dibbled on November 14, 1940. Over 90 per cent. of the seeds had germinated on November 19. Vacancies were filled on November 24. The first appearance of aphids was noted on December 10. Aphid attack was particularly severe on the strain C. D. Spraying with a solution of soft soap (1 oz. per gallon) provided effective control. On December 14, vines of the strain C. D. were staked in the plots relegated to that treatment. Plants in all varieties were thinned to one per hill on the same day.

The strain C. D. was earliest; flowers were observed in this strain on December 24. Flowering in Trinidad and V. 4 was recorded on December 26 and 29 respectively. Pods in C. D. were ready for picking on January 5, 1941. A reappearance of aphids was observed on that date; spraying brought the pest again under control. The area received weedings on December 14 and 24. Dry pods were picked on January 17, February 8, 18 and 26, and March 3, 1941. On February 8, all the C. D. vines were observed to be dead or moribund, and no harvests were available in that strain after that date. Bird damage was severe in the staked C. D. plots.

The analysis of variance of yields of dry seeds (Appendix 5) reveals a variance ratio for varieties significant at the 0.1 per cent. point. The variance ratios for spacings and for the interaction between spacings and varieties do not attain significance. Yield data are summarized in Table 7. The strain V. 4 significantly outyields C. D. (in both staked and unstaked plots) and Trinidad; the yield of V. 4 is roughly three times that of Trinidad, and 17 times the average yield of C. D.

TABLE 7

Yields of Dry Cowpea Seeds in oz.

(Yields in lb. per acre are given in brackets below plot totals.)

Spacings	Varieties				Total	Significant Difference
	V. 4.	Trinidad	CD. Staked	CD. Unstaked		
4 ft. by 3 ft. ..	300.0 ..	69.5 ..	37.0 ..	59.0 ..	465.5 ..	—
	(707.8) ..	(164.0) ..	(87.3) ..	(139.2) ..	(274.6) ..	—
4 ft. by 1 ft. ..	418.1 ..	190.6 ..	40.9 ..	64.6 ..	714.2 ..	—
	(986.5) ..	(449.7) ..	(96.5) ..	(152.4) ..	(421.3) ..	—
Total ..	718.1 ..	260.1 ..	77.9 ..	123.6 ..	1179.7 ..	193.0
	(847.1)	(306.8)	(91.9)	(145.8)	(347.9)	(227.7)

In the strain C. D., the yield of staked plots is appreciably but not significantly less than that in unstaked plots. Rather different results had been obtained by Fernando and Fernando (1941). In the instance of all the three varieties of cowpea investigated by these writers, staking produced large and significant increases in the yield of both snap and dry-shell beans. It was argued that staking provided more efficient arrangement of the photosynthetic surface in relation to incident light. The benefit of staking would be particularly felt in

varieties with dense and persistent foliage. The failure of the strain C. D., in which the foliage is sparse and evanescent, to profit by staking is not difficult to explain; there would be no appreciable shading of leaves even in unstaked plants. Moreover, in the present experiment, bird damage would have depressed the yield of staked plants.

Although the closer spacing produced consistent increases in yield in the instance of all the varietal treatments (Table 7), the non-significance of these increases prevents the present writer's recommending the 4 ft. by 1 ft. spacing with confidence. Till superiority of this spacing is demonstrated statistically, the 4 ft. by 3 ft. spacing or an intermediate spacing—say, 4 ft. by 2 ft.—should be preferred.

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APPENDIX I

Analysis of Variance of Weights of Cucumber Fruits Harvested at Matale

	D.F.	S.S.	M.S.	V.R.	1 per cent. point.	0.1 per cent. point.
Blocks .. 3 ..	3	585.445	—	—	—	—
Spacings .. 3 ..	3	1254.175	418.058	8.22*	6.99	13.90
Error .. 9 ..	9	450.760	50.084	—	—	—
Total .. 15 ..	15	2290.38				

* Significant at the one per cent. point.

APPENDIX 2

Analysis of Variance of Weights of Cucumber Fruits Harvested at Tabbowa

	D.F.	S.S.	M.S.	V.R.	5 per cent. point.
Blocks .. 3 ..	3	644.44	—	—	—
Spacings .. 3 ..	3	1430.62	476.87	6.29†	3.86
Error .. 9 ..	9	682.56	75.84	—	—
Total .. 15 ..	15	2757.62			

† Significant at the five per cent. point.

APPENDIX 3

Analysis of Variance of Weights of Luffa Fruits

	D.F.	S.S.	M.S.	V.R.	0.1 per cent. point.
Blocks	3	62056	20685.3	20.69	13.90
Spacings	3	62876	20958.7	20.96*	13.90
Error	9	9000	1000.0	—	—
Total	15	133932			

* Significant at the 0.1 per cent. point.

APPENDIX 4

Analysis of Variance of Weights of Brinjal Fruits

	D.F.	S.S.	M.S.	V.R.	0.1 per cent. point.
Blocks	4	1256.45	—	—	—
Treatments	3	4745.39	—	—	—
(Varieties)	(1)	(4672.62)	4672.62	49.55†	18.64
(Spacings)	(1)	(52.16)	52.16	—	—
(Interaction)	(1)	(20.61)	20.61	—	—
Error	12	1131.57	94.30	—	—
Total	19	7133.41			

† Significant at the 0.1 per cent. point.

APPENDIX 5

Analysis of Variance of Weights of Dry Cowpea Seeds

	D.F.	S.S.	M.S.	V.R.	5 per cent. point.	0.1 per cent. point.
Blocks	3	640.1	—	—	—	—
Treatments	7	35675.1	—	—	—	—
(Varieties)	(3)	(32092.7)	10697.6	21.1†	—	9.73
(Spacings)	(1)	(1932.8)	1932.8	3.8	4.60	—
(Interaction)	(3)	(1649.6)	549.9	1.1	3.34	—
Error	14	7084.3	506.0	—	—	—
Total	31	43399.5				

† Significant at the 0.1 per cent point.