THE EFFECT OF NITROGEN LEVELS AND INTRA-ROW SPACING ON THE GROWTH AND YIELD OF WATER MELON (Citrullus lanatus Thumb Mansf.)

By

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A thesis submitted to the post-graduate school Ahmadu Bello University Zaria, in partial fulfilment of the requirement for the award of degree of master of Science in Agronomy.

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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.

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Date: 15/3/2000

CERIFICATION

This thesis tittled "THE EFFECT OF NITROGEN LEVELS AND INTRA-ROW SPACING ON THE GROWTH AND YIELD OF WATER MELON (Citrullus lanatus Thumb Mansf.)" by Umar Mohammed Majia 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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DEDICATION

This work is dedicated to the memory of "LATE HAJIIA SA'ADATU DALHA" for her Love and caring attitude to her children and their friends.

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ABSTRACT

An experiment was conducted at the National Horticultural Research Institute Farm Bagauda, Kadawa (11°39'N,8°02'E) in the Northern Guinea Savanna Ecological zone during 1992/93 dry season to determine the effect of varying nitrogen levels and intra-row spacing on the growth and yield of water melon (Citrullus lunatus Thumb.) under irrigation. Treatments tested consisted of three levels of nitrogen fertilizer (0,30 and 60kgN/ha) and four intra-row plant spacings, (1.0, 1.5, 2.0 and 2.5m) arranged in randomised complete block design (RCBD) and replicated three times.

The results showed that increase in nitrogen levels increased the leaf number of plant, leaf area, days to 50 percent flowering, total fruit yield per hectare, mean fruit weight and 100-seed weight. Increasing the intra-row spacing from 1.0 to 2.5m significantly increased leaf number per plant, leaf area, days to fruit maturity, fruit size, fruit (total and marketable) yield per hectare and seed weight per fruit.

The highest fruit yield of 68.6t/ha was obtained from the spacing of 2.5m and nitrogen rate of 60kgN/ha.

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CHAPTER ONE

1.0 INTRODUCTION

Water melon (Citrullus lanatus Thumb Mansf. - syn. Citrullus vulgaris Schard) is a trailing annual fruit belonging to the family cucurbitaceae (Whitaker and Davis, 1962). The cucurbitaceae are among the important plant families that supply man with edible fruits and useful fibres. The plant has slender hairy stem (vine) that grow up to 5m long with large cordate but deeply pinnated leaves of 3-4 lobes of segements each. Flowers are unisexual and located at the axils. There is a predominance of male flowers over female flowers in the ratio of 4:1 or 5:1. The male flowers appear earlier containing 3 or more stamens while the female flowers has a short stigma and an inferior ovule (Greensill, 1976, Rice et al. 1978).

Available evidences shows that the watermelon is indigenous to tropical Africa (Thompson, 1939; Stucky, 1951; Whitaker and Davis, 1962; Grubben, 1977; Splittestoesser, 1979 and Nichols, 1989). Whitaker and Davis (1962), indicated India as a strong secondary centre of origin of Citrullus vulgaris. Splittestoesser (1979) reported that water melon was taken from Africa to Europe and America in the sixteen century. Early French explorers were reported to have found Red Indians growing water melon in the Mississipi valley, in Massachusettes and Florida regions prior to 1664 (Thompson, 1939).

Water melon require relatively dry warm climate with full sunshine (Herklots, 1972). It can also grow under humid climate provided that a relatively dry period occurs during the fruits setting and maturity. Watermelon grows best on light sandy to sandy loam, well drained but slightly acidic (PH 5 - 6) soils, and is very sensitive

to water logged or poorly drained soils (Herklots, 1972; Splittstoesser, 1979; James et al. 1986 and Saddique, 1992).

Watermelon is an important fruit of commerce, utilized as fresh juicy desert. Most of the commercially grown varieties produces large juicy and sweet edible fruits which may be globular, oval or oblong in shape. The outer skin of the fruit may be green, cream - pale or stripped with red, pink or yellow in flesh, depending on the variety. Fruits of watermelon are easily damaged and in a warm and humid atmosphere, they can be stored for only short periods. According to Saddique (1992), the dry perched seeds of watermelon are sometimes ground and baked into bread while oil extracted from the seeds is also useful for cooking and for lighting. The seeds can also be processed into livestock feed.

