BIBLIOGRAPHY

LANGBIS, SAMUEL P. APRIL 2007. Growth and Yield Response of Chinese Kale ('Kai-lan') to Row and Plant Spacings. Benguet State University, La Trinidad, Benguet.

Adviser: Pepe E. Toledo, PhD

ABSTRACT

The study was conducted at the Balili Experiment Station, Benguet State University, La Trinidad, Benguet from November 2006 to January 2007 to determine the effects of row and plant spacings on the growth and yield, establish the best row and plant spacings, and assess the economics of the different row and plant spacings for 'Kai-lan' production.

Results revealed that the weekly plant height three weeks after seeding were significantly taller at 10 x 10 to 15 x 15 cm and 15 x 10 cm spacings during the first and second weeks of measurements after transplantint. There were no significant differences were observed from the third to the fourth and the final height at first harvest.

Spacing at 25 x 25 cm considerably increased the average marketable plant weight but a distance of 10 x 10 cm significantly increased marketable, total and computed marketable yields and benefit:cost ratio.

The population of insect pests (flea beetles, aphids and diamond-back moth) and the occurrence of the disease (powdery mildew) was significantly higher with closer than with wider spacings.

TABLE OF CONTENTS

INTRODUCTION

Pechay or Pak Choi is one of the most common leafy vegetables grown by the farmers in the Cordillera Administrative Region (CAR) and is usually sold in the market year round. Two important types of pechay species are grown in the region namely: the heading type (*Brassica pekinensis* Rupr) and the non-heading type (*Brassica napus* var. *chinensis*). Both types belong to the *Brassicaceae* or *Cruciferae* family.

A newly introduced non-heading type of pechay developed by the Chinese plant breeders is ‘Kai-lan’, also known as Chinese broccoli or Chinese kale is becoming popular to the farmers and consumers in the country. As a member of the *Brassica oleracea* group, it belongs to the Alboglabra cultivar group and of the same species as broccoli and kale (Anon., 2006). It is described as slightly bitter leafy vegetable featuring thick, flat, glossy blue-green leaves with thick stems and several tiny, almost vestigial flower heads similar to those of broccoli. Its flavor is very similar to that of broccoli, though not identical, being a bit sweeter.

‘Kai-lan’ is widely eaten in Chinese cuisine, and especially in Cantonese cuisine (Anon., 2006). Common preparations include stir-fried with ginger and garlic, and boiled served with oyster sauce. Unlike broccoli where only the flowering parts are normally eaten, with this crop, the leaves and stems are eaten as well, normally sliced into bits with the proper size and shape to be eaten with chopsticks.

Plant spacing affects plant growth and development due to competition for light, mineral nutrients, soil moisture, air and space. In vegetable production, spacing is one of the cultural management practices often not considered by farmers to optimize yield with good quality produce. In Chinese kale production particularly ‘Kai-lan’, a newly introduced species, planting distance had not yet been established as there are no reports found in the literature.

Moreover, return on investment will be maximized if the ideal planting distance is established in all vegetable crops. With the logarithmic population growth of the country, it is not just the worry of the officials but the country as well. As population increases, land area devoted for food production decreases to give way to housing and other infrastructures. The limited area should then be utilized to its maximum to produce food crops to provide proper nutrition to the population. It is in this context that this study was conceived.

The experiment was conducted at the Balili Experiment Station, Benguet State University, La Trinidad, Benguet from November 2006 to January 2007 to determine the effects of row and plant spacings on the growth and yield, establish the best row and plant spacings, and assess the economics of the different row and plant spacings for 'Kai-lan' production.

REVIEW OF LITERATURE

Plant Spacing

The ideal plant spacing(s) to attain a desired population in a given area to maximize yield and quality are those spacings that will not unduly increase production costs (Anon., 1990). As a rule, all crops tended to increase yields per unit area as plant population is increased but up to certain limit. He added that beyond that limit, the yield may or may not increase. The rationale of this idea is the wise utilization of area in terms of yield and quality (Bawang, 2006). It is also noteworthy to mention that the proper planting distance between plants depends on the growth habit, purpose, soil fertility status, method of cultivation, pest control, and harvesting method of the variety in question (Watts, 1972; Knott and Deanon, 1967; Kinoshita, 1972). Burton (1966) added that if spacing is too close, the individual plant will suffer from the competition of it's neighbors and the growth of the crop may be impaired. But he also contradicted that if spacing is too wide, the yield per unit area may also be lower despite increase in yield of individual plants. Furthermore, Vicente (1978) stated that higher incidences of insect pests and diseases were observed in carrot plants with closer spacings.

Colbong (1985) reported that in radish production, wider spacing resulted to the enhancement of maturation, produced higher number of leaves, more larger and longer storage roots, and heavier weight of individual storage roots.

