FLOWERING AND FRUITSET IN TATASAI PEPPER (*Capsicum annuum* I.) AS INFLUENCED BY NITROGEN NUTRITION AND PLANT POPULATION

BY

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CERTIFICATION

This thesis entitled "FLOWERING AND FRUITSET IN TATASAI PEPPER (Capsicum Annuum L.) AS INFLUENCED BY NITROGEN NUTRITION AND PLANT POPULATION" by Miss Furera Isma, meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria and is approved for its contribution to scientific and literary presentation.

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I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous form for a higher degree.

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Dedicated to Improved Pepper
growing in Nigeria

ABSTRACT

Two trials were carried out (1907 dry and wet seasons) to study the influence of nitrogen and plant population on flowering, fruitset and subsequent yield of pepper (Capsicum nnnuum L.) using the variety L-5962-2.

The treatments were four levels of nitrogen (0,75,150 and 300 kg/ha) and four spacings of 15, 30, 45 and 60cm between plants within a row giving plants populations of 112500, 55200, 37500 and 20000 plants respectively. Spacing between all the rows was 60cm.

Results showed that during the dry season increasing nitrogen increased total number of leaves, number of leaves at first flowering, total percentage of fruits and percent fruitset, while number of flower buds aborted before anthesis decreased. During the same season, increasing plant population increased plant height and number of days to first flowering while percentage of flower buds aborted before anthesis decreased.

The wet season trial showed an increase in number of branches at maturity, number of leaves at first flowering, number of days to first flowering, and fruit per plant yield with increasing nitrogen and plant population. Number of flower buds aborted before anthesis, however decreased with the increase in plant population and nitrogen.

There were positive correlations between yield and such characters as total number of leaves and number of leaves at first flowering, number of branches, number of days to first fruitset, percent fruitset and total number of fruits, while percentage of flowers aborted before and after anthesis were negatively correlated with yield.

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Chapter 1

INTRODUCTION

1.1 History, Botany and Uses

Peppers are vegetable crops belonging to the family Solanaceae and genus Capsicum which are native to tropical America. The crop was carried to the East Indies and then to Europe and now it is spread widely over different regions of the world. In Nigeria, pepper is mainly grown around the Guinea Savannah ecological zone as a monocrop both during the wet and dry seasons under irrigation. Here, pepper is mainly grown by the peasant farmers on a commercial scale.

Pepper is a variable annual herb or sub-herb. It is generally woody at the base, erect, very much branched and the growth in height could be from 0.5 to 1.5m. It's growth habit is sympodial. The main stem is terminated by one or sometimes two flowers after a certain number of leaves have been formed. The branches subtended by the terminal flower are formed and the sympodial nature continues. After anthesis (opening of the flower), the flowers remain open 2 to 3 days before fruit -set. The fruit is an indehiscent, many seeded berry variable in size, degree of pungency and the way it is borne

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depending on the variety. Generally, the number of days from seeding to maturity ranges from 120 - 150 (Jessup, 1964). Harvest of first fruit is usually 6 - 10 weeks after planting and can remain in production for another 8 weeks (Anon., 1955).

The pepper plant requires a well distributed rainfall ranging from 600 - 1200mm (Purseglove, 1977) and a mean temperature ranging from 18 - 26 °C during its growing period (Ware and McCollum, 1975). Pepper does well on a sandy loam soil which holds moisture fairly well with optimum pH of 5.5 - 7.0.

Pepper is used in various ways especially as condiment and as an ingredient in stews. The green pepper is also used for stuffing. Capsaicin from pepper is also used in the pharmaceutical industry as a powerful stimulant (Purseglove, 1977). Thus, due to their various uses peppers are gradually increasing in popularity.

1.2 Production and Production Constraints

The total world production of pepper was 6,888,000 tonnes annually with an average yield of 7,329kg per hectare in 1980 (FAO, 1980). In the 1960s and early 1970s Nigeria used to be an exporter of peppers especially the "Funtua types" which were in great demand in the world market, but

pepper export declined drastically during the later part of the 1970s (Olarewaju, 1981). Now, pepper production is on an area of 77,000 hectares with an average yield of 9,125kg^{ha-1} and the total annual production has been estimated at about 695,000 metric tons (FAO, 1983). About 50% of the production comes from Funtua and Makarfi regions of Kaduna State (Erinle, I.D., personal communication).

Decline of pepper production has been attributed to many factors which include high temperature and rainfall (Villareal, 1978) and also susceptibility to diseases and pests which can cause as much as 45.7% fruit-drop (Opoku-Asiama et al., 1987. In nigeria, very little data are available on spacing and fertilizer requirements of pepper and since fertilizer and spacing reguirement vary from region to region and lack of proper application can cause reduction in yield, it was considered necessary to carry out the experiment to further enlighten pepper farmers locally on the requirements of pepper production.

The objectives of this research work thus, were to study the effects of different levels of nitrogen and different plant populations on the flowering, fruitset and yield of pepper (C.annuum L.).

Chapter 2

LITERATURE REVIEW

2.1 Flowering And Fruitset In Pepper

In the pepper plant, many flowers formed are aborted before anthesis or shed after anthesis, and even when the flowers are not shed many fail to set fruit. Nagaratnam and Rajamani (1963) and Mote et al. (1975) working in India reported that the percentage of flowers produced per plant was 11%. Gopalaratnam (1933) reported 6% while Warade and Singh (1977) reported 5%. However, Purseglove (1977) reported 40 - 50% fruitset. Production of a good flower which will quickly develop into a fruit requires a strong-growing plant, as weak vegetative growth results in the production of small blooms which either abort or develop slowly into small, poor-shaped peppers (Smith 1980). This balance between plant vigour and fruit development is controlled by certain factors which include nitrogen fertilization and plant population. However, very little literature is available in this country on the effects of these two factors on the flowering and fruitset of peppers.

