

**EFFECTS OF PLANT DENSITY AND NITROGEN
FERTILIZER LEVEL ON CUCUMBER (Cucumis sativa L.)**

By

FATIMA MALIK EL-BAD A WI

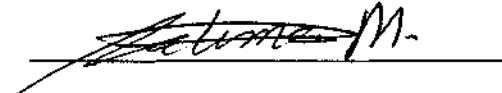
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DEPARTMENT OF AGRONOMY
FACULTY OF AGRICULTURE
AHMADU BELLO UNIVERSITY, ZARIA

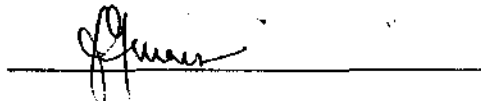
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DECLARATION

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 application for a higher degree.


Fatima Malik El-Badawi

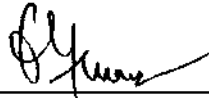
The above declaration is confirmed


Dr. E.B. Amans
(Major Supervisor)

Date 20/9/94

CERTIFICATION

This thesis entitled "Effects of Plant Density and Nitrogen Fertilizer Level on Cucumber (Cucumis sativa L.)" by Fatima Malik El-Badawi meets the regulation governing the award of the degree of Master of Science of the Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.



DR. E.B. AMANS
Chairman
Supervisory Committee



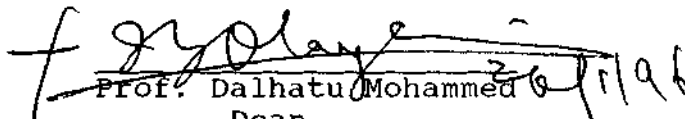
Prof. M.K. Ahmed
Member
Supervisory Committee



Dr. J.D. Olarewaju
Member
Supervisory Committee



Prof. S.T.O. Lagoke
Head
Department of Agronomy



Prof. Dalhatu Mohammed
Dean
Postgraduate School

Date _____

AHMADU BELLO UNIVERSITY, ZARIA

DEDICATION

To my family, Malik, Sarah, Hala, Mustapha and Hind.
To George Skevofilax (Moubarak) and my close friends Aisha and
Sugra.

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El-Badawi, Fatima

ABSTRACT

In order to study the response of cucumber to different nitrogen levels and planting densities a field trial was conducted at the Institute of Agricultural Research Farm, Samaru, Ahmadu Bello University Zaria during the 1992 rainy season. Four N levels (0, 25, 50, 75kg/ha) and four planting densities (10,000, 20,000, 30,000 and 40,000 plants/ha) were tested in factorial combinations. The experiment was laid out in a randomized complete block design.

Nitrogen application significantly increased fresh and dry weight of the vines, mean fruit weight, circumference of fruit, and total yield per ha. The mean fruit weight and yield per/ha were maximum at 75 kg N/ha. Although values at 75 KgN were not significantly different from those at 50 KgN/ha, the regression of yield/ha on nitrogen levels was linear ($r^2= 14.6\%$)

The fresh and dry weight of the vines were reduced but the fruit circumference, length and yield/ha were increased as plant density was increased from 10,000 to 30,000 plants/ha. The regression of yield/ha on plant density indicate a linear response ($r^2= 23.9\%$).

The interaction between nitrogen levels and plant density was significant on the fresh and dry weight of vine, increasing density without applied N had no significant effect on vine fresh weight and dry weights. Maximum fruit yield/ha was obtained with 40,000 plants/ha at 75 KgN/ha in this experiment. The linear yield responses to both N and plant density suggest even higher plant density and N levels.

Further work is needed to determine the optimum levels of density and N.

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- 3 - Previous cropping history of the experimental site

CHAPTER ONE

INTRODUCTION

Cucumber (Cucumis sativa. L.) belongs to the family cucurbitacea. The cucurbits are widely distributed in the tropics of both hemispheres (North and South). The family contains 90 genera in which 750 species are common to both the old and new worlds.

1.1 History and Origin

Cucumber is believed to have originated from parts of the Middle and Far East such as the Egyptian and Indian Peninsula (Herkets, 1972) where there were known to be cultivated since 3000 to 4000 years B.C.

It is believed that from India it was introduced to China during the "Han dynasty" in the 2nd century B.C. where though not considered native, the crop has been cultivated for at least between 800 - 1000 years or more. The crop spread rapidly westward into Europe, the Americas and the rest of Africa.

1.2 Botanical Description and General Morphology.

Cucumber is a monoecious, annual herbaceous plant which either trails on the ground or grows as a climber. It is a very tender vine-crop, but adapted to warm climate

The plant trails or climbs to heights ranging from 1.5 - 4.5 meters by means of tendrils.

The staminate or male flowers are produced in clusters with short slender pedicel, whereas the pistillate or female flowers are produced on the same plant but singly or occasionally in twos. The flower usually start to develop from 2 - 3 weeks after planting and normally the first flowers do get aborted. The flowers of some English varieties of cucumber are parthenocarpic (that is develop fruit with out seeds). The fruit which is a berry or pepo may vary from near globular to oblong or cylindrical in shape, often slightly curved and prickly when young, with slight elevation. The seeds are relatively small 8 - 10 mm long, white and smooth.

Cucumber has quite a short maturation period from planting to fruit set, and harvest commences from 7 - 9 weeks. The root system is extensive and develop a strong tap-root which according to Darwin and Thomas (1962) may penetrate the soil at the rate of 2.5 cm per day to depth of 90 - 120 cm. Numerous horizontal laterals develop rapidly and spread widely in the soil, although branching of the tap-root is not extensive below the 60 cm level. Lateral root extension is usually equal to and often exceeds that of the shoot and other above ground parts.

1.3 Environmental Requirement:

Cucumber requires warm temperatures and is usually cultivated in warm climate. The lower limit required for germination as reported by Thompson (1939) is between 11-18°C. The percentage and rate of germination increases with the rise of temperature to a limit of about 30 °C. High humidity favours

development of disease on the foliage.

Where earliness of planting is the primary consideration, sandy or sandy loams are preferred. But for higher yields, loams or clay loams are better. Heavy soil make the crop to yield for longer periods and produce larger fruits . However, the soils have to be well drained but with good moisture retention. Soil containing an abundance of humus or organic matter are considered the most desirable for the culture of cucumbers. Cucumbers are sensitive to acid soils and grow better on near - neutral or slightly alkaline soils.

1.4 Importance of Cucumber:

Cucumber is an important constituent of a great many salad dishes as well as its demand in the pickling industry (Anderson, 1941). As a vegetable the fruit tissue may be of low nutrient value but it contains good level of essential minerals and vitamins.

The composition of the cucumber fruit per 100 g edible material is as follows. (all values are given in grams) :-
91 -97g water, 0.3 - 0.5g fibre, 1.8 -2.6g sugar, 0.3 - 0.5g Ash, trace - 0.2g fat, 0.6 - 1.4g protein, 8 - 19mg Ascorbic acid, 0 - 0.04mg carotene, 0.02 - 0.1mg thiamine, 0.02 - 0.11mg Riboflavin, 0.1 - 0.6mg Niacin, 15 - 23mg Calcium and 0.3 - 0.8 mg Fe. It has a total acidity of 3.2 - 7.9 me and a calorific value of 9 - 16 Kcal per 100g. (Duckworth 1966)

The seed is not only a rich source of food protein but also contain about 42% of high quality oil (-Duckworth 1966).