In Nigeria, commercial production of watermelon (especially during the dry season) is largely restricted to the seasonally damp or flooded "Fadama" and river valleys of the Sudan and Sahel savannas (Amans et al. 1992). Although there are no official production data for the country, the states of Borno, Yobe, Bauchi, Kano, Jigawa and Kaduna are the leading areas of watermelon production in Nigeria (personal communication). A number of varieties are available among which are the early maturing varieties (also called ice-box types) which mature in 70 - 75 days with round friuts of 3 - 5 kg. These include such varieties as Golden Midget (red flesh), New Hampshire Midget (red flesh), Rhode Island Red (red flesh), Sugar Baby (red flesh) and Yellow Baby (yellow flesh). However, Sugar Baby, Congo and Petit Sweet are the most popularly grown varieties in Nigeria.

The production practices vary quite widely among farmers in Nigeria. The

seeds of watermelon are planted directly to the field at spacings that vary greatly, but the National Horticultural Research Institute (NIHORT) recommends a spacing of 2.0 x 1.0 - 2.0m (Anon., 1988, 1989; Saddique, 1992). The usual planting time for late season or irrigated crop is from middle of August to early September, although this also vary among the farmers as well as location. For instance in the southern guinea savanna, the crop is planted in April and September for the early and late crop respectively. In the Northern guinea to sahel savanna, planting is best in June/July for the rainy season crop, and October for the dry season crop (Anon. 1987 and 1988).

Despite the increasing popularity of watermelon production in the Nigeria savanna, very little research has been done to study the environmental and cultural requirements of the crop. Such study is neccessary as a means to identifying ways of improving the crop yield and output. It was in view of this paucity of information that the present work was initiated to study the crop response to nitrogen fertilization and interplant spacing. The specific aims of the experiment are:

1. To study the effects of varying nitrogen fertilizer levels and intra-row spacing on the growth and yield of watermelon.
2. To find out whether significant interaction exist between intra-row spacing and nitrogen level such as to determine the appropriate combination of these factors for optimum yields of the crop.

CHAPTER TWO

2.0 LITERATURE REVIEW

There is a general paucity of research information on the cultural requirements of watermelon, particularly under Nigerian condition. Much of the available literature reviewed, therefore, relates to research work carried out elswhere, mainly outside the tropics.

2.1 Effect of Nitrogen levels on growth and development of watermelon

The application of nitrogen fertilizer has been known to enhance early vegetative growth and uniform stand establishment of most cultivated crops. This is because nitrogen is a constituents of protein, enzymes and chloropyll, thus involved in all processes associated with the protoplasm. enzymic reaction and photosynthesis. Knysh and Vakulenko (1976), Mccollum (1980) and Rice et al., (1987) have reported that the use of nitrogenous fertilizers prior to flowering in watermelon has been found to boost rapid vegatative growth and development of the plant.

2.2 Effect of Nitrogen levels on the yield and quality of watermelon.

It is expected that good plant growth would lead to higher yields (economic yields). However, not much research has been done on the effects of nitrogen levels on the yields of watermelon. The few works reported by Knysh and Vakulenko (1976), Bhosale et al. (1978), Ogunremi (1978) and Brinen et

al. (1979) involved the use of compound rather than straight nitrogen fertilizers. In some of the work reported in Nigeria by Ogunremi (1978), the response of egusi melon (a close relative of watermelon) cultivars " Bara" and "Serewe" to various levels of nitrogen (ranging from 0-73kgN/ha) was investigated. The results showed positive crop response in terms of fruit size to the application of up to 48kg N/ha. Similarly Bhosale et al.(1978), in another study on watermelon variety "Sugar Baby" in under graded levels of nitrogen, reported that the highest yield of 26t/ha was obtained with nitrogen applied at 75 and 100kg/ha; but in combination with P_2O_5 at 30kg/ha and K_2O at 75 or 100kg/ha.

However, Locascion and Halsey (1962), in another experiment with "Charleston Gray" cultivar did not observe any significant effect due to rate of N fertilizer application on yields. But, the method of N-application had a significant effect, in that split application increased the number of melon fruits by 20%, the yield of marketable grade by 25% and the average fruit weight by 4% compared with a single application. Knysh and Vakulenko (1976) reported that although applied nitrogen level had no significant effect on friut sugar, dry matter and vitamin `C' contents, the fruit size was significantly increased with increasing N-fertilization. Belik and Koleboshina (1989) also reported increased fruit size in response to higher fertilizer rates. Greensil (1976) noted that the application of nitrogen to watermelon during its reproductive phase can lead to the formation of hollow fruits.

2.3 Effect of Intra-row spacing on growth and development of Watermelon.

The degree of spacing among plant stands do often exert strong influence on growth and development by way of interplant competition for light, space, nutrient and water supply. The growth and vigour of young plants has been found to be strongly affected by intra-row spacing between the plant stands (Mohammed, 1993). An increase or decrease in intra-row plant spacing beyond a certain optimum range will influence the degree of inter-plant competition, thereby affecting the vigour and rate of growth.