2.2 Effect of Nitrogen On Flowering, Fruitset And Yield Of Pepper

Nitrogen is very important for growth and production of pepper. It is a constituent of protein, enzymes and

many metabolic intermediates involved in synthesis and energy transfer. According to Noroa and Loomis (1981), in the field, both growth rate and tissue composition of plants in general will vary with nitrogen, water supply, plant competition and other environmental factors. Cochran (1936) stated that in general, pepper plants that received relatively high nitrogen treatment set significantly higher percentage of blossoms than did plants receiving low nitrogen. Also, leaves are retained longer and fewer flower buds and fruits are shed (Addicott and Lynch, 1955). In some species nitrogen also led to delayed flowering (Frank, 1965).

Very little data are available in Nigeria on the influence of nitrogen on pepper flowering and fruitset. In 1977, Addae-Kagya and Norman working with eggplants which also belong to the family solanaceae showed that high nitrogen (about 90^{kgha-1}) greatly increased vegetative growth, but showed no significant effect on flowering, fruitset and subsequent yield. Thomas and Heilman (1964)' also showed that applying nitrogen beyond 134^{kgha-1} reduced yield of peppers while Ozaki and Ozaki (1955) and Ozaki and Ray (1957) reported reductions in yield with nitrogen applied at 400^{kgha-1}. Apparently, the higher rates resulted in more vegetative growth at the expense

of fruitset and fruit growth. Plant height in pepper has also been shown to be directly related to nitrogen levels (Maynard et al., 1962).

Several workers have shown an increase in yield with increasing nitrogen levels up to a limit which varied from one environment to another. This increase could be attributed to enhanced flowering and fruitset as shown by Cochran (1932) and Maynard et al. (1962). While Patil (1976) reported that nitrogen at between 33.4 and 50.1 $^{kgha-1}$ increased the early yields of single stemmed pepper plants, Cuocolo (1967), Khan and Suryanarayana (1978) and Ramachandran and Subhail (1981) all showec that the best results as regards yields were obtained at 120 $^{kgha-1}$. According to them the increase was due to increased number of shoots and fruits per plant. Ramachandran and Subhail (1981) also showed an increase in the weitht of 100 fruits; while Cuocolo (1967) showed that the average fruit size remained unchanged with the various nitrogen levels. Sinha (1975) obtained highest yields at 105 $^{kgNha-1}$ applied at the transplanting and fruit-setting stage. While Covarelli (1976) showed an increase in fruit weight and number at 200 $^{kgha-1}$ nitrogen and (as opposed to Covarelli's [redacted] results) any further increase to 224 $^{kgha-1}$ provided only a small

increase in yield. Kaniszewski et al. (1987) showed that under irrigation nitrogen up to 225^{kgha-1} resulted in increased total and marketable yields, whereas without irrigation the yield increased only with nitrogen up to 150^{kgha-1}.

2.3 Effect of Plant Population On Flowering, Fruitset and Yield Of Pepper

As in the case of nitrogen, information is scanty on the effect of plant population on flowering, fruitset and yield of pepper. In general, it affects growth of plants, if too closely spaced, competition occurs between plants for water, nutrients and sunlight (Topoleski, 1967). Mezhunts (1979) showed that close spacing reduced leaf size and number, decreased photosynthetic productivity and diminished dry weight in capsicums. Optimum spacing with regards to high yields was given as 8 plants^{m-2}. Wider spacing in peppers do not necessarily result in lower yields (Smith, 1980), but yield per plant has been shown to be greatly reduced when the number of plants per unit area is increased even though the yield per unit area may increase. In tomatoes for example, this is due to the modification of its fruiting ability (Gerard and Cowley, 1964). Apart from the reduction in the number of fruits per plant, higher population was also associated with reduction in the average fruit weight per

plant (Vittum and Tapley, 1953; Moor et al. , 1958). Pevna (1979) also found a positive correlation between stand density and yield but a negative one between stand density and individual plant production in peppers, but there was no marked influence on fruit weight. Rajewar and Patil (1979) working with three cultivars spaced at 45 x 30, 45 x 45 and 60 x 60cm showed that spacing had no effect on flower number per plant, but fruit number per plant was highest at the widest specing for two of the cultivars.

Recommended spacings for pepper include 60cm between rows and 45cm within rows (Anon, 1955) and 76 - 107cm between rows and 45cm within rows (Jessup, 1964). Attempts to increase fruit yield by raising plant population have not given clear, consistent result; Ozaki 1962) obtained highest yields at 8cm spacing within rows while Sinha (1975) obtained the best yields at the closest spacing of 20x20cm compared to 20x30cm and 40x40cm. Patil and Vijay (1979) reported that mean yield of ripe pepper fruits increased when the spacing was reduced from 45 x 60cm to 30 x 30cm. Joshi et al. (1980) also obtained the best fruit yields in tomatoes at 30 x 30cm spacing. Chougoule and Mahajan (1979) and Rastogi et al. (1980) reported highest yields at spacings of 30 x 45 and 45 x 45cm respectively.

Metalwally et al. (1982) obtained best results with regards to yield at 30 x 60cm, but the different treatments had no significant influence on individual fruit weight.

Ramachandran and Subhail (1981) also showed decreased number of shoots and fruits per plant with increased plant density and obtained highest yields of fruits from plots with plants spaced at 30 x 20cm receiving 120^{kgha-1} nitrogen. Fawusi (1977) obtained best yields of tomatoe fruits with two doses of NPK applied at two weeks after transplanting and at fruitset with the plants spaced at 45.5 x 122cm or 30.5 x 91cm while Rastogi et al. (1979) obtained best yields of garden eggs at either 45 x 30 or 60 x 30cm spacing receiving 45^{kgha-1} nitrogen.

Chapter 3

MATERIALS AND METHODS

The experiment was conducted during the 1987 dry season at the IAR irrigation site and 1987 rainy season at the I.A.R. Horticultural Field Unit, Samaru which is located on Latitude 11°11'N, Longitude 07°38'E and is 686m above sea level. The soil of the experimental fields is a well-drained sandy loam. Data on the physico-chemical properties of the soils are given in appendix A.