Cucumber is generally pleasant to eat raw or cooked. In many tropical and arid environments it acts as a source of water supply to the people, providing refreshment and coolness. Cucumber is sometimes used for medicinal purposes in that it prevents constipation and gives intestinal hygiene. Cucumber is also an important source of income and trade.

1.5 Production Limitation

Adverse environmental factors such as high humidity, high temperature, low soil fertility are major constraints to increasing the output of cucumber. High temperatures and high humidity of the rainy season, reduce plants productivity and encourage pest and diseases (-Thompson. 1939)

Generally, vegetables including cucumber require rich fertile soils. The soils of the Nigerian savanna are generally low in organic matter and mineral nutrients, particularly nitrogen and phosphorus-(Lombin et al. 1989). The growth of plants may therefore be adversely affected in such soils resulting in low crop yields unless adequate provision for manuring of the cucumber crop is made.

The crop is often planted at wide spacings (at 1 x 1 m or 1 x 1.5 m) or wider when interplanted with other crops/vegetables. In many cases the present crop spacings appear

to be a waste of land area. Under low fertility condition wide spacing may appear reasonable, but closer spacings supported by optimum nutrient supply may be more profitable to both the crop and the farmer.

1.6 Objectives of The Study:

No work has been done in the Nigerian savanna to study the response of cucumber to nutrient fertilization and plant density, two important factors that influence crop productivity. Although experimental data is scarce, observation on farmers' fields suggest that the limited "garden" space can be better exploited with closer spacing. However it is likely that the level of soil fertility may need to be enhanced, particularly with respect to nitrogen which is often the more limiting nutrient.

It is on the basis of the above assumption that the present study was undertaken with the following objectives:

1. To study the response of cucumber to planting density and determine the optimum plant density for yield and crop quality.
2. To study the response of cucumber to nitrogen application and determine optimum amounts or levels.
3. To determine if there are any significant interaction between plant density and nitrogen fertilizer level.

CHAPTER TWO

LITERATURE REVIEW

Generally there is not much work conducted on the cultural requirement of the cucumber. Much of the works reviewed here were carried out in other countries, and there is no reported research work on either planting density or nitrogen needs of cucumber in the Nigerian savanna.

2.1 Plant Density

In a research work by Liebeg (1981). 5 - week old plants of cucumber (cv. Pepinex) were planted at different densities between 1.1 and 4.9 plants/m squares. The fruit yield of cucumber was found to increase with increasing plant density. But allowing for the cost of transplanting, the most economical planting density was found to be 2 plants/m sq.

In an investigation carried out by Bach and Hruska (1981) the effect of plant density and diversity were studied on the growth, reproduction and survival of the cucumber. Plants were grown at two row spacings (56 and 77cm between the plants) and two diversities (monoculture and, polyculture with Zea mays and broccoli). It was realized that both the density and the diversity strongly affected the plant growth and reproduction. Plants at low densities had greater values for vine length, growth rates, number of flowers and fruit yield, than those at higher densities.

Douglas et al. (1982) carried out a trial with a related crop

butter-cup squash (Cucurbita maxima) on population. The crop was planted at 1.5 or 3m row spacing. The highest total yield (approx. 27 tonnes/ha) as well as yield of large sizes of marketable fruits were obtained at closet spacing. Similarly Gowon and Slak (1982) carried out a trial on butter-cup squash in which two cultivars were planted at densities of 0.26 - 1.5m sq/plant. The plant total fruit yield rose with increase in plant density but marketable yield was, however, highest at 0.38m sq/plant. Prabhakar et al (1985) also determined the response of musk-melon (Cucumis malo cv. Hara madhu) in relation to spacing. Plants were grown at 60, 90 and 120cm apart in a 5 - year trial. The highest yield was obtained with the closet spacing.

Hammouda et al (1986), in a two year trial with cucumber (cv Balady), studied the effect of density and irrigation. The plants were spaced at 30, 40, 50 and planted singly or in 2/hill giving a density range of 19000 - 62000 plants/ha, and irrigated every 5 - 10 days. The highest yields were realized from the plots with 2 plants/hill spaced 40cm irrigated every 5 days.

Hanna et al (1987) carried out a trial on the spacing of fresh market cucumber involving vertical training of the vines. In the two years field trial it was observed that yield was higher and fruit rot reduced in vertically trained plants in comparison to those that were trailing. It was also found that optimum spacing for fresh market cucumber was generally 30 - 45cm within the row, but this spacing could be reduced with vertically trailed vines to produce higher yields.

In another experiment by Nerson et al (1988) on pickling melon (P6 - 3 - 133 - 80) and pickling cucumber ("Uniset"), 3 plant densities 33,333, 50,000 and 100,000 plants/ha were compared. The results obtained showed that both crops produced more marketable crop yields at 100,000 plants/ha than 33,333 plants/ha. Interestingly the amount of vegetative matter produced per unit fruit also increased with increasing density for cucumber.

Dwerkat and Kostewiez (1989) carried out a study on a related crop of Zucchini squash (Cucurbita pepo). Two field studies were conducted in fall 1982 and spring 1983 to evaluate row arrangement (single verses double row per bed) and within row plant spacing (0.30, 0.45, 0.60, 0.75m). The early yield in spring decreased from 0.75 to 0.30m spacing while the early yield in fall had a similar - trend but the difference were not significant. Results suggest that closer spacing increases competition for nutrients and other factor that influence fruit maturation. Total yield increased linearly in both experiments as the inter-plant spacing decreased from 0.75 to 0.30m. The result agree with those of Bradley and Rhodes (1969) who found that marketable squash yields increases as inter - plant spacing decreased from 0.90 - 0.30m.

2.2 Nitrogen Fertilization

Nitrogen deficiency causes restriction in growth and yield of plants The amount of nitrogen required by plants varies widely and depends on specie, age of plant, as well as the status of

other essential growth factors. Excess nitrogen on the other hand causes luxuriant vegetative growth which may delay maturity, reduce fruit quality or result in an accumulation of potentially hazardous concentration of nitrate (NO_3) within the plant tissue (Anonymous, 1979).

Rapid growth of crop and good fruit yield are brought about by adequate supply of nitrogen. Thompson (1939) mentioned that the application of 10 - 15 tons of manure per hectre, is beneficial. But where manure or other Organic matter is not available, an excellent crop can be grown with application of inorganic fertilizers.

In Sweden, Ingested (1973) observed that the optimum concentration by weight of nutrients in the seedling was 100-N, 75-K, 13-P, 9-Ca and 9-mg. The ratio of ammonium nitrogen to nitrate Nitrogen in the nutrient supply was near unity (even though seedlings were sensitive to high levels of ammonium nitrogen).

In a preliminary trial by White (1973) of pickling cucumber, varying rate of nitrogen (0, 34.0 and 68.0kg/ha) were incorporated at sowing. The results obtained showed nitrogen had little effect on yields and gross returns. In former USSR, Sevast et al (1974) reported that increased yields of cucumbers were got from plots receiving farm-yard manure up to 40 tonnes/ha and in addition compound inorganic fertilizer NPK at 42:30:90 and 60:12:90kg/ha.

In the USA Windham (1973) reported that the best yields of cucumber can be obtained using nitrogen fertilizer rate ranging between 24.4 - 44.8kg/ha.

