EFFECT OF CULTIVAR, NITROGEN LEVEL AND FREQUENCY OF INSECTICIDE SPRAYING ON CHINESE CABBAGE

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Chinese cabbage (*Brassica pekinensis* Rupr) belongs to the family cruciferae. It is probably a native of China and Eastern Asia and is believed to be grown there even before the time of Christ (1, 4). Uses of this crop include a salad made out from the tender and succulent leaves. It is often cooked with other vegetables, fish, and meat. It is relatively rich in calcium and vitamins A & C (1, 11).

Chinese cabbage is very sensitive to high temperatures and is usually grown in the highlands or in the lowlands when it is planted during the cool months of the year. Painstaking work in breeding and selection through the years has produced promising lines and cultivars which will increase its successful culture under varying agro-climatic conditions. The hybrids of the first generation (F_1) in particular grow vigorously and are quite resistant to diseases which are very successful in Japan even if they are grown during a relatively warm season (10). A winter cultivar such as AVRDC Acc. No. 307, can produce yields as high as 63 tons/ha under cool winter conditions while a heat tolerant cultivar like AVRDC Acc. No. 177, can have a yield of 8.1 ton/ha under hot humid conditions (1).

Chinese cabbage is a green leafy vegetable and requires great amounts of nitrogen (6, 9, 10). This element is essential in the growth of plants. Most soils are commonly more deficient in nitrogen than any other element (19). Many tropical soils rapidly become low in plant nutrients when cultivated, particularly in nitrogen due to mineralization, leaching and erosion (22). A shortage of this element inhibits cell division and consequently reduces yield (9). Cabbage plants become stunted and heads remain small when nitrogen is deficient (15).

Nitrogenous fertilizers applied at the recommended levels may improve yields, provided other soil nutrients are not limiting and insect control measures are successful (20). The requirements of nitrogen for a crop have to be determined by actual field trials since it varies according to environmental conditions.

Rajput and Singh (18) reported that the effect of nitrogen on the height and number of leaves on cauliflower was directly proportional to the level applied and that maximum vegetative growth and yield were recorded when nitrogen application was 120 kg/ha.

In the Netherlands (15), the optimal dressing in cabbage is 240 kg N/ha or in a few cases even more. Heavier dressings when the other growing conditions are unfavourable serve no useful purpose. This may be one of the reasons why, in various countries, less than 100 kg N is applied per hectare. On the other hand, 150 and 300 kg/ha is recommended by Geus (6) for winter cabbage and for white processing cabbage, respectively.

A study on nutrient uptake and fertilizer response of vegetables in Taiwan (13), indicated that N and Ca were the two nutrients taken up by cabbage to the greatest degree. Nitrogen uptake was 210 kg/ha with a yield of 43 tons. In this regard, Lian recommended 250-350 kg N/ha. Ho (8) also stated that the most profitable rate of nitrogen fertilizer for cabbage on lateritic soil is 225 kg/ha.

If a target yield is 55 tons/ha in Japan, application of 90 kg N in addition to 16.53 tons of compost and stable manure should be made (10).

In the Philippines, 90-240 kg N/ha is recommended (16). However, an application of 600 kg/ha of 12-12-12 complete fertilizer (72 kg N) in Baguio has resulted in heavy yields, 30-35 tons/ha of good quality heads of common cabbage (2). Similarly, Gagni et al. (4) pointed out the use of 60-120 kg/ha. On the other hand, Villareal and Wallace (23) advocated the use of 700-1000 kg/ha of 12-24-12 complete fertilizer.

Ravages due to insect pests often constitute a major hindrance in successful vegetable production (3). Scientists have been producing a number of chemicals that can control insect pests. Insecticides play a major role in controlling insect pests; but their use has been criticised due to harmful side effects, oftentimes related to improper use, including overapplication and wrong timing.

Experiments showed that the diamondback moth can be controlled by DDT (7), Spanone, Surecide, Hostathion, S-2539 (21), and Diazion (12, 21).

Outstanding insecticides for aphids are Metadophos, Acephate, EPN, Naled (1), Monitor, Dibrom, Orthene (21), and Dusts containing 2.4% w/w nicotene or 0.125% gamma isomer BHC (12).

Surecide, Spanone (21) as well as Toxaphene, especially when combined with polyhedrosis virus (5), are effective insecticides for controlling cabbage looper. However, EPN, Dibrom, Monitor, Elsan and Orthene will also give a good cabbage worm control (21).

On the other hand, Mowat (14) reported Chlorfenvinphos "Birlane" as effective control for cabbage rootfly while Azem-phosmethyl "Gusathion" can greatly reduce damage but only good for a short period of time.

With few exceptions, the relative level of resistance of cruciferous crops was found to be primarily a characteristic of the crop species and secondary one of cultivar (17).

In this regard, the present study was aimed to compare the yield potential of two Chinese cabbage cultivars under varying levels of nitrogen fertilizer at different insecticide spraying intervals, and to study the interactions of various factors under investigation.

Materials and Methods

A 2 x 3 x 3 factorial experiment of a randomized complete block design replicated three times was conducted at Field No. 27 of AVRDC, Taiwan, ROC from October 8 to December 28, 1977. Three factors were investigated, cultivars, N fertilizer and insecticide spraying intervals. The open-pollinated cultivars used were Kyoto No. 3 (C_1) and Yamato-Noen (C_2), AVRDC Acc. Nos. 21 and 40, respectively. N levels were 0, 150, and 300 kg/ha (N_1, N_2, and N_3, respectively). Ammonium sulfate (21 percent N) was the nitrogen carrier. The insecticide spraying intervals were 11, 7, and 3 days (I_1, I_2 and I_3, respectively). The insecticide used was Sumiciden 20% EC at the rate of 100 gm a.i./ha with 1:3000 cc dilution.

Seeds were sown in seedflats. Seedlings were transplanted after 24 days of sowing (DAS). Each plot was a double row bed 1.5 m wide and 4.8 m long. Planting distance was 40 cm between plants within row and 50 cm between rows.

Phosphorus and potassium applications were fixed at 80 and 150 kg/ha, respectively. Borax and rice straw compost at the rate of 10 kg/ha and 10 tons/ha, respectively were also applied. All the required P_2O_5, K_2O, B, compost and 40% of N requirement were applied as pre-plant soil incorporation. The other N required was split into four side dressings at 7, 14, 28, and 43 days after transplanting (DAT).

Lasso was sprayed at the rate of 4 liters/ha after bed formation as pre-emergence weed control. Rice straw mulching was done at the rate of 5 tons/ha to suppress weed growth. The field was kept in good moisture condition by weekly furrow irrigation. To control diseases, Dithane M-45 was sprayed weekly.