3.1 Treatments and Experimental Design

The treatments composed of four levels of nitrogen (0,75,150 and 300^{kgha}) and four intra-row spacings (15, 30, 45 and 60cm) giving projected plant population densities of 112500. 55200, 37500, 28000 per hectare respectively, using the variety L-5962-2 (Average plant height is 27.05cm, with single flowers borne in the axils. The fruit is globuse and red when mature, average fruit weight is 19.5g, with average length and diameter being 5.5 and 4.12cm, respectively. Fruits are borne erect on the pedicel). The experimental design used was Randomized complete Block Design (RCBD) replicated three times during the dry season and 4 times during the wet season.

3.2 Field Operations

The experimental sites were ploughed and harrowed to

obtain a good tilth and made into ridges 60cm apart. Before ridging basal applications of 30 kg /ha P_2O_5 (single superphosphate) and 70kg/ha K_2O (muriate of potash) were made.

Nitrogen application; The plants were topdressed with split doses 10 and 20 days after transplanting. Calcium ammonium nitrate (26&N) was used as the source.

The Nursery plot was thoroughly tilled before beds were prepared. Healthy pepper seeds were drilled in the beds at rows 15cm apart. They were then mulched and watered regularly. After germination, the mulch was removed and placed in between the rows of seedlings. The seedlings were kept weed-free and five weeks after sowing they were transplanted in the field.

Transplanting was done on ridges in February 1987 for the dry season and July 1987 for the wet season. This was done when the field was moist and only healthy and uniform seedlings were transplanted.

Weeding was done forthnightly starting from two weeks after transplanting until the plants had reached maturity. The plants were sprayed with Cymbush (Cypermethrin - 50 mls in 10L of water) against insect infestation weekly and fortnightly during the wet and dry seasons respectively.

Harvesting of fruits started 15 and 10 weeks after transplanting during the dry and wet seasons respectively and this was done at five day intervals. At each harvest ripe fruits were hand-picked by twisting off to detach fruit from the stem.

3.3 Data Collection

Meteorological data on temperature, humidity, pan-evaporation and hours of sunshine were recorded for the period of the experimentation and these are shown in Appendix B.

Assessment of Plant Characters: This was started one week after transplanting. Five plants of the same size were selected from each plot and tagged for the purpose. Data on the following characters were obtained;

Growth Characters

1. Plant height (cm)
2. Total number of leaves
3. The two characters above were measured every three weeks.)
4. Number of leaves at first flowering.
5. Number of days to first flowering.
6. Number of days to first fruitset.
7. Number of days to maturity.

Yield Components and Yield

1. Total number of flowers.
2. Percent flower buds aborted before anthesis.
3. Percent flowers aborted after anthesis.

(The three characters above were taken every four days.)

4. Percent fruitset ie $\frac{\text{No. of fruits}}{\text{No of flowers}} \times 100$
5. Fruit weight (all fruits per plant at each harvest were measured and the total averaged).
6. Total number of fruits per plant.
7. Yield - This was taken as the cumulative fresh weight of the total number of fruits per plant (kg/plant).

3.4 Statistical Analysis

Data collected were analysed statistically (using Anova) to test treatment effects using the F test as described by Shedecor and Cochran (1967). Means of the effects of plant population and nitrogen were compared using Duncan's Multiple Range Test (Duncan, 1955).

Chapter 4

RESULTS

4.1 Growth Characters

4.1.1 Plant height

With the dry season trial there was a significant increase in plant height with increasing plant population from 55200 to 28000 plants^{ha-1} and a non-significant one during the wet season (Table 1). Nitrogen had a significant effect on plant height during the wet season. Plant height was significantly higher at 75$^{kgNha-1}$ than at either 0 or 300^{kgha-1} which were statistically the same.

4.1.2 Number of leaves at first flowering

In the dry season trial plant population had no significant effect on the number of leaves at first flowering (Table 2). However, in the wet season, with each increase in plant population number of leaves increased significantly, the difference between 55200 and 37500 plants populations however being non-significant.

Nitrogen in both seasons influenced the number of leaves at first flowering, increasing the number significantly with each increase in level except from 0 to 75^{kgha-1} which was not significant during the dry season.

4.1.3. Total number of leaves

In both trials plant population had no significant influence on number of leaves (Table 3).

However, nitrogen influenced number of leaves as the levels were increased during the wet season, the 0 level nitrogen being significantly lower than the other levels which were statistically the same. In the dry season 300^{kgha-1} nitrogen significantly produced more leaves than all the other levels which did not differ statistically.

4.1.4 Number of Branches at Maturity

Neither plant population nor nitrogen had any significant influence on the number of branches at maturity during the dry season (Table 4).

In the wet season the plant population of 37500 plants^{ha-1} which was at par with 55200 and 28000 plants^{ha-1} was significantly higher than 112500 plants.$^{ha-1}$ With nitrogen, 150^{kgha-1} significantly produced the highest number of branches followed by 75^{kgha-1}. The 0 level of nitrogen significantly produced the lowest number of branches.

4,1.5 Number of days to first flowering

In the two seasons both plant population and nitrogen influenced the number of days to first flowering significantly (Table 5). During the dry season flowering was delayed significantly more at 38000 plants^{ha-1} than at 112500 plants, but statistically the same at 55200 and 37500 population. With regards to nitrogen, 150 and 300^{kgha-1} which did not differ statistically led to increased number of days to first

Flowering more than 0 and 75^{kgha-1}. In the wet season, flowing was significantly earlier in the 112500^{ha-1} plant population than in either the 37500 or 2800 populations and with each increase in nitrogen level flowering was significantly delayed, the differences between 0 and 75^{kgha-1} and 75 and 150^{kgha-1} being non-significant.