Yuasa and Aboba (1981) studied the response of greenhouse cucumber to nitrogen transformation in the soil. The results showed that at high concentration of nitrogen, vegetative growth of cucumber is stimulated but the yield of fruits was not improved. The uptake of N.P.K by the roots remained constant irrespective of the external N - levels in the substratum or in the hydroponic culture solution. When tagged (N^{15})- ammonium sulphate was applied at planting, 70% of it was absorbed and this formed 40% of total nitrogen uptake. But when N^{15} was applied after planting 54% of it was absorbed suggesting a need for early than delayed application of N.

In Zimbabwe, Prabhakar et al (1985) carried out studies on yield and yield quality of musk, melon (Cucumis melo cv - Hora - modhu) (a related crop to cucumber) in relation to spacing and fertilizer. The trial was carried out over 5 years, plants received, nitrogen at 0, 50, or 100kg/ha, P_2O_5 at 0 or 60,kg/ha and K_2O at 0 or 60kg/ha. Yields at 0, 50 and 100kg/ha were 12.49, 44.63 and 46.86g/ha respectively. P and K at 60kg/ha gave 16% yield higher respectively over zero rates. Nitrogen at 100kg/ha plus P at 60kg/ha gave the highest yields of 63.82g/ha.

In another trial carried out in New Zealand on Melons (a crop related to cucumber). The effect of

vine pruning and nitrogen on yield and quality of two melon cultivars (Prince PR and Tenkie) was studied. ^(Anon, 1986) Nitrogen fertilizer was applied at 30 and 120kg/ha and the vine pruned to varying extent to modify total number of fruits retained on each plant. It was found that the higher the rate of nitrogen applied the higher the marketable yields which were increased by 20% and 34%.

Dwerkat and Kostewiez (1989) carried out a work on row arrangement, plant spacing yield nitrogen rate effects on yield of Zucchini squash (*Cucumis pepo* var *melo pepo* C). Nitrogen rates of 17, 134, and 202kg/ha were used in the fall and 134, 202, 268kg/ha used in the spring. It was found that early yield in fall increased linearly as nitrogen rate increased from 67 - 202kg/ha on in spring as nitrogen rate increased from 134 - 202kg/ha but levelled off after that. Total yield response was linear to nitrogen in fall but quadratic in spring. Total yield in spring was highest at intermediate rate of nitrogen (202kg/ha)

2.3 Interaction Between Density/Spacing and Nitrogen

Fertilizer Levels:

From an investigation carried out by Dwerkat and Kostewiez (1989), it was observed that differences in nitrogen rates became more pronounced as plant spacing decreased. With 67kgN/ha yield gradually decreased as spacing decreased from 0.75 - 0.30m. In contrast yield increased with decrease in plant spacing at nitrogen rates of 134 and 202kg/ha. The rate of 67kg/ha was

insignificant to meet nutrition requirement of plant as plant density increased from 11,111 to 55,556 plants/ha. The lower nitrogen rate at high plant densities adversely affected the balance between vegetative and reproductive growth. No significant interaction occurred in spring. A simple regression analysis of total yield on plant population density made for each nitrogen rate in both experiments showed that the overall response was linear in fall and quadratic in spring. The decline in the slope of nitrogen at 67 shows that nitrogen at this level was insufficient for the high densities. The positive slope of nitrogen at 202kg/ha line confirm expected high yields at high population with higher nitrogen - rates. The linear response show that potentially higher yields could be obtained with higher nitrogen - rate then those used.

CHAPTER THREE

3 MATERIALS AND METHODS.

3.1 Experimental Site

The experiment was conducted during the rainy season (July-September) of 1992 at the Institute for Agriculture Research farm Samaru (longitude 11° 12', latitude 07° 37'E; 686m above sea level). The long term annual rainfall of the area is 1087mm and the soil range as described by Lombin *et al* (1989) from sandy-clay loams of good water holding capacity but low cation exchange capacity. Soil samples taken from the site were bulked and analysed for physical and chemical properties using standard procedures as described by Black (1965). The soils were slightly acidic and low in organic carbon, total Nitrogen, exchangeable, cations, and available phosphorus. Details of soil analysis are presented in appendix I.

The meteorological data for the site during the 1992 rainy season is presented in appendix II. The previous cropping history of the experimental site is presented in appendix III.

3.1.1 Treatments and Experimental Design

The treatments were made up of a factorial combinations of four levels of nitrogen (0, 25, 50, 75kg/ha) and four plant densities (10,000, 20,000, 30,000 and 40,000 plants/ha). The treatments were laid out in a randomized complete block design and replicated three times. The plot size was 5m x 1.5m.

3.1.2 Variety Used

The cucumber cultivar used was "Beit Alpha" (obtained from pioneer seed company Nigeria limited) Approximately 250gm of the seed was used.

3.2 Cultural Practices

3.2.1 Land Preparation and Planting

The site was ploughed and harrowed two weeks before marking out into narrow (1.5m) flat beds of 5.0m lengths. Each bed was planted to two rows of planting at 1.0m apart. The intra-row spacing was varied at 100, 50, 33 and 25cm to give the planting densities of 10,000, 20,000, 30,000 and 40,000 plants per ha, respectively. Three seeds were sown per hill but later (2 weeks after sowing) thinned to one plant per stand.

3.2.2 Fertilizer Application

At land preparation a basal application of 45kgP₂O₅/ha of single super phosphate was applied per bed and incorporated into the soil prior to sowing of the seeds.

Nitrogen was applied as per treatment in two equal split application (source of nitrogen was calcium ammonium Nitrate 26%N). The first dose was applied two weeks after sowing and the remaining half at six weeks after sowing.

3.2.3 Weeding and Crop Protection.

The field was weeded manually using hand hoes. A total of three hoe weeding were carried, at about 3, 6 and 8 weeks after sowing. The crop received a total of three sprays of cypermethrin to protect against possible insect pest the field was sprayed at 3, 5, and 7 weeks after planting.

3.2.4 Harvesting.

Fruits were harvested by hand picking at 7 and 9 weeks after planting when they grew to marketable acceptable sizes and the dull green colour changed to glossy green. The fruit is detached from the vine. The fruits were cleansed of soil particles by washing before measurement on weight and dimension were made.

3.3 Data Collection:

3.3.1 Growth Characters:

Three plants were randomly selected from each plot and tagged for the purpose of collecting data for certain growth and yield attributes.

3.3.2 Stand Count

The number of plants per plot were counted two weeks after sowing.

3.3.3 Vine Length

Vine length was measured on 3 randomly tagged plants/plots. The main (primary) vines were measured from the terminal apex to the base of the plant at weekly intervals starting 4 weeks after planting until the eighth week.

3.3.4 Number of Leaves

The number of leaves per plant were counted on tagged plants, at weekly intervals, starting at 4 weeks after crop planting until eighth week.

3.3.5 Number of Flowers

The number of flowers per plant were counted on the tagged plants on weekly interval from the fourth week after planting until the eight weeks (flowering began between 2 - 3 weeks after planting).

3.3.6 Number of Fruits Per Plot

The cumulative number of fruit per plot were recorded at harvest, and the mean number of harvested fruits per plant was then obtained.

3.3.7 Weight of Fruits Per Plot

Fruits harvested per plot were weighed at harvest. The mean weight of fruits per plant was got by dividing the weight of fruit/plot by number of fruit per plot.

3.3.8 Length and Circumference of Fruits Per Plot

Fruits from each plot were measured for length and circumference, (the length and circumference were measured using a string) mean length and circumference per fruit calculated.