In sweetpotato, Thompson (1959) said that closer spacings increase the yield of marketable storage roots while Martin and Leonard (1970) stated that wider spacings tend to produce fewer but larger storage roots. While in potato, more tubers were harvested with closer spacing (Dampilag, 1979). Hendro and Scrnjako (1975) reported that closer spacing likewise increased yield in potato but with higher percentage of small but lower percentages of big tubers.

On the other hand, Bilango (1996) also reported that in heading lettuce plants spaced spacing of 30 cm x 30 cm, resulted to the highest yield and total weight of marketable heads while those spaced at 20 cm x 20 cm were lower. Plants spaced at 35 cm x 35 cm, 40 cm x 40 cm and 45 cm x 45 cm produced heavier heads with the least non-marketable heads but lowest total yield.

In pole snapbean, Amboy (1981) found that plants spaced at 20 cm x 20 cm produced the highest pod yield/plot, pod number and weight/plot, tallest plant and computed yield/ha.

Colbong (1985) reported that radish plants spaced at 15 cm x 15 cm, 20 xm x 20 cm and 25 cm x 25 cm outyielded other spacings in terms of marketable roots and economic value.

Row Spacing

According to Grubinger (Undated), the way vegetable rows are arranged in the field depends on how much space a crop needs, as well as the seeding, transplanting and cultivation equipment to be used. Row spacings that give the highest yield for particular crops may not be suitable for cultivating weeds or for promoting air circulation to prevent development of disease. They may not be the best when it comes time to harvest, either. Extension publications list a dozen or more different row spacings that optimize the yield of various vegetables, yet many growers use just one system of arranging plants in order to enhance the efficiency of field operations. Ideally, the arrangement of rows conforms not only to tractor wheel spacing, but also to equipment used to form beds, set transplants, control pests, and harvest the crop, resulting in a production system that's suited to the farm from start to finish. He cited some examples of planting systems from three different farms as follows:.

David Trumble, of Good Earth Farm in Weare, NH, grows 40 species of vegetables on three acres of land to supply the 80 families in his Community Supported Agriculture program. In the past, he used many different row spacings and a lot of hand labor in an effort to optimize the yield of each crop, but found that this approach actually hurt his yields because without mechanization his weed control was not very effective. Now, using a 2-row transplanter and an Earthway push seeder, he plants everything in double rows, 24 inches apart, on flat ground.

Paul Harlow and Dennis Sauer raise 60 acres of vegetables at Harlow Farm in Westminster, Vermont. To enhance the speed and efficiency of field operations in order to meet the demands of wholesale markets, the dozen or so crops they raise are grown on a 2 row/2-bed system. Each bed gets planted with two rows of crops, 14 inches apart. Direct seeded crops such as carrots, beets, parsnip and turnips are sown with a Stanhay precision seeder. Transplanted cabbage, lettuce, peppers and kale are set using a 4-row Lannen transplanter.

David and Chris Colson of New Leaf Farm in Durham, Maine, grow four acres of vegetables primarily for direct sale to restaurants. Lettuce and leafy greens are grown in three rows per bed, with 16 inches between rows and plants staggered across the bed. Broccoli, peppers, and tomatoes are grown in double rows 24 inches apart on the bed. Summer squash and winter squash are grown in a single row per bed.

As mentioned above, there is no single recipe for row spacing to enhance efficiency. Watts (1972) stated that planting distances will be about 30 to 45 cm apart and thinning to 7 to 10 apart from the rows to reached maximum weight and growth and development of the plants.

Plant Population Density

This term refers to the number of plants per unit area that determines land use efficiency (Wiley, 1979). Janick (1972) added that the yield per unit area determines to a large extent the efficiency of land utilization and that population pressure markedly affect plant performance. He mentioned that there two types of plant density relationships. Asymptotic relationship - the relationship between plant population and yield where the former increases the latter. Parabolic relationships - as plant population increases to a certain level, total yield increases but then declines as plant density further increase.

Hill (1987) stated that in low plant density planting, the plants were short, develop many branches producing high yield due to low competition pressure.

Bawang and Kudan (1990) added that low density planting tends to enhance early maturity in some vegetables such as cabbage and lettuce.

MATERIALS AND METHODS

Materials

The materials used in the study were Chinese kale seeds (‘Kai-lan’), fertilizers, fungicides, insecticides, watering cans, knapsack sprayer, grabhoe, weighing scale, identifying tags, pencil, and record book.