4.1.6 Number of days to first fruitset

There was a non-significant increase in number of days to first fruitset with increasing plant populations in both trials and with nitrogen in the dry season trial (Table 6(. However, number of days to fruitset was delayed with increasing nitrogen during the wet season; number of days to first fruitset was significantly more at 300^{kgha-1} than at the 0 level, but was statistically at par with 150^{kgha-1}. There was also no significant difference between the 0 and 75^{kgha-1} levels of nitrogen.

4.1.7 Number of days to maturity

The dry season trial was not influenced significantly by either the different populations or nitrogen levels (Table 7) However, plant population influenced the number of days to maturity in the wet season significantly; 112500, 55200 and 37500 plants^{ha-1} which were statistically the same were significantly higher than 28000 plants^{ha-1}. Maturity was delayed with increasing nitrogen levels as is shown on the

table. The 300^{kgha-1} level which was however significant delayed maturity more than the 0 level of nitrogen.

4.2 Yield Components and Yield

4.2.1 Total number of flowers

In the dry season both plant population and nitrogen levels did not have a significant influence on the total number of flowers (Table 8). In the wet season however, the highest number of flowers was obtained at the 37500 plants^{ha-1} followed by 28000 plants^{ha-1} which was not significantly different from the 112500 and 55200 plants^{ha-1}.

With nitrogen, 150^{kgha-1} produced the highest number of flowers. This was significantly higher than 75 and 300^{kgha-1} nitrogen which were statistically the same. The 0 level of nitrogen produced significantly the lowest number of flowers.

4.2.2 Percent flower buds aborted before anthesis

In both trials increasing plant population and nitrogen levels significantly reduced the percentage of flower buds aborted before anthesis (Table 9). However, in both seasons the difference between 55200 and 37500 plants^{ha-1} was not significant.

4.2.3 Percent flowers aborted after anthesis

The dry season trial was not significantly influenced by both plant populations and nitrogen (Table 10). However, 112500 plants^{ha-1} significantly produced the lowest percentage

of flowers aborted after anthesis during the wet season. The 55200, 37500 and 28000 plants^{ha-1} populations were not different significantly.
Nitrogen at 150^{kgha-1} which was statistically the same as 75^{kgha-1} produced the highest percentage of flowers aborted and the 300^{kgha-1} nitrogen level which was statistically the same as the 0 level produced the lowest percentage.

4.2.4 Total number of fruits

In both seasons number of fruits was not significantly influenced by plant population (Table 11). Nitrogen however, increased number of fruits significantly with increasing levels. In both seasons the 0 and 75^{kgha-1} nitrogen levels were significantly the same while the 150 and 300^{kgha-1} levels also did not differ statistically. The 75 and 150^{kgha-1} levels were also statistically the same.

4.2.5 Percent fruitset

Plant population did not significantly influence percent fruitset in both seasons, but in the dry season nitrogen significantly increased the number of flowers that set fruit with 300^{kgha-1} being higher than 0, 75 and 150^{kgha-1} which were not significantly different (Table 12). In the wet season percent fruitset was significantly higher at 300^{kgha-1} while the 75 and 150^{kgha-1} levels dis not differ

significantly. Percent fruitset was significantly lowest when no nitrogen was applied to the plants, the difference between the 0 and 75^{kgha-1} levels being non-significant.

4.2.6 Fruit fresh weight

Plant population had no significant influence on the average fresh weight of fruits (Table 13). Though nitrogen did not influence fresh weight of fruits during the dry season, in the wet season weight increased with increasing nitrogen, the 0 level being significantly lower than the other levels which did not differ significantly.

4.2.8 Fresh fruit yield

In the dry season neither plant population nor nitrogen had a significant influence on yield even though there was an increase with increasing nitrogen (Table 14). The wet season trial was not affected significantly by plant population either, but significantly increased yield with each increase in nitrogen.

4.3 Correlation

Correlation coefficient analysis was carried out to determine relations between growth characters, yield components and yield of pepper.

4.3.1 Dry Season

The growth characters such as total number of leaves and number of leaves at first flowering were positively

and significantly correlated to yield while number of days to first fruitset and number of days to maturity were negatively and significantly correlated to yield (Table 15). There was no correlation in plant height and number of branches at maturity with yield. The yield components - total number of flowers, total number of fruits and percent fruitset were positively and significantly correlated to yield while percentage of flowers aborted before and after anthesis were negatively correlated to yield. There was no correlation in fruit fresh weight with yield.

4.3.2 Wet Season

Significant positive correlations were obtained between yield and growth characters such as total number of leaves, number of branches at maturity and number of days to first flowering (Table 16). Plant height gave a significant negative correlation with yield. Yield components such as total number of fruits, percent fruitset and fruit fresh weight were positively and significantly correlated to yield. However, the percentage of flowers aborted before and after anthesis were negatively correlated to yield. There was not correlation in number of days to first fruitset and total number of flowers to yield.

Table 1: Effect of plant population and nitrogen on plant height of pepper variety L-5962-2 during the 1987 dry and wet seasons at Samaru.

Treatment	Plant Height (cm)	
Plant population ha^{-1} (cm)	Dry Season	Wet Season
112,500 (15)	27.9b	25.3
55,200 (30)	27.9b	25.0
37,500 (45)	28.8ab	24.8^{ns}
28,000 (60)	31.4a	23.9
SE	6.33	3.24
Nitrogen kgha)		
0	27.9	23.4b
75	28.2	27.0a
150	29.4	25.0ab
300	31.3	24.5b
SE	2.69	3.51

Means followed by the same letter(s) within a treatment are noted significantly different at 5% level of significance using DMRT.