3.3.9 Fresh and Dry Weight of Vine at Harvest

The vines of tagged plants were cut from the base after final harvest. These were cleaned and weighed. They were the oven-dried to a constant weight at 70 °C.

3.3.10 Total Yield Per Unit Area

The total yield /ha was obtained by projecting plot yields.

3.3.11 Statistical Analysis of Data

The data collected was subjected to analysis of variance and where "F" test showed significant difference, the means of such treatments were then compared using the Duncan Multiple Range test (Duncan 1955). Correlation coefficient were worked out as described by Snedecor and Cochran (1987) to determine the relationship between growth characters, yield components and fruit yield. Also a simple regression analysis of total yield on population density and on nitrogen levels was carried out.

CHAPTER FOUR

4. RESULTS

4.1 Growth of Cucumber

4.1.1 Vine Length:

The lengths of main vines from the 4th to 8th weeks after planting are shown in Table 4.1.1. Neither nitrogen application no variation in plant density influenced the growth of the vines significantly. The interaction between nitrogen and plant density was also not significant.

4.1.2 Number of Leaves:

Data on the number of leaves per plant is shown in Table 4.1.2. The mean number of the leaves per plant was unaffected by the nitrogen levels. Plant density did not affect the number of leaves at the fourth, fifth, sixth and seventh week but there was a significant effect at the eighth week. The lowest density of 10,000 plants/ha gave the best values for the number of leaves. Nitrogen levels and plant density interaction was not significant.

4.1.3 Fresh and Dry Weights of Vines

The effects of treatments on both the fresh weight (FW) and dry weight (DW) of vines at crop maturity are shown in Table 4.1.3. Response of both the FW and DW to nitrogen and plant density followed similar pattern. Nitrogen application significantly increased FW and DW over the control, but difference among rates applied were not significant.

The increase in plant density from 10,000 plants to 30,000

plants/ha had no significant effect on vine FW. But further increase in density to 40,000 plants/ha depressed vine FW. The vine DW was also depressed when the plant density was increased from 10,000 to 20,000 plants/ha or higher.

Table 4.1.1 Effect of nitrogen and plant density on vine length of cucumber at Samaru during the 1992 wet season

<u>Treatments</u> Nitrogen Kg/ha	Vine Length in cm at - weeks after planting				
	4 th	5 th	6 th	7 th	8 th
0	52.40	73.10	87.40	95.30	112.00
25	60.10	74.10	91.40	106.20	110.20
50	56.1	78.30	95.00	114.40	116.70
75	61.60	82.10	96.00	115.40	122.6
S.E±	3.97	4.44	5.24	7.45	7.49
Significance	N.S	N.S	N.S	N.S	N.S
<u>Plant density</u> (plants/ha)					
10,000	58.50	80.80	94.20	116.40	120.40
20,000	57.00	77.80	94.00	113.40	117.90
30,000	57.90	74.90	94.80	101.20	116.20
40,000	56.70	74.70	87.20	100.20	105.30
S.E ±	3.97	4.44	5.24	7.45	7.49
Significance	N.S	N.S	N.S	N.S	N.S
<u>Interaction Nx D</u>					
Significance	N.S	N.S	N.S	N.S	N.S

N.S = Not Significant

Table 4.1.2 Effect of nitrogen and plant density on number of leaves of cucumber at Samaru during the 1992 wet season

Treatment	Number of Leaves at - weeks after planting				
	4 th	5 th	6 th	7 th	8 th
Nitrogen Kg/ha					
0	16.40	20.50	20.30	23.30	18.67
25	19.17	20.17	22.80	23.80	19.75
50	16.67	20.56	22.70	22.30	22.25
75	15.83	19.92	20.20	20.20	18.25
S.E ±	1.30	1.78	2.75	2.56	1.86
Significance	N.S	N.S	N.S	N.S	N.S
Plant density (plants/ha)					
10,000	18.33	20.42	25.30	26.50	24.25a
20,000	16.58	20.42	19.60	21.30	19.75ab
30,000	17.42	19.83	20.60	20.20	16.73b
40,000	15.75	20.42	20.42	21.60	18.17ab
S.E ±	1.30	1.78	2.75	2.56	1.86
Significance	N.S	N.S	N.S	N.S	*
Interaction NxD					
S.E ±	2.59	1.44	5.49	5.12	3.71
Significance	N.S	N.S	N.S	N.S	N.S

Means followed by same letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant
* = Significant

TABLE 4.1.3 Effect of nitrogen and density on fresh and dry weight of vines of cucumber at Samaru during the 1992 wet season

<u>Treatments</u>	Fresh Weight Of Vines (g)	Dry weight of vines (g)
<u>Nitrogen Kg/ha</u>		
0	211.1b	30.6b
25	296.3a	58.6a
50	277.2a	48.9a
75	259.5a	51.6a
S.E ±	18.89	7.06
Significance	*	*
<u>Plant density (Plants/ha)</u>		
10,000	294.2a	69.4a
20,000	284.4a	46.7b
30,000	243.0a	35.1b
40,000	221.5b	38.5b
S.E ±	18.89	7.06
Significance	*	*
<u>Interaction (NxD)</u>		
Significance	*	*

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant

* = Significant

4.1.3a Interaction between Nitrogen levels and Plant density on vine fresh weight

The interaction between nitrogen and plant density on vine FW was significant (Table 4.1.3a). Increasing plant density had no significant effect on FW at the zero nitrogen level. When 25 - 75kg N/ha was applied, there was a significant reduction in the FW as plant density increased from 10,000 or 20,000 plants to higher plant density.

At the lower plant densities (10,000 - 20,000 plant/ha), the application of nitrogen significantly increased FW. But at 30,000 plant/ha nitrogen fertilization produced no significant effect while at the highest plant density, the application of the highest nitrogen level depressed vine FW.

4.1.3b Interactions between Nitrogen levels and Plant density on vine dry weight

The interaction between nitrogen and plant density was also significant on vine DW (Table 4.1.3b). The application of nitrogen up to 75kg/ha significantly increased vine DW at 10,000 - 20,000 plants/ha. At 30,000 plants/ha, the vine DW was unaffected by nitrogen application while at the highest plant density (40,000 plants/ha) the application of moderate nitrogen levels (25 - 50kg N/ha) produced higher DW than at 0 and 75kg N/ha which were at par. At 0 and 50kg N/ha, plant density did not influence vine DW. With 25kg N/ha, the highest plant density

had the highest DW. But with the highest nitrogen levels, vine DW was higher at lower plant densities (10,000 - 20,000 plants/ha) than at higher densities.

Table 4.1.3(a) Effect of the interaction of nitrogen levels and plant density on fresh weight of vines.

Treatments	PLANT DENSITY (Plants/ha)			
	10,000	20,000	30,000	40,000
Nitrogen Kg/ha				
0	183.5b	176.2b	243.8b	220.9b
25	387.9a	297.4a	234.7b	261.1b
50	383.3a	284.3a	280.5ab	260.2b
75	321.5a	359.8a	212.9b	143.8c
S.E \pm	37.79			

Mean followed by same letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T.

N.S. = Not Significant

* = Significant

TABLE 4.1.3 (b) Effect of the interaction of nitrogen levels and plant density on dry weight of vines

Treatments	PLANT DENSITY (Plants/ha)			
	10,000	20,000	30,000	40,000
Nitrogen Kg/ha				
	1	2	3	4
0	31.9b	19.7b	41.7b	29.1b
25	37.3b	33.8b	22.1b	50.3a
50	43.4ab	54.4a	48.7ab	49.0a
75	74.2a	78.8a	28.0b	25.6b
S.E \pm	13.99			

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

4.1.4 Number of Flowers:

Mean number of flowers sampled at 4, 5, 6, 7 and 8 weeks after planting as affected by the treatment are shown in Table 4.2.1. Both main effects of nitrogen and plant density were not significant on the number of flowers. The interaction of nitrogen and plant density also found to be insignificant.