Methods

Experimental design and treatments. The experiment was laid out in randomized complete block design (RCBD) with three replications. The treatments were as follows:

Code	Row Spacing (cm/row)	Population/plot	Hilll Spacing (cm/apart)
R_1	10	250	10
R_2	10	210	15
R_3	10	147	20
R_4	15	200	10
R_5	15	164	15
R_6	15		

			20
	130		
R_7		20	
			10
	150		
R_8		20	
			15
	110		
R_9		20	
			20
	92		
R_{10}		25 (Farmer's practice)	25
	(Farmer's practice) 75		

Land preparation and fertilizer application. An area of 200 m^2 was thoroughly prepared and divided into four blocks. Each block was further subdivided into plots with a dimension of 1 m x 5 m. These plots were leveled and holes were made in accordance with the specified treatments. Chicken manure (one handful, 155 g) and complete fertilizer at the rate of 100-100-100 kg N-P_20_5-K_20/ha were applied in the prepared holes and mixed thoroughly with the soil.

Planting. The seeds were directly seeded in the well prepared plot and covered thinly with soil followed by watering. Solution of nitrogenous fertilizer (46-0-0) at the rate of 10g/16 li water was applied once to the seedlings one week after emergence.

Care and management. Other cultural management practices such as pests control, weeding, hilling-up, and irrigation were done uniformly to ensure optimum growth and development of the plants.

Harvesting. All plants were hand harvested using a sharp knife at the marketable stage and was based first sign of opening of the first vestigial flower.

Data gathering. The data gathered and subjected to variance of analysis and mean separation test by Duncan's multiple range test (DMRT) were as follows:

1. Weekly plant height (week). This was obtained by measuring five randomly selected sample plants by measuring from the soil line to the tip of the shoot at weekly intervals until harvest.

2. Days from transplanting to harvesting. This was the number of days from of direct seeding to harvesting.

3. Yield. The yield were assessed as follows:

a. Average marketable plant weight (kg). This was computed using the formula:

Average (kg) = Total marketable plant weight (kg/plot) ¸ Number of marketable plants

b. Marketable yield (kg/plot). All marketable plants without defects were weighed at harvest.

c. Non-marketable yield (kg/plot). All diseased infected plants were weighed at harvest.

d. Total yield (kg/plot). This was the weights of marketable and non-marketable yields per plot.

e. Computed yield (t/ha). The marketable yield per plot was converted to tons/hectare using the formula:

Yield (t/ha) = Yield (kg/5m^2) x 2

where: 2 was a factor used to convert kg/5m^2 to t/ha

4. Incidence of insect pests and diseases. Observations on the presence of insect pests and diseases were done, identified and rated them using the following scale.

a. Insect

Rating	Description
1	No infestation
2	1-25% of the plants/plot were infested
3	26-50% of the plants/plot were infested
4	51-75% of the plants/plot were infested
5	76-100% of the plants/plot were infested

b. Disease

Rating	Description
1	No infestation
2	1-25% of the plants/plot were infested
3	26-50% of the plants/plot were infested
4	51-75% of the plants/plot were infested
5	76-100% of the plants/plot were infested

5. Benefit:cost ratio (BCR). This was obtained by recording the man-days/ha in transplanting and seedling costs and BCR was computed by using the formula:

BCR = Benefit-Cost ¸ Cost + 1

6. Documentation of the study through pictures.

RESULTS AND DISCUSSION

Plant Height

The weekly plant height three weeks after seeding up to first harvesting is shown in Table 1. During the first week of measurement, plants spaced at 10 x 10 to 15 x 15 cm were significantly taller that those with wider spacings with the exception of plants spaced at 15 x 20 cm. On the second week of measurement, plants spaced at 15 x 10 cm were markedly taller than those spaced at 20 x 15 up to 25 x 25 cm; however, plant heights measure were comparable to other plant spacings. On the other hand, there were no significant differences were observed from the third to the fourth and final height at first harvest.

These results are apparently due to shading at the early stages of growth but growth was not affected at the latter stages. Plants with closer spacings cannot grow sidewise, instead they grew upward in search for light. This agrees well with the findings of Mendoza

Table 1. Plant height three weeks after seeding up to first harvest

ROW X HILL SPACING (cm x cm)	WEEKLY HEIGHT MEASUREMENT (cm) 1	2	3	4	FINAL PLANT HEIGHT (cm)
10 x 10	7.05a	14.92ab	21.39a	33.60a	40.88a
10 x 15	7.06a	15.13ab	21.25a	34.03a	41.29a
10 x 20	7.15a	13.97abc	19.65a	32.09a	41.71a
15 x 10	7.43a	15.47a	22.33a	35.07a	45.55a
15 x 15	7.25a	14.16abc	20.43a	33.63a	41.59a
15 x 20	6.69ab	13.78abc	18.17a	31.24a	41.46a
20 x 10	5.88bc	13.69abc	19.95a	31.30a	42.22a
20 x 15	5.07c	12.10c	18.70a	33.17a	42.25a
20 x 20	5.65c	13.03bc	18.72a	32.32a	39.47a
25 x 25 (Farmer's practice)	5.27c	12.41c	20.69a	32.30a	40.84a

In a column, means with a common letter are not significantly different at 5% by DMRT

(1966) that closer spacing tends to enhance the production of taller plants. However, Cortez (1978) explained that closer spacing lead to greater competition for moisture, light and mineral nutrients.