Table 2: *Effect of Plant Population and nitrogen on the number of leaves at first flowering of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.*

Treatment	Leaves at first flowering	
Plant Population ha-1 (cm)	Dry Season	Wet Season
112500 (15)	36.8	22.1c
55200 (30)	35.5	26.4b
37500 (45)	40.0^{ns}	26.6b
28000 (60)	38.5	29.7a
SE	2.09	6.22
Nitrogen (Kg/ha)		
0	29.0c	15.4d
75	31.4c	22.8c
150	42.0b	26.9b
300	48.3a	40.1a
SE	15.71	20.70

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 3: Effect of plant population and nitrogen on total number of leaves of pepper (variety 1-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Total number of leaves	
Plant Population ha-1	(cm)	Dry Season	Wet Season
112500	15	105.3	44.1
55200	30	104.9	52.3
37500	45	103.8^{ns}	48.6^{ns}
28000	60	120.3	49.7
SE		13.64	6.8
Nitrogen (Kg/ha)			
0		87.7b	40.1b
75		107.1b	54.0a
150		150.6b	49.6a
300		133.9a	51.0a
SE		33.00	11.89

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 4: Effect of plant population and nitrogen on the number of branches of pepper (variety L-5962-2) at maturity during the 1987 dry and wet seasons at Samaru.

Treatment		Number of branches	
Plant Population ha^{-1}	(cm)	Dry Season	Wet Season
112500	15	30.9	20.9b
55200	30	33.7	24.6ab
37500	45	39.1^{ns}	29.9a
28000	60	33.6	27.1ab
SE		5.94	7.58
Nitrogen (kg/ha)			
0	32.6	32.6	18.6c
75		36.7	27.6ab
150		37.0^{ns}	31.8a
300		31.0	24.6bc
SE		5.17	11.04

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significant using DMRT.

Table 5: Effect of Plant population and nitrogen on number of days to first flowering of pepper variety L-5962-2 during the 1987 dry and wet seasons at Samaru

Treatment		Days to first flowering	
Plant population ha-1		Dry Season	Wet Season
	(cm)		
112500	15	97.1b	74.4c
55200	30	99.9ab	73.3bc
37500	45	99.9ab	76.2a
28000	60	101.6a	76.1ab
SE		3.23	2.83
Nitrogen (kg/ha)			
0		93.8b	72.3c
75.		97.5b	73.7b
150		105.0a	75.5b
300		104.27a	78.4a
SE		8.43	5.34

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 6: Effect of plant population and nitrogen on the number of days to first fruitset of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Days to first fruitset	
Plant Population	(cm)	Dry Season	Wet Season
112500	15	107.3	77.9
55200	30	107.5	78.3
37500	45	110.8^{ns}	79.7^{ns}
28000	60	108.3	80.4
SE		2.80	2.38
Nitrogen (kg/ha)			
0		111.3	79.5
75		107.1	78.5
150		106.7^{ns}	77.7ab
300		109.3	80.6a
SE		3.49	2.47

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 7: Effect of plant population and nitrogen on number of days to maturity of pepper (variety L-5962-2) during the dry and wet seasons at Samaru.

Treatment		Day to maturity	
Plant population ha^{-1}	(cm)	Dry Season	Wet Season
112500	15	143.8	114.8a
55200	30	144.0	114.7a
37500	45	142.9^{ns}	115.3a
28000	60	144.1	110.4b
SE		0.93	4.51
Nitrogen (kg/ha)			
0		143.3	111.9b
75		145.3	114.1ab
150		143.2^{ns}	112.9ab
300		143.2	116.3a
SE		1.78	3.78

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 8: Effect of plant population and nitrogen on the total number of flowers of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Total number of flowers	
Plant Population ha^{-1}	(cm)	Dry Season	Wet Season
112500	15	26.5	21.8b
55200	30	22.5	21.9b
37500	45	26.2^{ns}	25.6a
28000	60	22.3	23.3ab
SE		3.93	3.54
Nitrogen (kg/ha)			
0		20.8	19.5c
75		26.3	23.1b
150		25.4^{ns}	27.3a
300		25.0	22.7b
SE		4.30	6.41

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 9: Effect of plant population and nitrogen on the percentage of flower buds of pepper (variety L-5962-2) aborted before anthesis during the 1887 dry and wet seasons at Samaru.

Treatment		Flower buds aborted before anthesis %	
Plant population	(cm)	Dry Season	Wet Season
112500	15	36.6a	34.9a
55200	30	24.4b	28.5b
37500	45	21.8b	21.6c
28000	60	15.3c	21.8c
SE		14.2	12.7
Nitrogen (kg/ha)			
0		61.15a	51.8a
75		21.17b	35.1b
150		14.17c	11.8c
300		9.2c	8.0c
SE		33.1	41.2

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 10: Effect of plant population and nitrogen on the percentage of flowers of pepper (variety L-5962-2 aborted after anthesis during the 1987 dry and wet seasons at Samaru.

Treatment		Flowers aborted after anthesis %	
Plant population	ha-1	Dry Season	Wet Season
	(cm)		
112500	15	65.7	76.8b
55200	30	72.4^{ns}	78.1a
37500	45	77.5	75.9a
28000	60	76.7	73.7a
SE		5.9	3.7
Nitrogen (kg/ha)			
0		74.0	86.5c
75		77.2	80.8c
150		69.3^{ns}	73.5b
300		70.0	63.8a
SE		14.1	19.6

Table 11: Effect of plant population and nitrogen on the total number of fruits of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Number of fruits	
Plant population ha-1		Dry Season	Wet Season
	(cm)		
112500	15	5.0	5.3
55200	30	4.2	4.9
37500	45	5.7^{ns}	5.3^{ns}
28000	60	4.1	6.2
SE		1.30	1.07
Nitrogen (kg/ha)			
0		3.3b	2.6c
75		4.2b	4.4c
150		4.9ab	6.50ab
300		6.5a	8.2a
SE		2.33	4.86

Means followed by the same letter(s) within a treatment are not significantly different at 5% level of significance using DMRT.