4.2 Yield and Yield Components of Cucumber

4.2.1 Number of Fruits

There was no statistically significant effect of N - levels on the number of fruits produced at all five weeks of sampling (Table 4.2.2). Similarly the effect of plant density on the number of fruits produced per plant was not statistically significant at all sampling periods.

Interaction between nitrogen and plant density on number of fruit effects was not statistical significant.

4.2.2 Mean Fruit Weight

The effects of treatments on mean weight per fruit are shown in Table 4.2.3. The application of 50 kg N/ha significantly increased the mean weight per fruit. The effects of a lower rate of application were not significant when compared with the unfertilized crop.

Variation in the planting density produced no significant effect on mean weight per fruit. The interaction between nitrogen and plant density was not significant.

TABLE 4.2.1 Effect of nitrogen and plant density on mean number of flowers of cucumber at Samaru during the 1992 wet season

Treatment	Number of Flowers at - weeks after planting				
	4 th	5 th	6 th	7 th	8 th
Nitrogen Kg/ha					
0	2.67	3.75	3.17	2.75	1.25
25	3.17	3.50	3.42	3.67	2.08
50	2.42	2.92	3.50	2.75	1.25
75	2.33	3.17	2.67	2.42	1.42
S.E ±	0.28	0.58	0.57	0.51	0.39
Significance	N.S	N.S	N.S	N.S	N.S
Plant density (plants/ha)					
10,000	2.92	3.33	4.25	3.58	1.83
20,000	2.83	3.33	3.25	3.08	1.08
30,000	2.25	3.50	2.75	2.83	1.58
40,000	2.58	3.17	2.50	2.08	1.50
S.E ±	0.28	0.58	0.57	0.51	0.39
Significance	N.S	N.S	N.S	N.S	N.S
Interaction Nx D					
S.E ±	0.56	1.16	1.14	1.02	0.78
Significance	N.S	N.S	N.S	N.S	N.S

N.S = Not Significant

TABLE 4.2.2 Effect of nitrogen and plant density on number of fruits of cucumber at Samaru during the 1992 wet season.

Treatments	Number of Fruits at - weeks after planting				
	4 th	5 th	6 th	7 th	8 th
Nitrogen Kg/ha					
0	0.417	2.67	4.50	5.67	4.83
25	0.250	2.42	4.33	5.83	5.42
50	0.583	2.67	4.25	6.72	5.92
75	0.417	2.25	3.67	4.83	3.83
S.E ±	0.17	0.36	0.51	0.93	0.72
Significance	N.S	N.S	N.S	N.S	N.S
Plant density (plants/ha)					
10,000	0.333	2.42	4.33	6.00	5.83
20,000	0.417	2.30	3.83	5.25	4.75
30,000	0.417	2.75	4.58	6.83	4.42
40,000	0.500	2.50	4.00	5.17	5.00
S.E ±	0.17	0.36	0.51	0.93	0.72
Significance	N.S	N.S	N.S	N.S	N.S
Interaction Nx D					
S.E ±	0.34	0.72	1.03	1.86	1.44
Significance	N.S	N.S	N.S	N.S	N.S

N.S = Not Significant

TABLE 4.2.3 Effect of nitrogen and plant density on mean fruit weight of cucumber at Samaru during the 1992 wet season

Treatments Nitrogen (Kg/ha)	Mean Fruit Weight
0	159.2b
25	148b
50	224.8a
75	175.4a
S.E \pm	14.76
Significance	*
Plant density (plant/ha)	
10,000	198.5
20,000	166.1
30,000	174.4
40,000	168.4
S.E \pm	14.76
Significance	N.S
Interaction (Nx D)	
Significance	NS

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant

* = Significant

4.2.3 Circumference of Fruits

Table 4.2.4 shows the responses of fruit circumference to nitrogen levels and planting density. At first harvest was found to be significant. At both harvests, the application of 50kgN/ha gave the highest values, which was significantly higher than at 75kg N/ha during the first harvest but at par with both the lower and higher rates in the second harvest. The average fruit circumference (over the two harvest) was significantly higher at 75kg N/ha than at 25kg or 0kg N/ha.

The successive increase in plant density from 10,000 plants to 20,000 and 30,000 plants/ha led to significant increases in fruit circumference during the first harvest but further increase in plant density was of no significant effect. For the second harvest as well as the average of the two harvests, fruit circumference was maximum at 30,000 plants/ha but was significantly superior only when compared with the 20,000 plants/ha treatment. The interaction between nitrogen and plant density were found to be not significant.

4.2.4 Length of Fruits

The effect of nitrogen application and plant density on the mean length of cucumber fruit are shown in Table 4.2.5. The length of fruit from the first harvest was significantly increased when applied nitrogen level was raised from 0 to 50 kg/ha. Increasing the nitrogen level to 75 kg/ha produced fruits that were slightly shorter but not significantly different from those at 50 kg/ha.

TABLE 4.2.4 Effect of nitrogen and density on circumference of fruits of cucumber at Samaru during 1992 wet season

Treatments	Circumference of fruits at -----harvest		
	1 st	2 nd	Mean
Nitrogen Kg/ha			
0	12.25cd	13.81bc	13.17bc
25	12.26c	12.98bcd	12.62c
50	14.82a	15.47a	15.14a
75	13.48b	14.16ab	13.90ab
S.E ±	0.35	0.43	0.41
Significance	*	*	*
Plant density (plant/ha)			
10,000	12.85c	14.07abc	14.06ab
20,000	11.22d	12.45d	12.09b
30,000	14.76a	15.26a	14.70a
40,000	13.98ab	14.65ab	13.99abc
S.E ±	0.35	0.43	0.41
SIGNIFICANCE	*	*	*
Interaction NXD	N.S	N.S	N.S

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant

* = Significant

TABLE 4.2.5 Effect of nitrogen and density on length of fruits of cucumber at Samaru during the 1992 wet season

Treatments Nitrogen Kg/ha	Length of fruits at-----harvest		
	1 st	2 nd	means
0	12.85c	14.14ab	13.45ab
25	13.16bc	13.76ab	13.69ab
50	15.02a	15.01a	15.98a
75	14.22ab	14.98a	15.39ab
S.E ±	0.35	0.53	0.84
Significance	*	*	*
Plant density (plant/ha)			
10,000	13.91b	14.74a	14.65a
20,000	11.73c	12.83b	12.05b
30,000	15.21a	15.39a	15.10a
40,000	14.45ab	14.93a	14.90a
S.E ±	0.35	0.53	0.84
SIGNIFICANCE	*	*	*
Interaction NXD			
S.E ±	0.70	1.07	1.69
Significance	N.S	N.S	N.S

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant

* = Significant

The mean fruit length from the second harvest as well as the average length over the two harvest were not significantly influenced by nitrogen application, although the fruit length was maximum at 50 kg N/ha.

Increasing plant density from 10,000 to 20,000 and further to 30,000 plants/ha led to successive increases in mean lengths of the first harvested fruits. In the second harvest, fruit length at 20,000 plants/ha was lower than at other plant densities. The average of fruit length over the two harvest was maximum at 30,000 plants/ha, which was significantly superior to 20,000 but at par with other densities.