Belik and Veselovskii (1973) reported that leaf and photosynthetic activity of watermelon were increased with decreasing intra-row spacing. In a field trial conducted by Gadzhonov (1972), five different intra-row spacing that gave planting densities of 6,000, 8,000, 10,000, 15,000 and 30,000 plants/ha were evaluated. It was observed that uniform ripening of fruits was produced by a crop at densities of 10,000 and 15,000 plants/ha. In the work by Ogunremi (1978), intra-row spacing had no significant effect on number of leaves per plant, but the leaf area/plant and dry matter distribution were increased with close spacing. Similar result was obtained in India by Halsey (1960), who reported that the maximum leaf area/plant was achieved at closest than wider spacings.

2.4 Effect of Intra-row spacing on the yield and quality of watermelon

An optimum intra-row and between row spacings are necessary not only for better growth of the plant but to maximize yields. Several workers have reported

increase in marketable yield with wider spacing (Thompson, 1939; Halsey, 1961, Gadzhonov, 1971; Brinen et al. (1973) reported that better yields were obtained from the closer than wider spacings of plants. In other trials with variety "Charleston Gray" grown on sandy soils, Brinen et al. (1979) observed that while the marketable size fruit yield was decreased, the total yield/plant and mean fruit weight were increased with an increase in intra-row spacing from 1.5 to 4.5m. The total yield was increased linearly with the decrease in both between row and intra-row spacings.

In a five-year study Kononenko and Maksimora (1976) noted that a decrease in land area per plant from 2.94 to 0.74m^2 led to an increase of both the total and commercial grade fruit yields. But a further decrease in the area/plant to 0.49m^2 adversely affected the commercial grade yield although the total yield continued to increase. Halsey (1960) as well as Belik and Veselovskii (1973) also reported that the number of marketable fruits per/ha was increased as the plant spacing was reduced.

Seeds yield of watermelon fruits was found to increase with decreasing intra-row spacings. Gadhzonov (1970), in a three year study with the watermelon "Ramorna" planted at 30,000, 15,000, 10,000, 8,000 and 6,000 plants/ha, reported that the highest yield of seeds was obtained with planting density between 10,000 - 15,000 plants/ha. However, the relative land area per plant did not significantly affect the qualities of the seeds produced. Gadzhonov (1972) in another experiment, reported that the highest yield of seeds with the most uniform size and quality was obtained at close rather than wider spacing. This same author noted that the variation in seed size and weight as well as the highest number of small undeveloped seeds were produced with the lower plant density (wider intra-row spacings).

Peterson (1963) in an experiment involving four inter-row spacings of 0.6, 1.2, 2.4 and 3.6m reported that fruit size decreased with closer spacing. In addition decreasing plant spacing to 0.6m led to the fruit size becoming too small for optimum commercial grade. In another experiment by Kristov (1975), maximum fruit size of water melon was produced by plants occupying wider area of 1.5 - 2.0m^2 compared with 0.6m^2. This finding confirmed the work of Halsey (1960), who reported an increase in the size of melon due to wider spacing. Petkov (1970) also reported an increase in fruit size with wider spacing, but the chemical composition of fruit remain unaffected.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Location of Experiment

The experiment was conducted at the National Horticultural Research Institute Farm Bagauda substation near Kadawa (11°39"N, 8° 02"E) in Kano state, during the 1992/93 dry season.

The soil of the experimental site is moderately deep and well drained and has a loamy texture in the upper surface, but of clay loam in the sub-surface. Soil samples were augered from the experimental site to depths of 30 centimeters. The samples were bulked, air dried and analysed for its physical and chemical properties, in Appendix I.

The weather during the trial period (October - February) was dry with relatively mild temperatures (28 to 32°C). The detail data on the weather conditions covering the period of the experiment, obtained from a meteorological station at Kadawa is shown in Appendix 2.

3.2 Variety

The variety of watermelon used for this experiment was "Sugar Baby". This is one of the most popular cultivars grown in commercial quantities by farmers in the drier savanna region of the country. The variety is of medium sized, round shaped fruit with dark green skin and red fleshed; and of early maturity (about 80 - 85 days). The origin of this variety is not yet known but the seeds used were obtained from the

Premier Hi-bred seeds company in Zaria.