Table 12: Effect of plant population and nitrogen on percent fruitset of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Fruitset (%)	
Plant population ha-1	(cm)	Dry Season	Wet Season
112500	15	21.5	22.6
55200	30	19.3	22.4
37500	45	19.8^{ns}	20.4^{ns}
28000	60	19.5	26.5
SE		2.42	5.08
Nitrogen (kg/ha)			
0		15.4b	13.5c
75		18.1b	19.1bc
150		19.8b	23.7b
300		29.1a	35.7a
SE		10.31	18.89

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 13: Effect of plant population and nitrogen on fresh weight of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru

Treatment		Fruit fresh weight (g)	
Plant population		Dry Season	Wet Season
	(cm)		
112500	15	6.]	23.5
55200	30	6.2	23.9
37500	45	5.8^{ns}	26.4^{ns}
28000	60	6.1	27.2
SE		0.32	3.62
Nitrogen (kg/ha)			
0		6.2	20.0b
75		5.7	25.0
150		5.5^{ns}	27.4a
300		6.6	28.6a
SE		0.82	7.63

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

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Table 14: Effect of plant population and nitrogen on the yield of pepper (variety L-5962-2) during the 1987 dry and wet seasons at Samaru.

Treatment		Yield (kg/Plant)	
Plant Population	(cm)	Dry Season	Wet Season
112500	15	0.03	0.1
55200	30	0.03	0.12
37500	45	0.03^{ns}	0.16^{ns}
28000	50	0.02	0.18
SE		0.01	0.1
Nitrogen (kg/ha)			
0		0.02	0.05d
75		0.03	0.11c
150		0.03^{ns}	0.18b
300		0.05	0.24a
SE		0.02	0.03

Means followed by the same letter(s) within a treatment are not different significantly at 5% level of significance using DMRT.

Table 15: Correlation of yield, yield components and various growth characters of pepper during the 1987 dry season at Samaru.

Yield	1.0000												
Plant height	-0.0426	1.0000											
Total number of leaves	0.8343**	0.2232	1.0000										
Branches at maturity	-0.0039	0.1613	0.0902	1.0000									
Leaves first flowering	0.5366**	-0.3321	0.2099	0.0265	1.0000								
Days to first flowering	0.1583	-0.0697	0.3110.	-0.0179	0.5558.	1.0000							
Days to first fruitset	-0.2347	0.0253	-0.0596	0.1034	0.0873	0.2425	1.0000						
Days of maturity	-0.7323**	-0.0887	0.0586	-0.3233*	-.1222	0.0567	-0.0105	1.0000					
Total number of flowers	0.4107**	0.1185	0.0431	0.7358**	0.01012	0.0899	-0.3432	-3.3432	1.0000				
Total number of fruits	0.8967**	0.2194	0.2596	0.0623	0.4428**	0.2692	0.0650	-0.0998	0.3419*	1.0000			
% Fruitset	0.7405**	0.1217	0.2132	-0.4149	0.3833**	0.3483.	0.0472	0.2294	-0.3437*	0.6812	1.000		
Fruit fresh weight	0.0027	0.6674**	0.1977	0.0533	0.0662	-0.0220	0.0795	-0.0231	0.0057	0.2057	0.2015	1.0000	
Flower buds aborted before anthesis	0.3596*	-0.1230	-0.3554*	-0.0198	-0.4211**	-0.6310**	0.0941	-.0735	0.2090	-0.1894	-0.2919*	-0.1314	1.0000
Flowers aborted after anthesis	0.3637	0.0704	0.0869	0.6529..	-0.0681	-0.1033	-0.0377	-0.3200	0.8650**	0.2341	-0.3853**	-0.0025	0.0529	1.0000

*Significant at 5% Level for probability.

*Significant at 1% level of probability.

Fresh fruit yield
Plant height
Total numbers of leaves
Branches at maturity
Leaves at first flowering
Days to first flowering
Days to first fruitset
Days to maturity
Total number of flowers
Total number of fruits
% Fruitset
Fruit fresh wet
Flower buds aborted before anthesis
Flowers aborted after anthesis

Table 16: Correlation between yield, yield components and various growth characters of pepper during the 1987 wet season at Samaru

	Fresh fruit yield	Plant height	Total number of leaves	Branches at maturity	Leaves at first flowering	Days to first flowering	Days to first fruitset	Days to maturity	Total number of flowers	Total number of fruits	% fruitset	Fruit fresh wgt	Flowers aborted before anthesis	Flowers aborted after anthesis
Fresh fruit yield	1.0000													
Plant height	-0.5632	1.0000												
Total number of leaves	0.2988	0.6705**	1.0000											
Branches at maturity	0.3866**	0.3232**	0.4644**	1.0000										
Leaves at first flowering	0.8565**	-0.274	-02548*	0.1760	1.0000									
Day to first flowering	0.7516**	-0.1705	-0.0290	0.1581	0.5561*	1.0000								
Day to first fruitset	0.1987	-0.3798**	-0.2599	-0.2148	0.1999	0.7086**	1.0000							
Day of maturity	0.2849*	0.1333	0.0826	0.1380	0.2249	0.1235	0.0281	1.0000						
Total number of flowers	0.0232	0.1062	0.1972	0.7320**	0.1803	0.2716*	-0.0469	0.0220	1.0000					
Total number of fruits	0.9709**	0.0149	0.2212	0.4103**	0.6425	0.5021	0.0603	0.1381	0.4789**	1.0000				
% Fruitset	0.9272**	0.0035	0.2144	0.2161	0.0671**	0.4642**	0.0830	0.1200	0.1596	0.9311**	1.0000			
Fruit fresh weight	0.8172**	0.2805*	0.3936**	0.4404**	0.3501**	0.3264**	-0.0103	0.1983	0.1983	0.2928**	0.4835**	1.0000		
Flower buds aborted before anthesis	-0.8316**	0.1472	-0.1533	-0.2911*	-0.7595**	-.5566**	-0.0939	-0.1972	0.3330	-0.6716**	-0.6210**	-0.3423**	1.0000	
Flowers aborted after anthesis	-0.3398**	0.1373	0.0270	0.4548**	0.2495**	-0.0705	-0.0811	-0.0520	0.6515**	-0.2352*	-0.4846**	-0.0535	-0.1463	1.0000

*Significant at 5% level of probability.