Plants were harvested when heads were firm. Harvesting was done four times (Dec. 8, 14, 21, and 28). The data collected were:

1. *Plot yield (gm).* Total weight of marketable heads in an experimental plot of 20 plants. Non-wrapper leaves were not included. The yield per plot was converted into tons per hectare by using the formula,

$$\text{Yield} = \frac{\text{plot yield (gm)}}{\text{plot area (m}^2\text{)}} \cdot \frac{10{,}000\text{m}^2\text{/ha}}{1{,}000{,}000 \text{ gm/ton}}$$

2. *Maturity.* Days from transplanting to 50% plot harvest.

3. *Total vegetative growth (gm).* The total plant weight taken from 20 plant samples. Mean vegetative growth was determined.

4. *Mean weight of wrapper leaves 'WL" (gm).* The total weight of the leaves making up the head excluding the head core. Taken from four plant samples.

5. *Mean weight of non-wrapper leaves* "NWL" *(gm).* All leaves not making up the head were classified as non-wrapper leaves, presumably active organs of photosynthesis. Taken from 20 plant samples.

6. *Mean weight of head core (gm).* The weight of head stem from four plant samples used in item (4) above.

7. *Mean number of wrapper leaves.* The total number of leaves making up the head. Taken from four plant samples used in item (4) above.

8. *Mean number of non-wrapper leaves.* Taken from 20 plant samples used in item (5) above.

9. *Disease damage rating:*

   a) Soft rot – percent of infection per plot.
   b) Turnip mosaic virus – percent of infection per plot.
   c) Downy mildew – none, light, moderate, and severe.
   d) Alternaria leaf spot – none, light, moderate, and severe.

10. *Insect damage rating.* Based on insect counts per 10 plants samples; and on subjective rating such as none, light, moderate, and severe.

11. *Weather data.* Covering the period of growing until maturity.

Results and Discussion

Statistical analyses were made to determine significant effects (Table 2).

Marketable yield. The differences in yield between cultivars, among nitrogen levels and insecticide spraying intervals were highly significant (Table 3 and Figure 1). The interaction between cultivars and insecticide spraying intervals was highly significant (Table 14). The interaction between insecticide spraying intervals and nitrogen levels was highly significant (Table 19).

The cultivar Yamato-Noen gave a higher yield due to heavier head weight, more wrapper leaves, earlier maturity, and lower insect and disease damage. Lowest yields were obtained from plants without N fertilizer. These plants exhibited stunted growth and consequently low vegetative growth and poor head formation. Plants sprayed with insecticide at 11-day intervals gave low yields, since aphid population was highest and insect damage was greatest. The interactions reveal that high yields can be achieved by nitrogen fertilization and by controlling pests through frequent sprays.

Maturity. Differences in maturity between cultivars and among nitrogen levels were highly significant (Table 3 and Figure 2). The interaction of cultivars with nitrogen levels was highly significant (Table 8). The days to maturity for Yamato-Noen decreased about 40 percent as nitrogen levels were increased.

Maturity is a characteristic of every cultivar. However, conditions which may stimulate rapid growth like the presence of sufficient quantity of nitrogen may cause a decrease in the days to mature.

Mean vegetative growth. Cultivars, nitrogen levels and insecticide spraying intervals showed a highly significant variations in mean vegetative growth (Table 3 and Figure 3). The interaction of cultivars with insecticide spraying intervals was highly significant (Table 15). The interaction between nitrogen levels and insecticide spraying intervals was significant (Table 20).

The cultivar Kyoto No. 3 gave a greater vegetative growth since it produced larger leaves which ran parallel to the weight. The increasing vegetative growth obtained by an increment in nitrogen fertilizer is accounted for by the growth stimulating effect of nitrogen. Increasing the insecticide spraying frequency caused an increase in vegetative growth since insect damage was lessened.

Mean head weight. Variations among nitrogen levels and insecticide spraying intervals were highly significant (Table 3 and Figure 4). When cultivars and insecticide spraying intervals were combined, highly significant interaction was recorded (Table 16). Nitrogen levels and insecticide spraying intervals interaction was highly significant (Table 21); so was the three-factor interaction (Table 23).

Head weight differences between cultivars and among nitrogen levels account for the number of wrapper leaves. Variation among insecticide spraying intervals can be explained by differences in insect damage. Insects impaired the quality of outer wrapper leaves.

Mean weight of wrapper leaves. Nitrogen levels as well as insecticide spraying intervals vary with each other highly significantly (Table 3). However, the interactions of cultivars with insecticide spraying intervals (Table 17); and nitrogen levels with insecticide spraying intervals were highly significant (Table 22). The three-factor interaction was significant (Table 24).

The absence of considerable difference between cultivars in spite of their remarkable variation in the number of wrapper leaves is due to the characteristic ability of Kyoto No. 3 to produce bigger size leaves which consequently weigh heavier.

Mean weight of non-wrapper leaves. The differences between cultivars and among nitrogen levels were highly significant (Table 4).

Kyoto No. 3 gave heavier weight of non-wrapper leaves since it produced more non-wrapper leaves. However, the plants without nitrogen gave the lowest weight although the number of non-wrapper leaves was greatest. This was caused by the small size of the leaves produced by plants with lowest level of nitrogen.

Mean weight of head core. The difference among nitrogen levels was highly significant (Table 4); and that among insecticide spraying intervals was significant (Table 4). The interaction of cultivars with nitrogen levels was highly significant (Table 9). Kyoto No. 3 showed a greater response to higher levels of nitrogen than did Yamato-Noen.

The caused of head core weight differences is the variation in vegetative growth and partly by varietal characteristics. It appeared that bigger plants produced bigger headcore.

Mean number of wrapper leaves. The difference in number of wrapper leaves between cultivars was significant (Table 4). Nitrogen levels showed a highly significant variation (Table 4). The interaction between cultivars and nitrogen levels was highly significant (Table 10).

The number of wrapper leaves depends on cultivar and partly on the earliness of head formation. However, adequate amount of nitrogen can induce early head formation.

Mean number of non-wrapper leaves. The number of non-wrapper leaves was highly significantly different between cultivars and among nitrogen levels (Table 4). There was a highly significant interaction between cultivar and nitrogen (Table 11).

The total number of all leaves produced by each cultivar were almost the same, 74 and 72 for Kyoto No. 3 and Yamato-Noen, respectively in spite of their considerable difference in maturity. This implies that number of leaves is not associated with growth duration.

Soft rot incidence. Between cultivars and among nitrogen levels, variations on soft rot incidence were highly significant (Table 4). The interaction between cultivars and nitrogen levels was highly significant (Table 12).

Soft rot incidence is closely related to the reaction of cultivars to this disease. However, maturity has something to do with it. The more the crop is delayed in the field, the more chances of soft rot infection. It appeared that increase in nitrogen supply increased the severity. This is probably due to the effect of this element in rendering the host plant more succulent.