<u>Days from Seeding to First Harvest</u>

Table 1 shows that plants spaced at 20 x 15 and 25 x 25 cm (Farmer's practice) were significantly harvested earlier compared to those spaced at 10 x 10 up to 15 x 15 cm but were comparable in days to harvesting with the other spacings evaluated.

These findings indicated that lower density of planting promotes faster vegetative growth resulting to earlier maturity supporting similar observations of Bawang and Kudan (1990) in some vegetable crops such as cabbage and lettuce. The early harvesting in plants grown at wider spacings was similar to the observations of Villanueva (1979) in snapbean where plants spaced at 10 x 25 cm flowered earlier than plants grown in the other spacings studied.

Table 2. Number of days from seeding to first harvest

ROW X HILL SPACING (cm x cm)	MEAN (cm)
10 x 10	49.0a
10 x 15	48.0a
10 x 20	48.0ab
15 x 10	48.0ab
15 x 15	47.0b
15 x 20	46.0c
20 x 10	46.0cd
20 x 15	45.0d
20 x 20	45.0cd
25 x 25 (Farmer's practice)	45.0c

Means with a common letter are not significantly different at 5% by DMRT

Yields

The average marketable plant weight, marketable, non-marketable, total, and computed yields and benefit:cost ratio are presented in Table 3. Plants spaced at 25 x 25 cm had considerably increased average marketable plant weight in comparison to the other spacings evaluated except for plants spaced at 20 x 10 up to 20 x 20 cm. However, plants spaced at 10 x 10 cm significantly produced higher marketable, total and computed marketable yields and had higher benefit:cost ratio than plants grown in the other spacings with the exception of plants spaced at 15 x 10 cm.

These results confirmed the statement of Anon. (1990) that as a rule, all crops tended to increase their yield per unit area as plant population is increased but up to a certain limit. Also, this indicates that this crop, Chinese kale, followed the asymptotic plant density relationship wherein the yield increases as the plant population is increased which is true for crops where only the vegetative parts are harvested (Bawang and Kudan, 1990).

Incidence of Insect Pests
and Disease

As presented in Table 4, the occurrence of insect pests (flea beetles, aphids and diamond-back moth) and disease (powdery mildew) was significantly higher with closer spacings than with wider spacings.

These results jibe with the findings of Vicente (1978) who found that higher incidences of insect pests and diseases were observed in carrot planted at closer spacing.

Documentation of the Study in Pictures

Figures 1 and 2 show the overview of the harvested Chinese kale (‘Kai-lan’) plants grown from the various rows and spacings treatments.

Figure 1a. Overview of the harvested Chinese kale ('Kai-lan') grown from the various plant rows and spacings

Figure 1b. Overview of the harvested Chinese kale ('Kai-lan') grown from the various plant rows and spacings

Table 3. Average marketable plant weight, marketable, non-marketable, total, computed yields and benefit:cost ratio

ROW X HILL SPACING (cm x cm)	AVERAGE PLANT WEIGHT (kg)	YIELDS (kg/plot)			COMPUTED MARKETABLE YIELD (t/ha)	BENEFIT:COST RATIO
		Marketable	Non-marketable	Total		
10 x 10	0.038cd	9.13a	3.22a	12.35a	18.26a	109.57a
10 x 15	0.031d	6.21bc	3.55a	9.86bc	12.42bc	74.53bc
10 x 20	0.040cd	5.21c	2.92a	7.89bc	10.42bc	42.50c
15 x 10	0.045bcd	8.44ab	3.94a	12.38a	16.88ab	101.26ab
15 x 15	0.044bcd	6.02bc	2.90a	9.00bc	12.11bc	72.69bc
15 x 20	0.044bcd	4.95c	2.58a	7.52bc	9.89c	59.37c
20 x 10	0.051bc	6.66bc	3.03a	9.70b	13.33bc	79.97bc
20 x 15	0.057abc	6.38bc	2.65a	9.03bc	12.75bc	76.52bc
20 x 20	0.062ab	5.31c	2.35a	7.66bc	10.43c	63.75c
25 x 25 (Farmer' practice)	0.066a	4.58c	2.47a	7.05c	9.16c	54.94c