4.2.5 Total Fruit Yield (t/ha)

The effects of the nitrogen levels and plant density on total fruit yield are shown in Table 4.2.6. Raising the nitrogen fertilizer level from zero to 25 kg/ha produced no significant effect on yield. But further increase in the nitrogen level to 50 kg and 75 kg/ha led to significant increase in yield. The maximum yield occurred at 75 kg N/ha, but this level was not significantly different from 50 KgN/ha.

The effect of planting density on total yield was also significant. Increasing plant density from 10,000 to 20,000 plants/ha had no significant influence on yield/ha. But yields were significantly higher at 30,000 and 40,000 plants/ha. However, the difference between these two densities was not significant.

TABLE 4.2.6 Effect of nitrogen and plant density on fruit yeild of cucumber at Samaru during the 1992 wet season

Treatments Nitrogen (Kg/ha)	Harvest/ha Yield/ha (tonnes)
0	3.58b
25	3.16b
50	5.00a
75	5.32a
S.E ±	0.45
Significance	*
<hr/>	
Plant density (plant/ha)	
10,000	2.97b
20,000	3.46b
30,000	5.23a
40,000	5.40a
S.E ±	0.45
Significance	*
<hr/>	
Interaction (NxD)	
Significance	N.S

Means followed by some letter(s) within a treatment group are not significantly different at 5% level of significance using D.M.R.T

N.S = Not Significant
* = Significant

The interaction between nitrogen levels and planting densities on total yield was not statistically significant.

4.2.6 Simple Correlation Studies and Regression Analysis

Simple correlation analysis of various important parameters were made and the results are presented. (Table 4.2.7). The parameter include length of vine, number of leaves, number of flowers, number of fruits circumference of fruits, length of fruits, fresh weight of vines, dry weights of vines, total fruit yield, fruit weight.

The correlation showed that only the circumference of the fruits and the mean fruit weight were significantly and positively correlated to the total fruit yield.

The length of the vines were significantly and positively correlated to number of leaves, number of flowers, number of fruits, and fresh and dry weights of vines. The number of leaves were significantly and positively correlated to the number of flower and number of fruits.

The circumference of the fruit was significantly and positively correlated to the length of the fruits. The fruit weight was significantly and positively correlated to the total yield of fruits.

The fresh weight of the vines was observed to be positively

correlated to the number of fruit. The fresh and dry weight of the vines were observed to be negatively correlated to the circumference of the fruits.

Table 4.2.7

Correlation Table

	1	2	3	4	5	6	7	8	9	10
1	1.00									
2	0.29*	1.00								
3	0.40**	0.34**	1.00							
4	0.22	0.20	0.30*	1.00						
5	-0.07	-0.18	-0.02	-0.14	1.00					
6	-0.23	0.21	0.08	0.23	0.22	1.00				
7	0.05	-0.02	-0.16	0.11	0.39**	0.30*	1.00			
8	-0.24	0.10	-0.06	0.05	0.37**	0.67**	0.63**	1.00		
9	-0.19	-0.03	-0.40**	-0.02	0.33*	0.08	0.36*	0.16	1.00	
10	-0.23	-0.01	-0.30*	0.12	0.25	0.04	0.40**	0.14	0.68**	1.00

D.F = 46

Coef. of correlation at 5% = 0.288

Value 1% = 0.372

- 1 = Total yield of fruits (tonnes/ha)
- 2 = Mean weight of fruit
- 3 = Mean of circumference of fruit
- 4 = Mean length of fruit
- 5 = No. of fruits/plant
- 6 = No. of flowers/plant
- 7 = Length of vines
- 8 = No. of leaves/plant
- 9 = Fresh weight of vines
- 10 = Dry weight of vines.

* = Significant

** = Highly significant

Regression Analysis

A regression curve of the total yield of fruit per ha against both the planting densities and nitrogen rates were found to linear as shown in Figures 1 and 2.