Incidence of other diseases. The incidence of downy mildew, turnip mosaic virus and alternaria leaf spot were very low. Thus, no significant difference was recorded.

Insect damage. Highly significant variations were observed between cultivars, among nitrogen levels and insecticide spraying intervals (Table 4). The interaction between cultivars and insecticide spraying intervals was significant (Table 18). The interaction between cultivars and nitrogen levels was highly significant (Table 13). The combination of the three factors showed significant interaction (Table 25).

Insects prefer light colored plants to green ones (1). Cultivar Kyoto No. 3 which had more damage is lighter in color than Yamato-Noen. Insect damage was higher with increasing nitrogen levels since plants were induced vegetatively by higher nitrogen levels, thus rendering them more tender and succulent. Maturity is an important factor of insect damage. The more the crop is delayed on the field especially when insect population is high, the more they will be damaged.

Number of larvae. Surveying was done four times starting 40 days before the first harvest. However, only in the second surveying were few larvae recorded; no significant difference was observed among treatments. The temperatures were warm enough to permit the development of lepedopterous insect pests.

Aphid population. The distribution of aphid population is shown in Tables 5, 6, and 7. Each table represents one surveying. A tremendous increase in the number of plants containing more than 100 aphids was noted from the first up to the last surveying.

Summary and Conclusion

A 2 x 3 x 3 factorial experiment combining two cultivars of Chinese cabbage (Kyoto No. 3 and Yamato-Noen), three levels of nitrogen fertilizer (0, 150, and 300 kg/ha) and three insecticide spraying intervals (11, 7, and 3 days) was conducted during fall in 1977 at AVRDC to compare the yield potential of two Chinese cabbage culti-

vars under varying levels of nitrogen fertilizer at different insecticide spraying intervals. The resume of the results are the following:

1. Kyoto No. 3 and Yamato-Noen vary in yield, maturity, vegetative growth, number and weight of wrapper and non-wrapper leaves and reaction to soft rot and aphids.
2. Application of nitrogen up to 300 kg/ha increased the yield tremendously up to 58.2 tons/ha compared to the control plants which gave only 4.5 tons/ha.
3. Increasing nitrogen reduced days to maturity of Yamato-Noen.
4. Increasing nitrogen application caused an increase in soft rot incidence and insect damage.
5. Increasing the frequency of insecticide spraying increased yield, head weight, headcore weight and reduced insect damage as well as aphid population.
6. Cultivars, nitrogen levels and insecticide spraying intervals showed considerable interactions.

In view of this, if maximum yield, both quantitatively and qualitatively, should be achieved, proper choice of cultivar is essential. Application of nitrogenous fertilizers and timely insecticide spraying should be included in the management of Chinese cabbage. It is suggested that economic analysis should be done to determine if heavy dressings and frequent sprayings are both profitable.

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Table 1. Air temperature, soil temperature, relative humidity, solar intensity, evaporation, and precipitation in AVRDC (October-December, 1977).

	Air Temperature Max	Air Temperature Min	Soil Temp 10 cm	Relative humidity	Solar intensity	Evap	Pptn
	°C	°C	°C	%	Ca/cm^2	mm	mm
Oct	30.1	19.7	27.8	77.0	414.5	5.07	0.01
Nov	25.9	15.5	24.0	78.4	307.8	3.89	0.91
Dec	26.6	15.8	22.1	76.8	295.3	3.26	0.56
Mean	27.5	17.0	24.6	77.4	339.2	4.07	0.49

Table 2. Significance of treatment means by factors for variable measured[a/].

Factors \ Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Cultivar (C)	**	**	**	NS	NS	**	NS	*	**	**	NS	NS	NS	**
Nitrogen (N)	**	**	**	**	**	**	**	**	**	**	NS	NS	NS	**
Insecticide frequency I	**	NS	**	**	**	NS	*	NS	NS	NS	NS	NS	NS	**
C-N	NS	**	NS	NS	NS	NS	**	**	**	**	NS	NS	NS	**
C-I	**	NS	**	**	**	NS	NS	NS	NS	NS	NS	NS	NS	*
N-I	**	NS	*	**	**	NS	NS	NS	NS	NS	NS	NS	NS	NS
C-N-I	NS	NS	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	*

a/** – highly significant; * – significant; NS – non-significant

1. Marketable yield
2. Maturity
3. Mean vegetative growth
4. Mean head weight
5. Mean weight of wrapper leaves
6. Mean weight of non-wrapper leaves
7. Mean weight of headcore
8. Mean number of wrapper leaves
9. Mean number of non-wrapper leaves
10. Soft rot incidence
11. Turnip mosaic virus
12. Downy mildew
13. Alternaria leaf spot
14. Insect damage

Table 3. Summarized data on marketable yield, maturity, mean vegetative growth, mean head weight, and mean weight of wrapper leaves in Chinese cabbage.

	Yield	Maturity	Mean vegetative growth	Mean head weight	Mean weight of wrapper leaves
Cultivar	(ton/ha)	(days)	(gm)	(gm)	(gm)
Kyoto No. 3	33.3[b]	77[a]	2494[a]	1090[a]	1053[a]
Yamato-Noen	37.4[a]	65[b]	2288[b]	1167[a]	1134[a]
LSD .05	2.9	0.78	124	88	86
.01	3.9	1.07	162	118	105
Nitrogen (kg/ha)					
0	4.5[c]	78[a]	954[c]	249[c]	241[c]
150	43.4[b]	69[b]	2739[b]	1326[b]	1286[b]
300	58.2[a]	66[c]	3479[a]	1811[a]	1754[a]
LSD .05	3.6	0.97	152	107	103
.01	4.8	1.32	204	144	139

Table 3. Cont'd.

	Yield	Maturity	Mean vegetative growth	Mean head weight	Mean weight of wrapper leaves
Insecticide spraying interval (days)					
11	32.3[b]	71[a]	2250[b]	1039[b]	1006[b]
7	34.9[b]	71[a]	2417[a]	1094[b]	1061[b]
3	38.9[a]	71[a]	2505[a]	1253[a]	1214[a]
LSD .05	3.6	0.97	152	107	103
.01	4.8	1.32	204	144	139
Mean	35.4	71	2391	1129	1094
C. V. (%)	14.9	2.1	9.4	14.0	13.9

Within columns means with uncommon letters are significantly different at the 5% levels.

Table 4. Summarized data on mean weight of non-wrapper leaves, mean weight of headcore, mean number of non-wrapper leaves, mean number of wrapper leaves, soft rot incidence, and insect damage in Chinese cabbage.