In a column, means with a common letter are not significantly different at 5% by DMRT

Table 4. Occurrence of insect pests (flea beetles, aphids, diamond-back moth) and powdery mildew disease

ROW X HILL SPACING (cm x cm)	INSECT PESTS	POWDERY MILDEW
10 x 10		
	3.15a	
		2.20a
10 x 15		
	3.00ab	
	2.07ab	
10 x 20		
	2.87ab	
		2.00a
15 x 10		
	2.87ab	
	2.07ab	
15 x 15		
	2.87ab	
		1.70c
15 x 20		
	2.53c	
		2.00b
20 x 10		
	2.73c	
		2.00b
20 x 15		
	2.73c	
		2.00b
20 x 20		
	2.20d	
		2.00b
25 x 25 (Farmer' practice)		
	2.00d	
		2.00b

In a column, means with a common letter are not significantly different at 5% by DMRT

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted at the Balili Experiment Station, Benguet State University, La Trinidad, Benguet from November 2006 to January 2007 to determine the effects of row and plant spacings on the growth and yield, establish the best row and plant spacings, and assess the economics of the different row and plant spacings for 'Kai-lan' production.

Results revealed that the weekly plant height three weeks after seeding were significantly taller at 10 x 10 to 15 x 15 cm and 15 x 10 cm spacings during the first and second measurements. No significant differences were observed from the third to fourth and final height at first harvest.

Spacing at 25 x 25 cm considerably increased the average marketable plant weight against the other spacings evaluated except plants spaced at 20 x 10 up to 20 x 20 cm. However, plants at 10 x 10 cm significantly produced higher marketable, total and computed marketable yields and benefit:cost ratio than the other spacings with the exception of plants spaced at 15 x 10 cm.

The occurrence of insect pests (flea beetles, aphids and diamond-back moth) and disease (powdery mildew) was significantly higher with closer spacings than with wider spacings.

Conclusion

Based from the results of the study, it is therefore concluded that to obtain higher yield and profitability, plant spacing at 10 x 10 and 15 x 10 cm be used in Chinese kale production under open field culture.

Recommendation

From the preceeding results and discussion, it is recommended that either 10 x 10 or 15 x 10 cm could be used as plant spacing for Chinese kale production during the cool and dry season cropping. However, a similar study is further recommended for the rainy season cropping.

LITERATURE CITED

ALOS, J.N. 1996. Growth and yield of mustard 'Taiping P' as affected by plant spacing. BS Thesis. BSU, La Trinidad, Benguet. P. 6.

AMBOY, M. 1981. Influence of different types of fertilizer study on the growth and yield of snapbean. MS Thesis. MSAC, La Trinidad, Benguet. P. 48.

ANONYMOUS. 2006. Kai-lan. Wikipedia. The Free Encyclop. 210.6.194.214.

_____. 1990. Vegetable Training Manual. AVRDC, Shanhua, Tainan, Taiwan, ROC. P. 181.

BAWANG, F.T. 2006. Production and Postharvest Technologies of Vegetables in the Mid- elevation and High Altitude Tropics. Baguio City: Baguio Allied Printers. P. 39.

_____ and S.L. KUDAN. 1990. Principles of production manual in Horticulture 100. BSU, La Trinidad, Benguet.

BILANGO, J.G. 1996. Effect of spacing on the growth and yield of lettuce cv. Great Lakes 54. BS Thesis. BSU, La Trinidad, Benguet. Pp. 1-2.

BURTON, W.H.. 1966. The Potato. Wageningen, The Netherlands: H. Veeman and Zamen. Pp. 131-132.

COLBONG, Y.G.. 1985. The effect of planting distance on the growth and yield of radish. BS Thesis. MSAC, La Trinidad, Benguet. P. 46.

COMPAY, D.F. 1995. Effect of planting distance on the growth and yield of tomato. BS Thesis. BSU, La Trinidad, Benguet. P. 14.

CORTEZ, L.C. 1978. Effect of distance of planting on the growth and yield of lettuce. BS Thesis. MSAC, La Trinidad, Benguet. P. 14.

DAMPILAG, H.B.. 1979. Influence of spacing on the maturity, some postharvest qualities and profitability of Chinese cabbage. BS Thesis. MSAC, La Trinidad, Benguet. Pp. 29-30.

GRUBINGER, V. Undated. Row spacing should enhance efficiency. Univ. Vermont Extension. Vermont. Unpaged.

HILL, M.J. 1987. Seed development, maturity and ripeness. Lecture presented during the Certificate on Seed Technology Course. Seed Tech. Centre, Massey

Univ., Palmerston North, New Zealand. P. 5.

JANICK, J. 1972. Horticultural Science. California: W.H. Freeman and Co. P.