3.3 TREATMENT AND EXPERIMENTAL DESIGN

Treatments tested were factorial combination of three levels of Nitrogen fertilizers (0,30 and 60KgN/ha) and four intra-row plant spacings (1.0m, 1.5m. 2,0m and 2.5m). The inter-row plant spacing was maintained constant at 2.0m. the treatments were arranged in a randomised complete block design and replicated three times. Plot size was of 4.5m x 6.0m dimension separated by 2.0m space between them.

3.4 CULTURAL PRACTICES

3.4.1 LAND PREPARATION AND PLANTING

The experimental site was first cleared of weeds, then ploughed and harrowed before it was marked out into plots. Planting was done manually on the 10th of Ocotober, 1992 soon after the plots were prepared. Three seeds of the watermelon were sown per hole at spacings that varied with the treatments. Plots were then irrigated immediately after seeds were sown. Seedlings were thinned to one plant per stand when they were two weeks after emergence.

3.4.2 Fertilizer Application

A base application of single super phosphate (18%$P_2 0_5$) and muriate of potash (60%$K_2 0$) fertilizers at the rates of 30kg $P_2 0_5$/ha and 30kg $K_2 0$/ha, respectively, were

broadcast and worked into the soil just before planting. The nitrogen treatment was applied in form of Calcium Ammonium Nitrate (26%N), in amounts that varied with the treatments. The application of the N was by side dressing in two equal split doses. The first dose was applied two weeks after sowing and the other half at flower initiation 6 weeks after sowing).

3.4.3 Irrigation

The crop was irrigated by controlled surface flooding of individual plots. This was carried out initially at 4 days interval upto 4 weeks after sowing (WAS). The irrigation interval was increased to once per week between 4th - 8th WAS, and to once in a fortnight from the 9th - 12th WAS when the crop reached maturity and harvest.

3.4.4 Weeds and pest control.

Weeds in the crop were controlled using hand hoes. The first hoe-weeding was at 4 weeks after sowing, and was repeated at 8 weeks after sowing. This was accompanied with earthing up the soil around the plant base to facilitate better drainage around the plant roots.

Cucumber beetles (Epilachna chrysomelina) were found attacking the leaves at 4 weeks after sowing, but were effectively controlled by spraying perfeckthion at the rate of 1.5l/ha using a knapsack sprayer. The spray was repeated at 8 weeks after sowing.

3.5 Observation Recorded

Four plants were randomly tagged in each plot and used for the purpose of recording the following observations listed under 3.5.1 to 3.5.4 every fortnight beginning four weeks after sowing (WAS).

3.5.1 Length of the main stem (Vine)

The vine length was measured in centimetres from the base of the stem to the shoot apex of the main vine using a measuring tape. The average length for the tagged plants represented the plot mean.

3.5.2 Number of branches per plant.

The number of branches per plant was determined by counting on each tagged plant. The average number of branches from the plants was used as plot mean.

3.5.3 Number of fully open leaves per plant.

Leaf number per plant was determined by counting the fully open leaves of each tagged plant per plot, and the average value represented the plot mean.

3.5.4 Leaf area per plant.

This was determined by first estimating the area of representative sample of leaves of different sizes (large, medium and small) from the tagged plant. These

leaves were detached from the plant and their surface area were each traced out and determined on milimeter graph paper. The total number of leaves per plant were graded and counted according to the samples whose areas were determined. The number of leaves was multiplied by leaf area and summed up to provide the apparent leaf area per plant. This method was applied to each of the tagged plants/plot and their mean values represented the plot reading.

3.5.5 Days to first flowering.

The number of days from sowing to the day of first appearance of flower in a plot was estimated from daily visit to the plots.

3.5.6 Days to 50% flowering.

The number of days from sowing to when about 50% of the plants per plot flowered were recorded.

3.5.7 Number of flowers per plant.

The number of flowers per plant was determined at 8 weeks after sowing; when most of the plants are in flower. A sample of four plants per plot was used to determine this parameter.

3.5.8 Days to maturity.

This was determined on per plot basis, by counting the days from planting to

when first fruit matured. Signs of fruit maturity (ripeness) in water melon include drying of the tendrils adjoining the fruit, production of dull hollow sound on percussion with the thumb as well as change of colour of the underside of melon fruit from pale white to creamy yellow. The fruits were inspected for these indicators at two day intervals.

3.5.9 Fruit yield/plant.

Average fruit yield per plant was determined by dividing the weight of total fruits harvested per plot by the number of plants from the plot.

3.5.10 Total fruit yield.

Total fruit yield was determined by weighing all the fruits harvested per plot. These plot yields were converted to per hectare basis.

3.5.11 Marketable grade fruit yield.

Not all fruits produced were found to be marketable. Rot-affected and very small fruits (less than 15cm diameter) were culled from the total fruits harvested and discarded. The remaining healthy and larger fruits which constitute the marketable grade fruits were weighed and the plot yield converted to per hectare basis.