	Mean weight of non-wrapper leaves	Mean weight of headcore	Mean No. of non-wrapper leaves	Mean No. of wrapper leaves	Soft rot incidence	Insect damage+
Cultivar	(gm)	(gm)	—	—	%	
Kyoto No. 3	1452^a	35^a	31^a	43^a	2.2^a	1.3^a
Yamato-Noen	1168^b	31^a	25^b	47^a	0^b	0.8^b
LSD .05	74	5.4	2.9	4.1	1.26	0.2
.01	99	7.2	3.9	5.6	1.71	0.29
Nitrogen (kg/ha)						
0	821^c	5^c	42^a	23^b	0^b	0.5^b
150	1432^b	40^b	22^b	54^a	0.6^b	1.3^a
300	1676^a	56^a	19^c	57^a	2.8^a	1.4^a
LSD .05	90	6.6	3.6	5.1	1.56	0.20
.01	121	8.9	4.8	6.8	2.10	0.36

Table 4. Cont'd.

	Mean weight of non-wrapper leaves	Mean weight of headcore	Mean No. of non-wrapper leaves	Mean No. of wrapper leaves	Soft rot incidence	Insect damage+
Insecticide spraying interval (days)						
11	1270[a]	29[b]	26[a]	46[a]	1.1[a]	1.5[a]
7	1355[a]	32[b]	29[a]	44[a]	0.9[a]	1.1[b]
3	1304[a]	39[a]	29[a]	45[a]	1.4[a]	0.6[c]
LSD .05	90	6.6	3.6	5.1	1.56	0.20
.01	121	8.9	4.8	6.8	2.10	0.36
Mean	1310	33	28	45	1.1	1.1
C. V. (%)	10.2	29.3	16.5	18.9	58.8	36.7

Within columns, means with uncommon letters are significantly different at the 5% level.

+Rating: 0 = none; 1 = light; 2 = moderate; 3 = heavy.

Table 5. Aphid population distribution in two Chinese cabbage cultivars fertilized with varying levels of nitrogen at different insecticide spraying intervals (11-7-77).

	Aphid population size			
	0	1-100	100-1000	1000
Cultivar	No. of plants per 10 plant sample			
Kyoto No. 3	7.8	1.9	0.2	0.07
Yamato-Noen	7.1	2.7	0.2	0
LSD .05	0.10	0.25	NS	NS
.01	1.13	0.34		
Nitrogen (kg/ha)				
0	7.7	2.2	0.1	0
150	7.4	2.5	0.1	0
300	7.3	2.2	0.4	0.1
LSD .05	0.12	NS	NS	NS
.01	0.16			
Insecticide spraying interval (days)				
11	5.9	3.5	0.5	0.1
7	7.5	2.4	0.1	0
3	9.0	1.0	0	0
LSD .05	0.12	0.31	0.6	NS
.01	0.16	0.41	0.9	
Mean	7.5	2.3	0.2	0.03
C. V. (%)	6.0	29.7	12.0	

Table 6. Aphid population distribution in two cultivar of Chinese cabbage fertilized with varying levels of nitrogen at different insecticide spraying intervals (11-24-77).

	Aphid population size			
	0	1-100	100-1000	1000
Cultivar	No. of plants per 10 plant sample			
Kyoto No. 3	7.3	2.1	0.5	0.1
Yamato-Noen	5.3	4.0	0.6	0.1
LSD .05	0.12	0.14	NS	NS
.01	0.54	0.19		
Nitrogen (kg/ha)				
0	6.9	3.0	0.1	0
150	6.2	3.0	0.7	0.1
300	5.8	3.3	0.7	0.2
LSD .05	0.15	0.17	0.17	0.16
.01	0.66	0.23	0.23	0.20
Insecticide spraying interval (days)				
11	3.7	5.0	1.1	0.2
7	5.6	3.9	0.4	0.1
3	9.7	0.3	0	0
LSD .05	0.15	0.17	0.17	0.16
.01	0.66	0.23	0.23	0.20
Mean	6.3	3.1	0.5	0.1
C. V. (%)	3.7	8.3	21.6	17.3

Table 7 Aphid population distribution in two cultivars of Chinese cabbage fertilized with varying levels of nitrogen at different insecticide spraying intervals (at harvesting).

	Aphid population size			
	0	1-100	100-1000	1000
	No. of plants per 10 plant sample			
Cultivar				
Kyoto No. 3	4.40	0.80	0.20	4.60
Yamato-Noen	4.90	2.70	0.80	1.50
LSD .05	0.25	0.29	0.16	0.31
.01	0.34	0.51	0.21	0.41
Nitrogen (kg/ha)				
0	6.70	2.10	0.30	0.90
150	3.60	1.40	0.90	4.10
300	3.70	1.70	0.30	4.20
LSD .05	0.31	0.36	0.20	0.38
.01	0.41	0.48	0.26	0.51
Insecticide spraying interval (days)				
11	1.80	2.60	0.50	5.10
7	3.90	2.00	0.80	3.30
3	8.30	0.60	0.20	0.80
LSD .05	0.31	0.36	0.20	0.38
.01	0.41	0.48	0.26	0.51
Mean	4.70	1.70	0.50	3.10
C.V. (%)	9.80	31.20	31.20	18.00

Table 8. Effect of the interaction of cultivar and nitrogen level on maturity of Chinese cabbage (days).

Nitrogen level (kg/ha) / Cultivar	0	150	300	Mean
Kyoto No. 3	78	77	76	77
Yamato-Noen	78	61	56	65
Mean	78	69	66	71
C. V. (%) 2.05				
LSD .05 0.97				
.01 1.32				

Table 9. Effect of the interaction of cultivar and nitrogen level on the weight of headcore in Chinese cabbage (gm).

Nitrogen level (kg/ha) / Cultivar	0	150	300	Mean
Kyoto No. 3	2	39	64	35
Yamato-Noen	7	41	47	32
Mean	5	40	56	34
C. V. (%) 10.15				
LSD .05 6.6				
.01 8.9				

Table 10. Effect of the interaction of cultivar and nitrogen level on the mean number of wrapper leaves in Chinese cabbage.

Cultivar \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3	10	56	62	43
Yamato-Noen	37	52	54	47
Mean	24	54	58	45
C. V. (%) 16.53				
LSD .05 5.1				
.01 6.8				

Table 11. Effect of the interaction of cultivar and nitrogen level on the mean number of non-wrapper leaves in Chinese cabbage.

Cultivar \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3	49	23	22	31
Yamato-Noen	36	22	17	25
Mean	43	22	19	28
C. V. (%) 18.88				
LSD .05 3.6				
.01 4.8				

Table 12. Effect of the interaction of cultivar and nitrogen level on soft rot incidence in Chinese cabbage (%).

Cultivar \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3	0	1.10	5.50	2.2
Yamato-Noen	0	0	0	0
Mean	0	0.55	2.75	1.1
C.V. 58.75				
LSD .05 1.56				
.01 2.10				

Table 13. Effect of the interaction of cultivar and nitrogen level on insect damage in Chinese cabbage.