KINOSHITA, K. 1972. Vegetable Production in the Sub-tropics and Tropics. Tokyo, Japan: Overseas Tech. Coop. Agency. P. 272.

KNOTT, J.E. and J.R. DEANON. 1967. Vegetable Production in Southeast Asia. UPLB, Los Baños, Laguna. P.

MARTIN, J.H. and W.H. LEONARD. 1970. Principles of Field Crop Production. New York: McMillan. P. 281.

MENDOZA, A.V. 1966. The effect of nitrogen on the yield of snapbeans. BS Thesis. MSAC, La Trinidad, Benguet. Pp 16-18.

THOMPSON, H.C.. 1959. Vegetable Crops. New York: McGraw-Hill Publ., Co., Inc. P. 560.

VICENTE, B.Y.. 1978. Effect of spacing on the root size and yield of carrots. BS Thesis. MSAC, La Trinidad, Benguet. P. 23.

WATTS, R.L.. 1972. Vegetable Gardening. New York: Orange Judd Inc. P. 259.

WILEY, R.W.. 1979. Intercropping: It's importance and research needs. I. Competition and yield advantage. Field Crops Abstr. 32:1-10.

APPENDICES

Appendix Table 1. Plant height on the first measurement (cm)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	7.00	7.16	7.00	21.16	7.05
R_2	7.32	6.44	7.42	21.18	7.06
R_3	6.44	7.66	7.46	21.56	7.19
R_4	6.38	8.00	7.92	22.30	7.43
R_5	7.06	7.32	7.38	21.76	7.25
R_6	6.00	6.20	7.86	20.06	6.69
R_7	5.30	6.00	6.33	17.63	5.88
R_8	4.20	5.00	6.02	15.22	5.07
R_9	5.52	5.61	5.82	16.95	5.65
R_{10}	5.00	5.50	5.30	15.80	5.27

Analysis of Variance

Source of	Degrees of	Sum of	Mean	Computed	TABULAR F

variation	freedom	squares	square	F	0.05	0.01
Replication	2	3.455	1.727			
Factor A	9	21.633	2.404	10.30**	2.41	5.51
Error	18	4.202	0.233			
Total	29	29.290				

** = Highly significant

Coefficient of variation = 7.49%

Appendix Table 2. Plant height on the second measurement (cm)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	14.98	14.72	15.06	44.76	14.92
R_2	14.68	15.84	14.88	45.40	15.13
R_3	14.62	13.72	13.58	41.92	13.97
R_4	15.42	16.50	14.50	46.42	15.47
R_5	14.84	11.12	16.52	42.48	14.16
R_6	14.06	14.50	12.68	41.24	13.78
R_7	13.66	14.20	13.20	41.06	13.69
R_8	11.76	12.00	12.53	36.29	12.10
R_9	13.34	12.56	13.20	39.10	

13.03

R_{10}	11.04	12.40	13.80	37.24	12.41

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	2	0.294	0.147			
Factor A	9	34.137	3.793	2.71*	2.41	5.51
Error	18	25.223	1.401			
Total	29	59.654				

= Significant
Coefficient of variation = 8.54%

Appendix Table 3. Plant height on the third measurement (cm)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	19.48	22.50	22.20	64.18	21.39
R_2	19.96	22.10	21.70	63.76	21.25
R_3	18.62	20.92	20.00	59.54	19.85
R_4	22.02	22.18	22.80	67.00	22.33
R_5	20.97	20.40	19.92	61.29	20.43
R_6	13.96	19.90	20.66	54.52	18.17
R_7	20.42	19.70	19.72	59.84	19.95
R_8	20.30	18.40	17.40	56.10	18.70
R_9	16.68	20.38	19.10	56.16	18.72
R_{10}	20.40	17.58	24.10	62.08	20.69

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	11.928	5.964			

Factor A	9	8.275	5.364	1.61ns	2.41	5.51
Error	18	59.809	3.323			
Total	29	120.012				

ns = Not significant
Coefficient of variation = 9.05%

Appendix Table 4. Plant height on the fourth measurement (cm)

TREATMENT	REPLICATION I	REPLICATION II	REPLICATION III	TOTAL	MEAN
R_1	30.00	36.80	34.00	100.80	33.60
R_2	31.40	36.08	34.60	102.08	34.03
R_3	29.88	33.70	32.70	96.28	32.09
R_4	35.10	34.40	35.70	105.20	35.07
R_5	32.04	34.40	34.44	100.88	33.63
R_6	31.22	31.30	31.20	93.72	31.24
R_7	31.30	31.10	31.50	93.90	31.30
R_8	35.70	31.80	32.00	99.50	33.17
R_9	29.72	35.00	32.24	96.96	32.32
R_{10}	30.30	30.80	35.80	96.90	32.30