*Significant at 1% level of probability.

Chapter 5.

DISCUSSION

5.1. Effect of Plant population

Generally, during the dry season plant population had no significant influence on most of the growth characters except plant height and number of days to first flowering which increased with increasing spacing. The same was observed of the yield components except for number of flower buds aborted before anthesis. However, during the wet season trial growth characters such as number of branches at maturity, number of leaves at first flowering, number of days to maturity and yield components such as total number of flowers, number of flower buds aborted before and flowers aborted after anthesis were all significantly influenced by spacing.

Effect of plant population During the Dry Season

The increase in plant height and number of days to first flowering with increasing plant population is probably due to less competition between the plants for nutrients (notably nitrogen), water and sunlight. It has been shown by Mezhunts (1979) that dense plant population reduced leaf number, decreased photosynthetic productivity and diminished dry weight in capsicums. Number of flower buds aborted before anthesis increased as spacing decreased.

This is probably because there was a modification of the fruiting ability of the peppers to enable them get enough nutrients considering the suggestion of Murfet (1977) who said flower and fruit abscission occurs until the number of fruits matches the resources available for fruit and seed production. The non-significant influence of plant population on flower number per plant and fruit weight agreed with findings of Palevitch (1969), Rajewar and Patil (1979) and Metalwally et al. (1982) respectively who showed spacing effects as non-significant on those characters.

Effects of Plant population During Wet Season

An increase in growth characters such as number of branches at maturity, number of leaves at first flowering, number of days to first flowering and number of days to maturity indicates that vegetative growth was to some extent increased with increasing plant population. As has already been suggested, the more dense the population, the more the competition between plants for water, nutrients and sunlight and so plants spaced wide apart had sufficient resources. That is probably also why number of days to flowering and maturity were delayed. With regards to yield components and yield the 37500 plants ha^{-1} produced the highest number of flowers followed by the 7 000 plants ha^{-1}. With initial vigorous growth there is more branching and this leads to

more flowering and healthier fruits. The abortion of more flower buds before anthesis at the lower spacings and less flowers after anthesis agrees with the suggestion that closer populations modifies the fruiting ability of the plants is modified to enable it support a good crop.

5.2. Effects of Nitrogen

During the dry season nitrogen had a significant influence on total number of leaves, number of leaves at first flowering, number of days to first flowering and yield components such as number of flower buds aborted before anthesis, total number of fruits and percent fruitset. Nitrogen effect was greater in the wet season trial where all characters assessed were significantly affected by nitrogen.

The results obtained for the growth parameters agreed with findings of various workers such as Maynard et al. (1962) who showed that plant height is directly related to nitrogen levels. Also, there is generally more vegetative growth (Frank, 1965) and leaves retained longer on the shoot as can be seen with the increase in number of branches and leaf area as nitrogen increases.

Nitrogen is required for plant growth and production and as has been suggested by Noroa and Loomis (1981), both growth rate and tissue composition vary with nitrogen amongst other factors. The shorter plant height and fewer

number of branches at maturity at 300$^{kaNha-1}$ obtained during the wet season can be attributed to the fact that increase in vegetative growth with increasing nitrogen is only up to a certain limit which varies. Nitrogen significantly influenced number of leaves at first flowering, number of days to first fruitset (during the wet season) and number of days to maturity and increase in these characters with increasing nitrogen may be due to delay flowering (as a result of more initial vegetative growth and this corresponds to findings of Frank (1965) above. The influence of nitrogen on the total number of flowers, total number of fruits, percent fruitset, fruit fresh weight and yield by increasing these characters with increasing levels indicates that fewer flower buds are shed, and flowering and fruitset enhanced and as shown by some workers such as Covarelli (1976), Khan and Suryanarayana (1978) and Ramachandran and Subhail (1981) this could be due to increased number of shoots and fruits per plant. Total number of flowers during the wet season is seen to be lower as 300^{kgha-1} than at 150^{kgha-1}; excess nitrogen can delay flowering, with more vegetative growth at the expense of flowering, and this has been shown by various workers such as Ozaki and Ray (1957). Increasing nitrogen decreased number of flower buds aborted before and flowers aborted after anthesis. Cochran (1936) showed that

peppers receiving relatively high nitrogen set significantly more blossoms. This also agrees with findings of Addicott and Lynch (1955). As a result, total number of fruits and percent fruitset significantly increased leading to the subsequent increase in yield.

5.3. Correlations

The positive correlations obtained between yield and growth characters such as total number of leaves, number of branches at maturity (during the wet season), number of leaves at first flowering and number of days to first fruitset (during the wet season) goes to show that these characters are important determinants of yield. This corresponds to findings of Kirti et al. (1971) and Ado et al. (1987) who showed yield to be strongly correlated to number of branches. There was a negative correlation between yield and plant height in both seasons; Salisbury and Ross (1969) suggested this to be due to a competition for nutrients among vegetative organs and fruits (especially young fruits) possesing a large "drawing power" for mineral salts, sugar and amino acids. Yield components such as total number of flowers, total number of fruits, percent fruitset and fruit fresh weight (during the wet season) which were positively correlated to yield indicates them to be important yield attributes. Nandpuri et al (1969), Kirti et al (1971), Gill et al. (1977) and Ado et al.(1987) showed fruit number and fresh weight to be positively correlated to yield. The

negative correlations obtained between number of flower buds aborted before or flowers aborted after anthesis and yield suggests that flower abortion either before or after anthesis retards the yield of pepper plants due to fewer fruits being set.

As Ado et al.(1987) suggests, the inconsistency in results obtained by different workers with regards to correlation indicate that correlation of individual characters depend on the group of genotypes being evaluated.