Cultivar \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3	0.5	1.5	1.9	1.3
Yamato-Noen	0.4	1.1	0.9	0.8
Mean	0.45	1.3	1.4	1.05
C.V. (%) 36.74				
LSD .05 0.20				
.01 0.36				

Rating used: 0 = none; 1 = light; 2 = moderate; 3 = heavy.

Table 14. Effect of the interaction of cultivar and insecticide spraying interval on the yield of Chinese cabbage (tons/ha).

Cultivar \ Insecticide spraying interval (days)	11	7	3	Mean
Kyoto No. 3	27.8	31.9	40.2	33.3
Yamato-Noen	36.7	37.9	37.5	37.4
Mean	32.3	34.9	38.9	35.4
C.V. (%) 14.93				
LSD .05 3.57				
.01 4.80				

Table 15. Effect of the interaction of cultivar and insecticide spraying interval on the mean vegetative growth in Chinese cabbage (gm/plant).

Cultivar \ Insecticide spraying interval (days)	11	7	3	Mean
Kyoto No. 3	2241	2481,	2759	2494
Yamato-Noen	2259	2353	2252	2288
Mean	2250	2417	2506	2391
C. V. (%) 9.35				
LSD .05 151.54				
.01 203.60				

Table 16. Effect of the interaction of cultivar and insecticide spraying interval on the mean head weight in Chinese cabbage (gm).

Cultivar \ Insecticide spraying interval (days)		11	7	3	Mean
Kyoto No. 3		947	1001	1321	1090
Yamato-Noen		1130	1197	1184	1170
Mean		1039	1099	1253	1130
C. V. (%)	14.02				
LSD .05	107.19				
.01	144.00				

Table 17. Effect of the interaction of cultivar and insecticide spraying interval on the mean weight of wrapper leaves in Chinese cabbage (gm/plant).

Cultivar \ Insecticide spraying interval (days)		11	7	3	Mean
Kyoto No. 3		914	969	1277	1053
Yamato-Noen		1099	1153	1151	1134
Mean		1007	1061	1214	1094
C. V. (%)	13.93				
LSD .05	103.24				
.01	138.70				

Table 18. Effect of the interaction of cultivar and insecticide spraying interval on insect damage in Chinese cabbage.

Cultivar \ Insecticide spraying interval (days)	11	7	3	Mean
Kyoto No. 3	1.8	1.4	0.6	1.26
Yamato-Noen	1.1	0.8	0.5	0.80
Mean	1.45	1.1	0.55	1.03
C. V. (%) 36.74				
LSD .05 0.20				
.01 0.36				

Rating used: 0 = none; 1 = light; 2 = moderate; 3 = heavy.

Table 19. Effect of the interaction of nitrogen levels and insecticide spraying interval on the yield of Chinese cabbage (tons/ha).

Insecticide spraying interval (days) \ Nitrogen level (kg/ha)	0	150	300	Mean
11	6.8	38.3	51.7	32.2
7	3.0	42.8	59.1	35.0
3	3.7	49.1	63.9	38.9
Mean	4.5	43.4	58.2	35.4
C. V. (%) 14.93				
LSD .05 4.12				
.01 5.54				

Table 20. Effect of the interaction of nitrogen level and insecticide spraying interval on the mean vegetative growth in Chinese cabbage (gm/plant).

Insecticide spraying interval \ Nitrogen level (kg/ha)		0	150	300	Mean
(days)					
11		1022	2517	3212	2250
7		865	2837	3549	2417
3		976	2865	3677	2506
Mean		954	2740	3479	2391
C. V. (%)	9.35				
LSD .05	174.90				
.01	235.10				

Table 21. Effect of the interaction of nitrogen level and insecticide spraying interval on the mean head weight in Chinese cabbage (gm).

Insecticide spraying interval \ Nitrogen level (kg/ha)	0	150	300	Mean
(days)				
11	321	1201	1596	1039
7	163	1306	1813	1094
3	262	1473	2024	1253
Mean	249	1326	1811	1129
C. V. (%) 14.02				
LSD .05 123.77				
.01 166.29				

Table 22. Effect of the interaction of nitrogen level and insecticide spraying interval on the mean weight of wrapper leaves (g/plant).

Nitrogen level (kg/ha) / Insecticide spraying interval (days)	0	150	300	Mean
11	310	1167	1543	1007
7	158	1268	1758	1061
3	256	1424	1962	1214
Mean	241	1286	1754	1094
C. V. (%) 13.93				
LSD .05 119.20				
.01 160.20				

Table 23. Effect of the interaction of cultivar, nitrogen level, and insecticide spraying interval on the mean head weight in Chinese cabbage (gm).

Insecticide spraying interval (days) \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3				
11	342	1121	1379	947
7	0	1273	1731	1001
3	183	1607	2174	1321
Mean	175	1334	1761	1090
Yamato-Noen				
11	300	1280	1812	1131
7	326	1370	1895	1197
3	340	1339	1874	1184
Mean	322	1330	1860	1171
LSD .05	85.52			
.01	117.58			
C. V. (%)	14.02			

Table 24. Effect of the interaction of cultivar, nitrogen level and insecticide spraying interval on the mean weight of wrapper leaves in Chinese cabbage (gm/plant).

Insecticide spraying interval (days) \ Nitrogen level (kg/ha)		0	150	300	Mean
Kyoto No. 3	11	327	1093	1323	914
	7	0	1235	1672	969
	3	179	1555	2097	1277
Mean		169	1294	1697	1053
Yamato-Noen	11	293	1240	1763	1098
	7	316	1301	1844	1154
	3	333	1292	1827	1151
Mean		314	1278	1811	1134
C. V. (%)	13.93				
LSD .05	84.29				
.01	113.20				

Table 25. Effect of the interaction of cultivar, nitrogen level and insecticide spraying interval on insect damage in Chinese cabbage.

Insecticide spraying interval (days) \ Nitrogen level (kg/ha)	0	150	300	Mean
Kyoto No. 3				
11	0.6	2.3	2.6	1.8
7	0.6	1.6	2.0	1.4
3	0.3	0.6	1.0	0.6
Mean	0.5	1.5	1.86	1.26
Yamato-Noen				
11	1.0	1.3	1.0	1.1
7	0.3	1.0	1.0	1.8
3	0	1.0	0.6	0.5
C. V. (%) 36.74				
LSD .05 0.20				
.01 0.29				

Rating used: 0 = none; 1 = light; 2 = moderate; 3 = heavy.