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	TABULAR F 0.01
Replication	2	21.961	10.980			

Factor A	9	41.127	4.570	1.22ns	2.41	5.51
Error	18	67.496	3.750			
Total	29	130.584				

ns = Not significant

Coefficient of variation = 5.89%

Appendix Table 5. Final plant height at first harvest (cm)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	35.72	45.00	41.92	122.64	40.88
R_2	35.32	44.50	44.04	123.86	41.29
R_3	36.20	44.34	44.58	125.12	41.71
R_4	43.50	44.68	48.48	136.66	45.55
R_5	41.08	41.00	42.68	124.76	41.59
R_6	41.24	43.84	39.30	124.38	41.46
R_7	40.44	43.10	43.12	126.66	42.22
R_8	44.60	40.54	41.92	127.06	42.35
R_9	36.18	41.90	40.32	118.40	39.47
R_{10}	38.92	38.40	45.20	122.52	40.84

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	88.415	44.207			
Factor A	9	66.522	7.391	0.95ns	2.41	5.51
Error	18	140.384	7.799			
Total	29	295.321				

ns = Not significant

Coefficient of variation = 6.69%

Appendix Table 6. Number of days from seeding to first harvest

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	48.0	49.0	49.0	146.0	48.67
R_2	49.0	48.0	48.0	145.0	48.33
R_3	48.0	48.0	48.0	144.0	48.00
R_4	48.0	48.0	48.0	144.0	48.00
R_5	47.0	47.0	48.0	142.0	47.33
R_6	46.0	46.0	46.0	138.0	46.00
R_7	46.0	46.0	45.0	137.0	45.67
R_8	45.0	45.0	45.0	135.0	45.00
R_9	45.0	46.0	45.0	136.0	45.33
R_{10}	45.0	45.0	45.0	135.0	45.00

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	0.067	0.033			
Factor A	9	58.533	6.504	35.84**	2.41	5.51
Error	18	3.267	0.181			
Total	29	61.867				

** = Highly significant

Coefficient of variation = 0.91%

Appendix Table 7. Average marketable plant weight (kg)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	0.039	0.040	0.036	0.108	0.036
R_2	0.038	0.027	0.028	0.094	0.031
R_3	0.047	0.036	0.036	0.114	0.038
R_4	0.049	0.025	0.061	0.139	0.046
R_5	0.037	0.041	0.054	0.161	0.054
R_6	0.042	0.038	0.053	0.141	0.047
R_7	0.055	0.048	0.049	0.156	0.052
R_8	0.044	0.046	0.081	0.172	0.057
R_9	0.058	0.071	0.057	0.189	0.063
R_{10}	0.067	0.065	0.067	0.269	0.090

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	0.000	0.000			
Factor A	9	0.008	0.001	5.85**	2.41	5.51
Error	18	0.003	0.000			
Total	29	0.010				

** = Highly significant

Coefficient of variation =

23.22%

Appendix Table 8. Marketable yield (kg/plot)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	9.480	9.330	8.583	27.393	9.13
R_2	7.644	5.485	5.500	18.629	6.21
R_3	6.275	4.650	4.700	15.625	5.21
R_4	9.010	4.805	11.500	25.315	8.44
R_5	5.019	5.550	7.500	18.069	6.02
R_6	4.689	4.150	6.000	14.839	4.95
R_7	7.168	6.125	6.700	19.993	6.66
R_8	4.956	5.075	9.100	19.131	6.38
R_9	4.913	6.025	5.000	15.938	5.31
R_{10}	4.635	4.500	4.600	13.735	4.58

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	9.218	4.609			
Factor A	9	59.317	6.591	3.24*	2.41	5.51
Error	18	36.613	2.034			
Total	29	105.148				

* = Significant
Coefficient of variation = 22.68%

Appendix Table 9. Non-marketable yield (kg/plot)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	2.740	2.715	4.195	9.650	3.22
R_2	1.912	4.040	3.500	9.452	3.15
R_3	1.460	3.905	3.400	8.765	2.92
R_4	3.677	4.685	3.450	11.812	3.94
R_5	4.007	2.450	2.250	8.707	2.90
R_6	2.176	2.500	3.050	7.726	2.58
R_7	3.297	3.000	2.800	9.097	3.03
R_8	2.399	3.850	1.700	7.949	2.65
R_9	2.045	3.400	1.600	7.045	2.35
R_{10}	1.665	3.100	2.650	7.415	2.47