5.4. General Discussion And Conclusions

Number of days to first flowering, total number of flowers and number of flower buds aborted before and flowers aborted after anthesis are all influenced markedly. Shedding of flowers either at the bud stage or after anthesis is shown to lead to a low fruitset. Seasonal conditions as shown by Ado and Olarewaju (1987) can significantly influence yield and Olarewaju in a paper presented in 1981 says that failure of fruitset has been attributed to excessive wetness in the wet season and excessive dryness in the dry season. This excessive wetness during the wet season could also be the cause of the production of less leaves during that season (that is, due to water logging). Percent fruitset was nearly the same as the dry season. As purseglove (1977) and other workers have shown, heavy rainfall can sometimes lead to leaf shedding

and a poor fruitset. Most characters observed during the dry season were non-significant and even the yield lower than that of the wet season. Hall et al. (1977) and Ado and Olarewaju (1987) observed that the yield, weight per fruit, fruit length and diameter were much less in the dry season and also, number of days to maturity was longer. The warm weather during the wet season was more favourable than the Harmattan when the cold stagnated initial growth of the plant and the yield was also lower. This was also shown in experiments carried out by Nothman et al. (1979) where in the cool season growth was slow and fruit quality (size and colour) poor and also by Takashi et al. (1979) where number of flower buds per plant was more at 30°C than at 17°C; with the cold weather there is probably less endogenous auxin activity due to a reduction in leaf photosynthesis. Number of leaves during the wet season was less and percent fruitset nearly the same as the dry season. As Purseglove (1977) and other workers have shown, heavy rainfall can atimes lead to leaf shedding and a poor fruitset.

Various other factors such as temperature, light intensity and irrigation have been shown to significantly influence flowering, fruitset and yield in peppers. Ivanic et al. (1979), Palevitch et al. (1980) and Sadykor (1981) all showed the importance of irrigation in influencing the yield of peppers. Workers such as Cuolombe. (1979),

Kuo et al. (1980) and Yamaguchi (1983) have shown how either light intensity or temperature influence fresh fruit yield. It is obvious from this research work that neither too little nor an excess of nitrogen does any good for yield through improved flowering. With too little, flower abortion is maximized and with an excess there is more vegetative growth. As regards plant population however, in general, with the widest spacings there is less competition between the plants. Here, pepper is also shown to have generally done better during the wet season than in the dry season. From the literature it can also be seen that there are other factors (mainly environmental) working in a kind of interaction with plant population and nitrogen.

The positive correlations obtained between some of the characters assessed and yield shows that there should be an objective towards improving such characters since they determine yield to a certain extent. Also number of flower buds aborted before and flowers aborted after anthesis were negatively correlated to yield. As a result, ways of reducing flower abortion should also be studied so as to obtain higher yields.

For specific recommendations to be made to farmers in the Zaria, more work in that area needs to be done on other factors influencing flowering and yield of peppers.

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Appendix A Physico-chemical properties of the soil of the experimental sites.

	(Dry Season)		Wet Season)	
Soil characteristic	0-15cm	15-30cm	0-15cm	15-3-c.
pH in water	6.1	6.2	4.5	4.1
pH in $CaCl_2$	5.6	5.6	4.2	4.0
Physical classification				
% Clay	4	6	4	2
% Silt	52	40	48	44
% Sand	44	54	48	54
CEC (meg/100g soil)	5.6	7.9	4.1	2.6
Organic Carbon (%)	0.84	0.72	0.6	0.6
Available P (ppm)	11.57	27.66	22.94	51.99
Total N (%)	0.065	0.067	0.039	0.049
Exchangeable bases (meg/100g soil)				
Ca	2.25	2.37	1.06	0.94
Mg	0.71	0.72	0.35	0.34
K	0.21	0.20	0.154	0.179
Na	0.04	0.02	0.12	0.18

Appendix B Meteorological data at 10 day intervals during the periods of experiment (1986/87).

Month	days	Total rainfall (mm)	Mean temperature (°C) (max)	(min)	Relative humidity a.m.	p.m.	Sunshine (hrs)
December	21-31	-	27.6	12.4	22/4	22/5	6.5
January	1.10	-	28.8	11.7	21.8	19.2	8.5
	11.20	-	32.6	11.7	18.1	15.7	9.8
	21-31	-	30.2	13.9	24.0	21.4	9.2
February	9-10	-	30.9	15.0	12.9	9.7	8.0
	11-20	-	32.9	16.6	13.7	10.0	8.9
	21-28	-	34.6	17.5	9.9	10.4	10.0
March	1.10	-	32.7	16.4	10.3	7.9	8.3
	11-20	-	36.1	12.9	12.9	14.8	6.8
	21-31	-	35.6	32.9	18.1	25.4	4.1
April	1-10	-	35.3	20.9	29.4	10.6	7.7
	11-20	-	36.8	21.1	19.2	11.2	9.2
	21-30	-	35.9	23.1	6.9	7.8	4.1
June	1-10	8.5	29.8	20.6	81.5	63.5	6.4
	11-20	1.6	32.1	21.8	71.2	53.8	8.9
	21-31	4.5	30.1	21.0	76.7	68.2	7.5
July	1-10	5.2	30.5	20.6	77.6	61.7	8.4
	11-20	10.6	30.6	20.3	78.9	64.3	7.9
	21-31	10.7	29.2	19.7	82.6	68.6	6.8
August	1-10	10.5	29.9	19.9	83.0	67.7	7.0
	11-20	7.0	28.5	19.2	86.6	76.6	5.1
	21-31	8.0	29.2	20.4	86.5	72.8	6.1
September	1-10	3.3	29.9	20.4	78.7	64.8	8.0
	11-20	5.7	30.4	20.4	75.9	65.6	7.1
	21-30	1.2	31.0	20.3	78.2	59.1	8.9
October	1-10	4.3	30.8	20.0	73.4	67.1	8.0
	11-20	-	31.4	19.5	65.3	40.1	10.
	21-31	-	30.0	14.0	26.4	24.6	7.1

Source: Meteorological Unit, I.A.R., Samaru, Zaria.