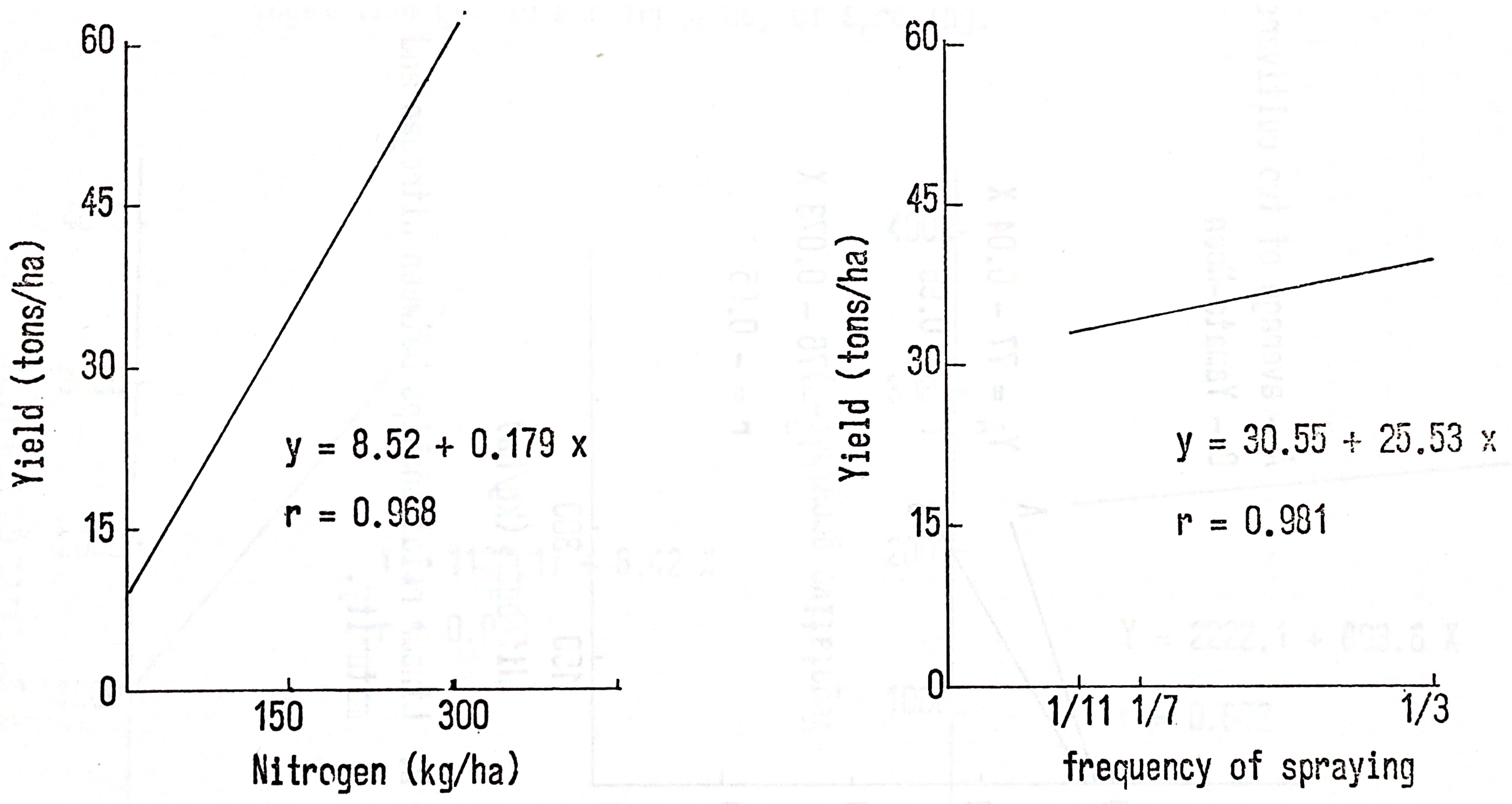


Figure 1. Linear relationships between yield and nitrogen and between yield and frequency of spraying.

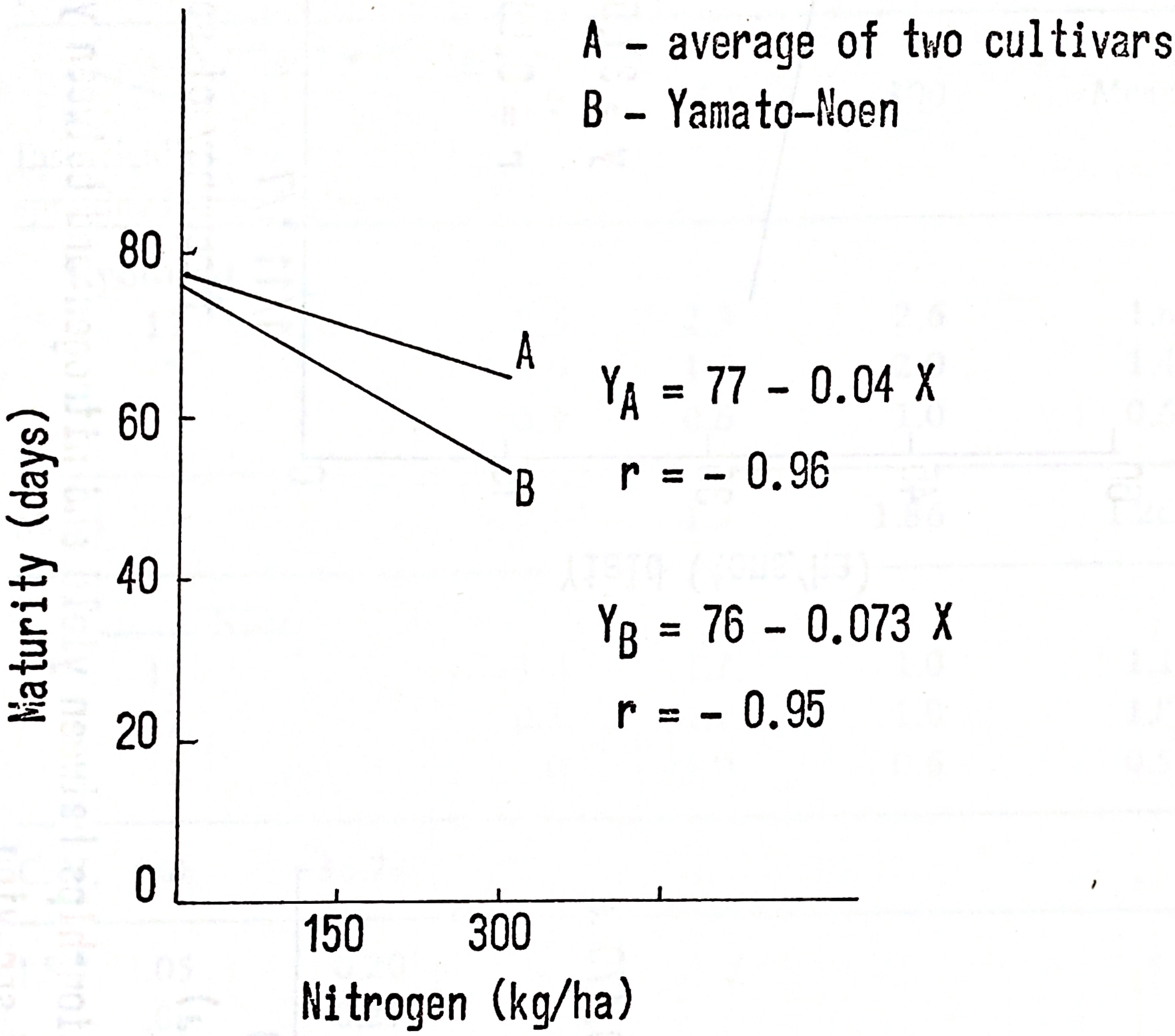


Figure 2. Linear relationships between nitrogen and maturity.