The yield response against plant density best fitted the following equation

$$y = 2.00 + 0.0904X \quad (r^2=23.9\%)$$

while the yield regression against nitrogen rates had the equation

$$y = 3.20 + 0.0283X \quad (r^2=14.6\%)$$

$$y = 200 + 0.0904 \times \text{spacing}$$

+ = calculated y values

o = actual mean y values

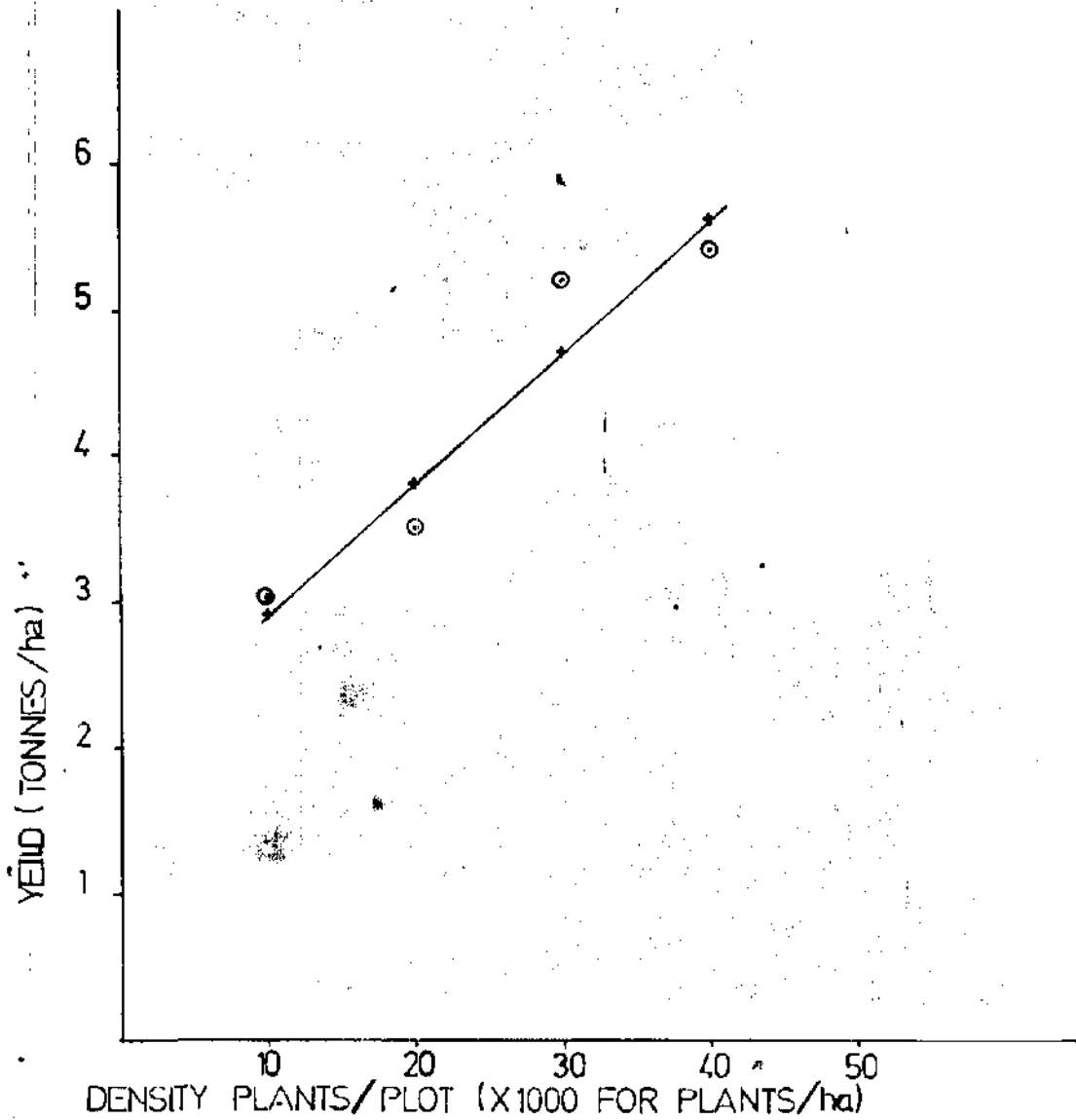


Figure 1 Regression of yield against plant density

$$y = 3.20 + 0.0283 \times \text{nitrogen level}$$

+ = calculated y values

o = actual mean; y values

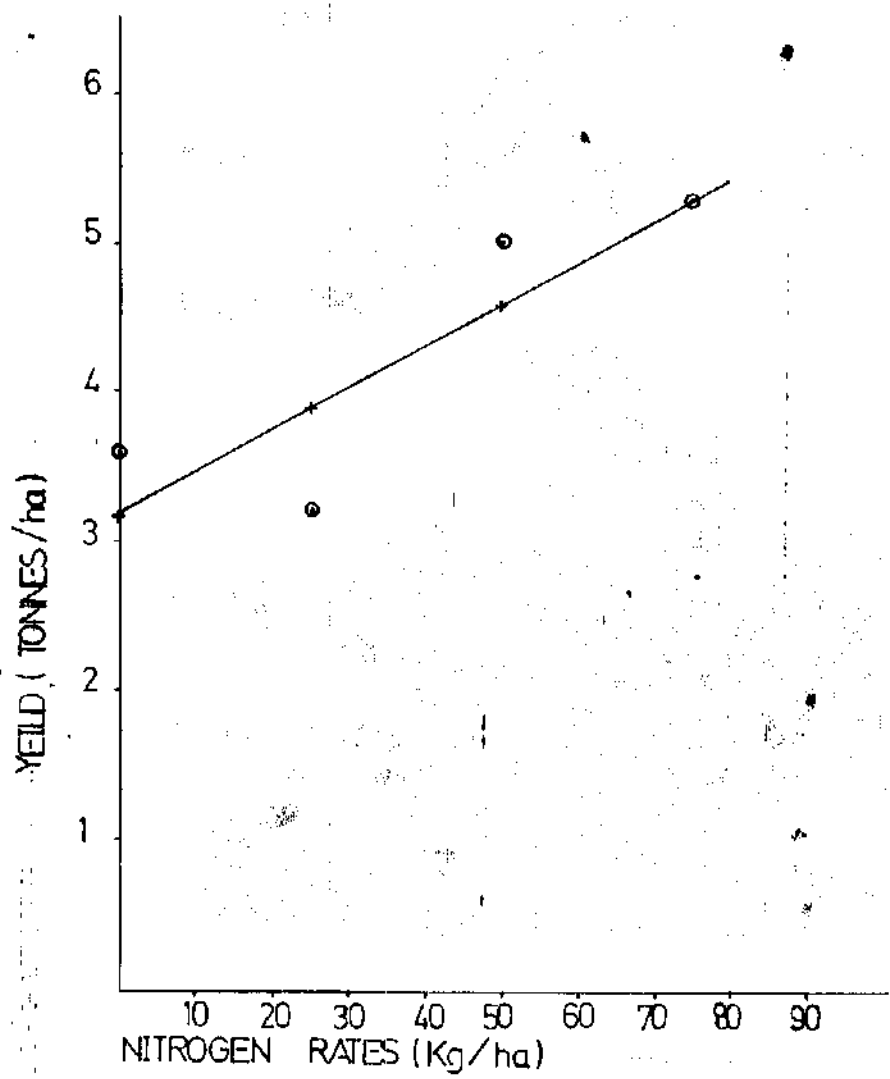


Figure:2 Regression of yield against nitrogen levels

CHAPTER FIVE

5. DISCUSSION

5.1 Effect of Nitrogen Levels

The study did not show any significant influence of results on N application on the vine length and number of leaves. But it was noted that as the N - level was increased the fresh and dry weights of the vines were increased, suggesting that the vegetative growth and dry matter accumulation per plant did respond positively to N fertilization.

It is possible that the apparent lack of response to N by the vine length and number of leaves was because by the time these parameters were sampled the plants had already attained full vegetative growth and were already initiating reproductive phase of growth. Thus, the priority in photosynthate utilization may at this stage go for dry matter accumulation growth of reproductive structure rather than for further vine elongation and leaf production. But from the above observation it can be concluded that N - does have a positive effect on the growth of the crop. The above observation sorts of agrees with the literature by Yuasa and Aboba (1981) which observed that root uptake of N.P.K. was constant whatever the external N - levels were, for cucumber and high levels of N do stimulate vegetative growth. The effects of N on number of flowers or fruits were also not significant but the circumference and the length of the fruits were significantly increased. N - levels of 50kg/ha gave the greatest circumference and length.

It was also observed that 50kgN/ha gave the highest values for the mean fruit weight. Although the maximum yield per ha was recorded at 75 KgN/ha, this level was not significantly different from yields 50kgN/ha. The yield per ha responded linearly to N up to the highest rate of 75 Kg/ha. Apparently, the lower rate of 50 KgN/ha was optimum for individual fruit growth. But on a per ha basis the higher level had slight advantage over 50 Kg/ha. These observation corroborates the findings of Thompson (1939) and Windham (1973) who reported that either manure or inorganic fertilizer application can give an excellent crop and better yields - depending on the soil and area, the exact rate do change but its was observed that rate ranging between 24.4 - 44.8kgN/ha gave best yields.

5.2 Effect of Planting Density

Similarly the effect of population density on the growth of the crop was observed to be statistically significant on the fresh and dry weights of the vines as well as the number of leaves. Though the effect of plant density on the length of vine was not statistically significant there was still a slight decrease in vine length as density increased.

It was observed that with increase in planting densities the vegetative growth in terms of fresh and dry weight of vines and the number of leaves. was reduced. This result agrees with that reported by Bach and Hruska (1981) in which lower plant densities produced longer vines than at high densities. At low densities plants have greater access to available soil nutrients and

moisture than possible under higher planting densities. The increasing competition for resources as plant density increases cuts down on the individual plants need for optimum growth resulting in a reduction in growth. The best growth was at the lowest plant density (10,000 plants/ha). This is in agreement with the findings of Liebeg (1981) who reported that the optimum plant density for cucumber was 2 plants/m². The need for a wide spacing of the plant/crop could be due to the fact that it is a trailing crop and more space availability allows for the vines to trail, the space could be reduced in cases where the vines are vertically trellized.

The planting densities of the cucumber crop was observed to produce a marked effect on the yield and yield attributes of the crop. The circumference and length of fruits were both maximum at 30,000 plants/ha rather than at lower plant densities. It was possible that the more vigorous vegetative growth under lower plant densities occurred at the expense of the reproductive growth. Thus, some measure of interplant competition which slowed vegetative growth apparently helped in mobilizing more of the limited nutrient resources to the reproductive stage. Although the size of fruit was maximised by increasing plant density up to 30,000 plants/ha, further increase in plant density to 40,000 plants/ha had insignificant influence on the fruit size. This agrees with the findings of Douglas et al (1982) who reported that largest sizes of marketable quality fruits of butter - cup squash was obtained at closer spacing. These results agree with the observation of Hanna et al (1987) reported that the best

optimum spacing for cucumber was between 30 - 45cm intra-row spacing which gave plant densities ranging between 30,000 - 60,000 plants/ha.