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	3.473	1.737			
Factor A	9	5.726	0.636	0.94ns	2.41	5.51
Error	18	12.213	0.679			
Total	29	21.413				

ns = Not significant

Coefficient of variation = 28.20%

Appendix Table 10. Total yield (kg/plot)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	12.220	12.045	12.778	37.043	12.35
R_2	9.556	9.525	9.000	28.081	9.36
R_3	7.735	8.555	7.100	23.390	7.89
R_4	12.687	9.490	14.950	37.127	12.38
R_5	9.026	8.000	9.850	26.876	9.00
R_6	6.865	6.650	9.050	22.565	7.52
R_7	10.465	9.125	9.500	29.090	9.70
R_8	7.355	8.925	10.800	27.080	9.03
R_9	6.958	9.425	6.600	22.983	7.66
R_{10}	6.300	7.600	7.250	21.150	7.05

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	3.877	1.939			
Factor A	9	96.379	10.709	6.32**	2.41	5.51
Error	18	30.514	1.695			
Total	29	130.769				

* = Highly significant
Coefficient of

variation = 14.18%

Appendix Table 11. Computed marketable yield (t/ha)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	18.960	18.660	17.166	54.786	18.26
R_2	15.288	10.970	11.000	37.258	12.42
R_3	12.550	9.300	9.400	31.250	10.42
R_4	18.020	9.610	23.000	50.630	16.88
R_5	10.038	11.100	15.200	36.338	12.11
R_6	9.378	8.300	12.000	29.678	9.89
R_7	14.336	12.250	13.400	39.986	13.33
R_8	9.912	10.150	18.200	38.262	12.75
R_9	9.826	12.050	10.000	31.876	10.63
R_{10}	9.270	9.000	9.200	27.470	9.16

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	37.377	18.689			
Factor A	9	237.069	26.341	3.22*.	2.41	5.51
Error	18	147.155	8.175			
Total	29	421.601				

* = Significant

Coefficient of variation = 22.72%

Appendix Table 12. Benefit:cost ratio

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	113.76	111.96	103.00	328.72	109.57
R_2	91.73	65.82	66.00	223.55	74.53
R_3	75.30	55.80	56.40	187.50	62.50
R_4	108.12	57.66	138.00	303.78	101.26
R_5	60.23	66.60	91.20	218.03	72.69
R_6	56.27	49.80	72.00	178.07	59.37
R_7	86.02	73.50	80.40	239.92	79.97
R_8	59.47	60.90	109.20	229.57	76.52
R_9	58.96	72.30	60.00	191.26	63.75
R_{10}	55.62	54.00	55.20	164.82	54.94

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	1345.673	672.836			
Factor A	9	8534.611	948.290	3.22*	2.41	5.51
Error	18	5297.522	294.307			
Total	29	15177.806				

* = Significant
Coefficient of variation = 22.72%

Appendix Table 13. Incidence of insect pests (rating)

TREATMENT	REPLICATION I	II	III	TOTAL	MEAN
R_1	3.0	3.2	3.2	9.40	3.13
R_2	2.8	3.0	3.2	9.00	3.00
R_3	2.8	2.6	3.2	8.60	2.87
R_4	2.8	2.8	3.0	8.60	2.87
R_5	3.0	2.8	2.8	8.60	2.87
R_6	2.6	2.6	2.4	7.60	2.53
R_7	2.8	2.8	2.6	8.20	2.73
R_8	2.8	2.8	2.6	8.20	2.73
R_9	2.0	2.2	2.4	6.60	2.20
R_{10}	2.0	2.0	2.0	6.00	2.00

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F 0.05	0.01
Replication	2	0.035	0.017			
Factor A	9	3.392	0.377	14.37**	2.41	5.51
Error	18	0.472	0.026			
Total	29	3.899				

** = Highly significant
Coefficient of variation = 6.01%

Appendix Table 14. Incidence of powdery mildew (rating)

TREATMENT	REPLICATION			TOTAL	MEAN
	I	II	III		
R_1	2.2	2.4	2.0	6.60	2.20
R_2	2.0	2.2	2.0	6.20	2.07
R_3	2.0	2.2	1.8	6.00	2.00
R_4	2.0	2.2	2.0	6.20	2.07
R_5	1.8	1.8	1.8	5.40	1.80
R_6	2.0	2.0	2.0	6.00	2.00
R_7	2.0	2.0	2.0	6.00	2.00
R_8	2.0	2.0	2.0	6.00	2.00
R_9	2.0	2.0	2.0	6.00	2.00
R_{10}	2.0	2.0	2.0	6.00	2.00

Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean square	Computed F	TABULAR F	
					0.05	0.01
Replication	2	0.075	0.037			
Factor A	9	0.261	0.029	3.77*	2.41	5.51
Error	18	0.139	0.008			
Total	29	0.475				

* = Significant
Coefficient of variation = 4.36%