Figure 3. Linear relationships between vegetative growth and nitrogen and between vegetative growth and frequency of spraying.

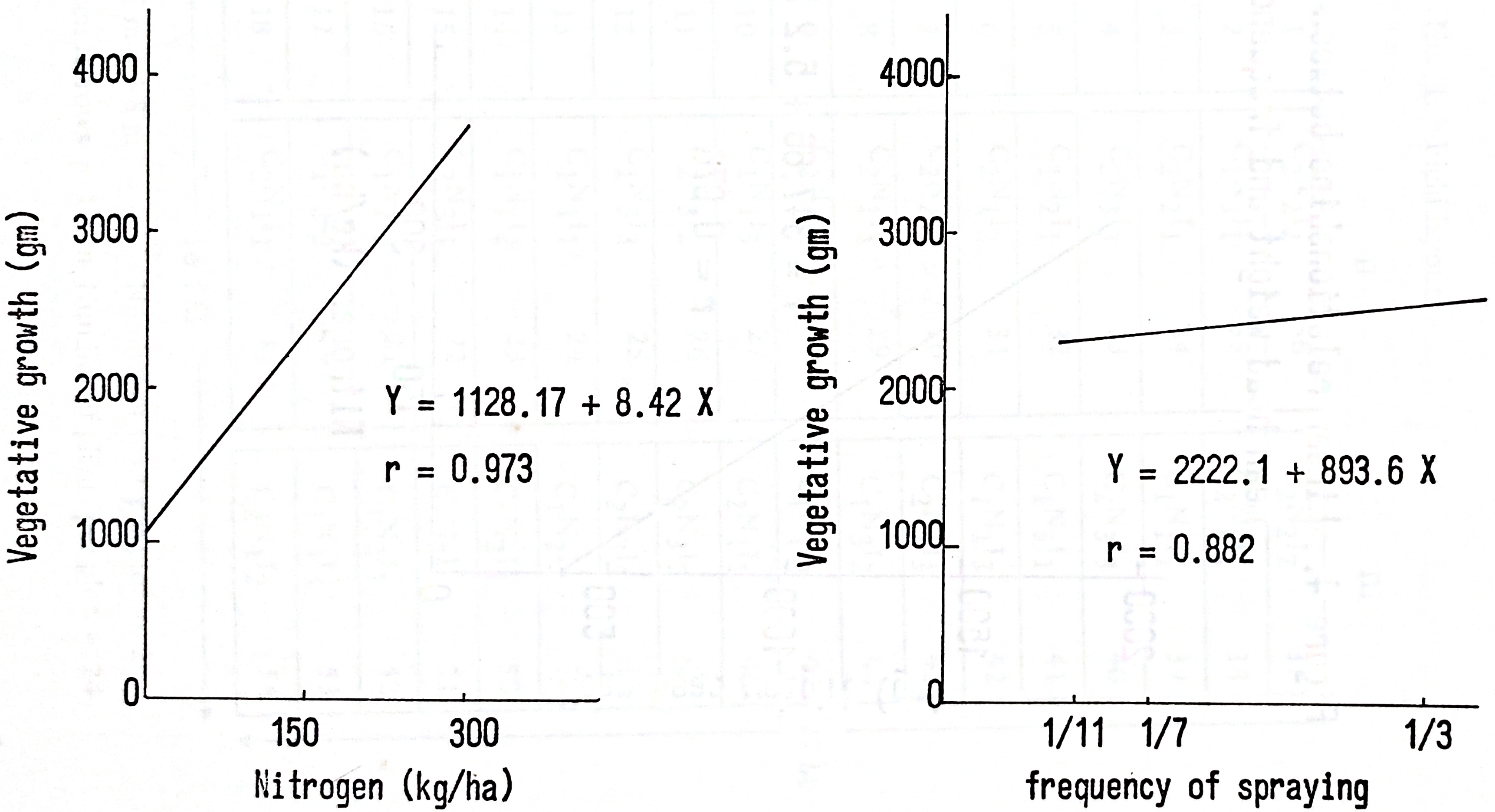
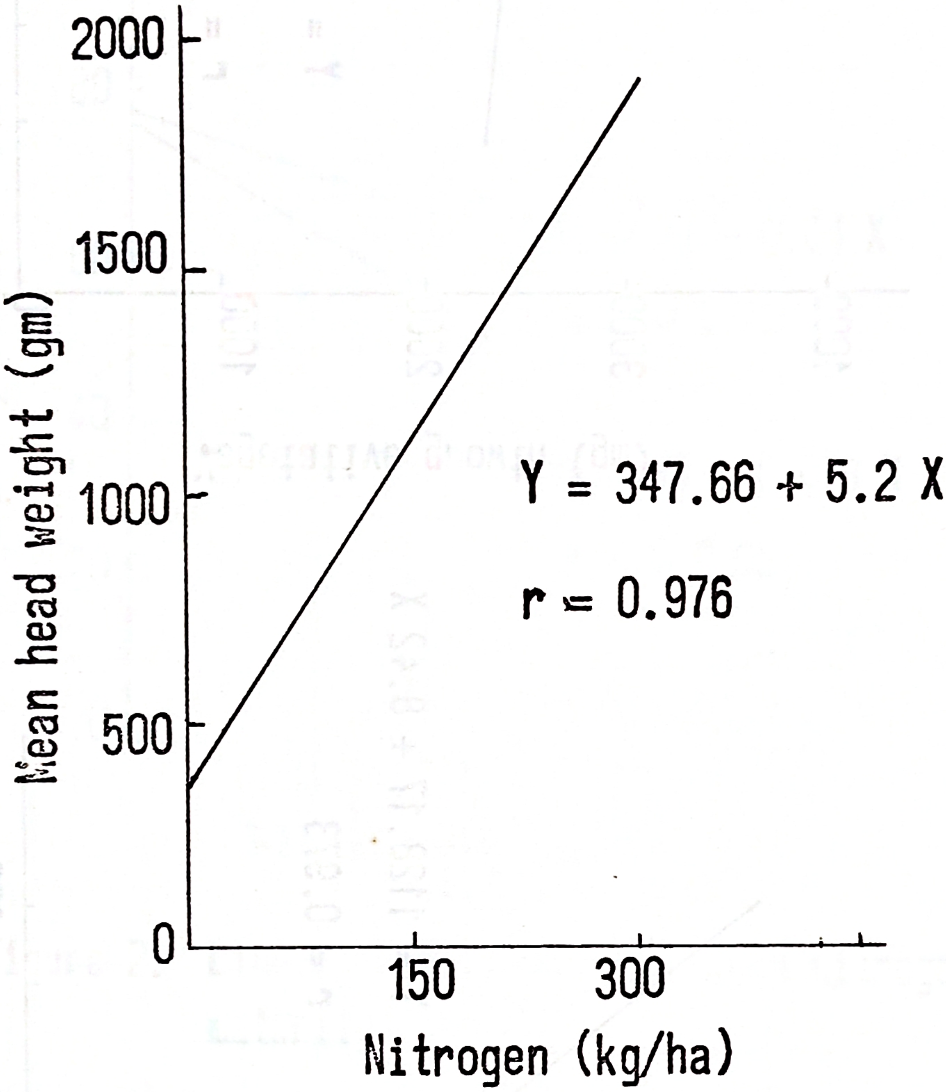