Despite the apparent increase in the length and circumference of the fruit as plant density was increased to 30,000 plants/ha, the actual weight per fruit was not significantly influenced by the change in density. More likely that if fruit dimension was increased with reduced vegetative vigour under moderately high plant density a slight reduction in the accumulation of photosynthate may have occurred as a compensatory response. Thus, the lack of significant response in fruit weight despite the increase in fruit dimension. Increasing plant density means more plant per unit plant area. Thus, the increase in total fruit yield/ha with increasing plant density was expected. This observation is in agreement with several findings (Liebeg 1981; Douglas *et al* 1982; Slak 1982; Prabhakar *et al* 1985; Hammouda *et al* 1986; Dwerkat and Kostewiez 1989). The linear response of total yield to plant density indicate that even higher plant density than the maximum tested (40,000 plants/ha) may still lead to further increase in yield.

5.3 Interaction Between Planting Densities and Nitrogen Levels

The interaction of nitrogen level and plant density was significant on fresh and dry weight of plant vine. Response to nitrogen application seems much better with lower plant density (10,000 - 20,000 plants/ha) than at higher plant densities. At

the higher plant densities response to nitrogen was either not significant or even became negative with the application of high rate of nitrogen (75 Kg/ha). It would have been expected that the demand for and, thus, response to nitrogen supply would have increased with increasing plant density. There are several possible reasons for the observed response to nitrogen under the varying plant density. It is possible that other growth or nutrient factor other than nitrogen may have been limiting, such that the threshold for nitrogen requirement by the crop become lower than expected. Another possibility could be due to the fact that for a specific nitrogen level the lower plant densities enabled individual plant more nitrogen uptake in comparison with individual plants at higher densities where there was a degree of competition. This agrees with the findings of Dwerkat and Kostewicz (1989).

5.4 Correlation Studies

The significant positive correlation between yield and yield components, number of flower, number of fruits, and growth characters such as vine length, number of leaves, fresh and dry weight of vines, may be attributed to the fact that these vegetative characters directly determined the extent of photosynthesis and amount of assimilates that were available for plant growth and ultimately the crop yield. Also the

positive correlation between the mean circumference of the fruits and total yield, and the mean weight of fruit per harvest, show that the increase of mean circumference of the fruits contributes to the increase in crop yield.

CHAPTER SIX

6. SUMMARY AND CONCLUSIONS

A field experiment was carried out at the Samaru institute for Agricultural Research farm Ahmadu Bello University Zaria during the 1992 wet/rainy season to study the effect of Nitrogen and densities on the growth and yield of cucumber.

The treatments consisted of four levels of nitrogen (0, 25, 50, 75kgN/ha) and four densities/plant population (10,000, 20,000, 30,000 and 40,000 plants/ha). The experiment was laid out in a randomized block design and replicated three times.

It was observed that nitrogen application increased growth to some extent and actually increased the crop yield, also fruit sizes were affected by nitrogen application especially at the rates of 50kgN/ha.

It was also observed that plant density also had a significant effect on the growth of the crop. Most of growth characters of the plant were negatively effected by high plant density due to high competition for available resources. But then the total yield of fruit per hectare was increased with increasing plant density.

The effect of the interaction of both the Nitrogen levels and population densities show that these too did have an effect on the growth and yield of the crop.

Based on the results obtained in this study it can be

summarized that:

1. Application of nitrogen upto the rate of 50kgN/ha produced significant increase in some of the yield components of the cucumber crop such as, mean fruit weight, and it was also observed that 50kgN/ha gave the greatest circumference and length for the fruit sizes, and was the most desirable rate for the best yields of the crop.
2. Planting densities of 10,000 plants/ha gave better growth attributes for the crop while the highest density of 40,000 plants/ha reduced the vegetative matter accumulation of the crop . Higher densities of 30,000 plants/ha and 40,000 plants/ha gave the best yield for the crop.
3. From the above study it can be concluded that the yield of Cucumber under conditions similar to the one in which this study was conducted, can be maximized with the use of 75kgN/ha and a plant density of 30,000 - 40,000 plants/ha.

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APPENDIX I

The physical and chemical properties of the soil collected up to a depth of 30cm from the experimental site at Samaru I.A.R farm.

Soil Properties

Characteristics

Physical properties:-

% sand	16
% silt	46
% clay	38
Textural class	Loam

Chemical properties:-

PH in H ₂ O	5.4
PH in 0.01m CaCl ₂	4.9
% organic carbon	0.48
Available Phosphorus (ppm)	9.00
% Total Nitrogen	0.05

Exchangeable cations (Meq/100g soil):

Ca	0.72
Mg	0.53
K	0.12
Na	0.11
C.E.C	5.20

APPENDIX II

The mean, maximum and minimum temperatures (Degree Centigrade) Relative humidity (%) and total rainfall (mm) and sunshine hours (hrs)

Month	Rainfall (mm)	Temperature		R.H %		Sunshine Hours
		Min T	Max T	10.00am	4.00pm	
Jan	-	12.3	26.7	21.5	14.6	5.3
Feb	-	15.0	30.0	12.6	9.1	7.9
Mar	-	19.5	35.0	23.4	16.6	5.9
Apr	32.3	22.4	35.4	41.3	29.9	7.4
May	73.1	22.1	33.0	66.4	49.7	7.4
Jun	112.4	19.7	29.6	71.3	57.9	6.2
Jul	243.6	19.8	28.4	82.6	68.1	6.2
Aug	287.3	20.0	29.5	83.0	74.8	4.9
Sep	229.7	20.2	29.5	78.6	65.1	4.6
Oct	39.9	17.7	31.5	61.1	35.2	8.9
Nov	2.6	15.1	29.7	32.4	35.0	6.9
Dec	-	12.3	29.6	25.1	24.6	7.9

Source: Meteorological Unit Data at the Institute for Agricultural Research, Samaru, Zaria. (1992)

APPENDIX III

Previous cropping history of experimental site.

<u>Year</u>	<u>Crop cultivated (wet seasons)</u>
1988	Maize, tomato, pepper.
1989	Cotton
1990	Maize
1991	Soyabean/cowpea

BIOGRAPHY

NAME: El Badawi Fatima Malik

DATE AND PLACE OF BIRTH: 27th July, 1969. Yabo Local Government
Sokoto State

HOME ADDRESS: Masoudia Gezira Province
P.O. Box 4278
Central Khartoum
SUDAN.

PREVIOUS QUALIFICATIONS:

- (a) G.C.E. London 'O' Level - Khartoum tutorial College,
Khartoum SUDAN 1981 - 1984.
- (b) I.J.M.B. (A - level). School of Basic studies Ahmadu Bello
University Zaria Nigeria. 1984 - 1986.
- (c) B. Agric. Ahmadu Bello University 1986 - 1990

POST HELD SINCE AWARD OF FIRST DEGREE:

- (a) Assistant to Head of division of agriculture for Union Bank
area office Kaduna (NYSC) 1990 - 1991
Year of admission for post graduate studies - 1991 January
Admission number MSc/Agric/5152/1991 - 1993