Figure 4. Linear relationships between mean mean head weight and frequency of



Appendix Figure No. 1. Field layout.

I		II		III	
$C_1N_3I_2$	1	$C_2N_2I_2$	36	$C_2N_2I_2$	37
$C_1N_1I_1$	2	$C_1N_3I_1$	35	$C_2N_2I_1$	38
$C_2N_3I_2$	3	$C_2N_2I_1$	34	$C_1N_1I_1$	39
$C_1N_2I_2$	4	$C_2N_3I_3$	33	$C_2N_3I_3$	40
$C_1N_1I_3$	5	$C_1N_2I_1$	32	$C_1N_3I_1$	41
$C_2N_1I_3$	6	$C_2N_1I_2$	31	$C_1N_1I_3$	42
$C_1N_2I_1$	7	$C_2N_2I_3$	30	$C_2N_1I_3$	43
$C_1N_2I_3$	8	$C_2N_1I_3$	29	$C_1N_3I_2$	44
$C_2N_3I_3$	9	$C_2N_3I_2$	28	$C_1N_1I_2$	45
$C_2N_2I_3$	10	$C_1N_1I_3$	27	$C_2N_1I_1$	46
$C_1N_1I_2$	11	$C_2N_3I_2$	26	$C_2N_3I_2$	47
$C_1N_3I_1$	12	$C_1N_3I_3$	25	$C_2N_3I_1$	48
$C_2N_2I_1$	13	$C_1N_1I_1$	24	$C_1N_2I_2$	49
$C_1N_3I_3$	14	$C_1N_1I_2$	23	$C_2N_2I_3$	50
$C_2N_2I_2$	15	$C_2N_3I_1$	22	$C_1N_2I_3$	51
$C_2N_1I_1$	16	$C_1N_2I_3$	21	$C_1N_2I_1$	52
$C_2N_1I_2$	17	$C_1N_2I_2$	20	$C_1N_3I_3$	53
$C_2N_3I_1$	18	$C_2N_1I_1$	19	$C_2N_1I_2$	54

27 M

16.4 M

Plot size = 1.5 m x 4.8 m Number of rows per plot = 2

Distance between furrows = 1.5 m Number of plants per plot = 24

Appendix Figure No. 2. Time Table of Activities

DAS	DATE	DAT	ACTIVITIES
0	Sept 14		Preparation of soil mixture in seed flats
0	Sept 15		Sowing of seeds and watering
2	Sept 17		Watering (germination of seeds)
8	Sept 23		Thinning, first (nursery) spraying
15	Sept 30		Second nursery spraying
21	Oct 6		Third nursery spraying
22	Oct 7		Land preparation for transplanting, basal fertilization and compost incorporation
23	Oct 8	0	Bed formation, herbicide application, transplanting and irrigation
24	Oct 9	1	Mulching rice straw
26	Oct 11	3	First spraying (I_1, I_2, I_3) insecticide & Dithane M-45
30	Oct 15	7	Second spraying (I_3)
31	Oct 16	8	First side dressing, irrigation
33	Oct 18	10	Fungicide spraying (Dithane M-45)
34	Oct 19	11	Second spraying (I_2) Third spraying (I_3)
37	Oct 22	14	First sampling on insect counts
38	Oct 23	15	Second spraying (I_1) Fourth spraying (I_3) Second side dressing, irrigation
40	Oct 25	17	Fungicide spraying (Dithane M-45)
42	Oct 27	19	Third spraying (I_2) Fifth spraying (I_3)
45	Oct 30	22	Hand weeding, irrigation
46	Oct 31	23	6th spraying (I_3)
47	Nov 1	24	Fungicide spraying Dithane (M-45)

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49	Nov 4	26	3rd spraying (I_1)
			4th spraying (I_2)
			7th spraying (I_3)
51	Nov 6	28	Third side dressing, irrigation
52	Nov 7	29	Second sampling on insect counts
53	Nov 8	30	Fungicide spraying (Dithane M-45)
53	Nov 8	30	8th spraying (I_3)
57	Nov 12	34	9th spraying (I_3)
			5th spraying (I_2)
58	Nov 13	35	Irrigation
60	Nov 15	37	Fungicide spraying (Dithane M-45)
61	Nov 16	38	4th spraying (I_1)
			10th spraying (I_3)
62	Nov 17	39	Third sampling on insect counts
65	Nov 20	42	11th spraying (I_3)
			6th spraying (I_2)
66	Nov 21	43	Fourth side dressing, irrigation
67	Nov 22	44	Fungicide spraying (Dithane M-45)
68	Nov 23	45	Fourth sampling on insect counts
69	Nov 24	46	12th spraying (I_3)
73	Nov 28	50	13th spraying (I_3)
			7th spraying (I_2)
			5th spraying (I_1)
			Irrigation
74	Nov 29	51	Fungicide spraying (Dithane M-45)
76	Dec 1	53	Fifth sampling on insect counts
77	Dec 2	54	14th spraying (I_3)
79	Dec 5	56	Irrigation
80	Dec 6	57	Fungicide spraying (Dithane M-45)
			15th spraying (I_3)
			8th spraying (I_2)
84	Dec 10	61	16th spraying (I_3)
			6th spraying (I_1)
89	Dec 15	66	Harvesting
			Data collection