3.5.12 Mean fruit weight of marketable grade.

The average fruit weight of marketable size fruit was determined by dividing

the total weight of this grade harvested per plot by its number.

3.5.13 Dry matter content of fruit (%).

A random sample of three fruits per plot were sliced into thinned pieces and oven dried at 70°C to a constant weight. The dry matter was expressed as percentage of the fruit fresh weight.

3.5.14 Sugar content of the fruits (%).

The sugar content of fruits were determined from the juicy flesh using Hand Refractometer. Average readings were taken per fruit, using a sample of the fruits per plot.

3.5.15 Seed yield per fruit (g).

Seeds per fruit basis were manually extracted, washed and sundried. The dried seeds were weighed. A sample of three fruits/plot was used.

3.5.16 100-seed weight (g).

Seeds, extracted from a sample of three fruits per each plot were washed and sundried. Sub-samples of 100 seeds per fruit were weighed and their mean value determined.

3.6 Statistical Analysis.

Data collected were subjected to statistical analysis of variance using the F-test for significance, as described by Snedecor and Cochran, 1967. The differences among the treatment means were then compared using Duncan' multiple range test (Duncan, 1955). Simple correlation analysis among the growth and yield parameters measured was also worked out.

CHAPTER FOUR

4.0 Results

4.1 Length of main vine

The effect of treatments on the length of main vine of watermelon plant, recorded at 4 and 8 WAS are shown in Table 1.

The variation in nitrogen level at 4 and 8 WAS and intra-row spacing at 4 WAS produced no significant effect; however, increasing the intra-row spacing at 8 WAS, showed that sowing at 2.5m produced longer main vine than 1.0m. The other differences were statistically at par.

The interactions between nitrogen and intra row spacing were also not significant.

4.2 Number of branches per plant

The number of branches per plant at 8 WAS as affected by nitrogen level and intra-row spacing is shown in Table 2. Neither the effect of nitrogen application nor that of intra-row spacing significantly affected the number of branches per plant.

None of the interactions was significant.

4.3 Number of leaves per plant

Data on number of leaves per plant counted at 8 WAS is shown in Table 2.

The variation in nitrogen and intra-row spacing produced significant effect on number of leaves. Application of 30kgN/ha gave higher leaf number than

Table 1: Effect of Nitrogen level and Intra-row spacing on length of main vine (m) of water melon at Kadawa during 1992/93 dry season

Treatments	4 WAS	8 WAS
Nitrogen (KgN/ha		
0	31.4	59.4
30	26.8	57.8
60	26.1	52.2
SE±	2.71	4.85
Intra - row spacing (M)		
1.0	33.6	44.3b
1.5	26.0	60.5ab
2.0	30.6	52.0ab
2.5	22.1	67.1a
SE±	3.13	5.60
Interaction		
N x S	NS	**NS**

Means followed by the same letter(s) within a column and treatment are not significant statistically at P=0.05 using DMRT.

NS = Not significant

Table 2: Effect of Nitrogen levels and Intra-row spacing on number of branches/plant and number of leaves/plant of water melon at Kadawa

Treatments	Number of branches/plant	Number of leaves/plant
Nitrogen (KgN/ha		
0	3.81a	46.0b
30	3.41b	51.0a
60	3.71a	49.0a
SE±	0.20	2.81
Intra - row spacing (M)		
1.0	3.7a	45.8b
1.5	3.9a	46.0b
2.0	3.6b	50.0a
2.5	3.3c	52.9a
SE±	0.23	3.25
Interaction		
N x S	NS	**NS**

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT.

control and 60kgN/ha. While increase in intra-row spacing increased the number of leaves per plant.

None of the interactions was significant.

4.4 Leaf area per plant

The main effect of treatments on leaf area per plant at 4 and 8 WAS are in Table 3.

Application of nitrogen had no significant effect on the leaf area per plants. However at 8 WAS, the application of 30kgN/ha significantly increased the leaf area. Further increase in nitrogen to 60NgN/ha reduced the leaf area per plant.

There was no significant different in leaf area by increasing the intra-row spacing from 1 to 2m at the 2 sampling period, but, further increase of intra-row spacing to 2.5m significantly increased the leaf area per plant.

The interaction between Nitrogen level and intra-row spacing on leaf area per plant was significant at 8 WAS (Table 4). At the 2.5 and 1.5m crop spacing, increase in nitrogen level had no significant effect on leaf area. But when spacing was reduced to 2.0 or 1.0m. Increasing N-level either from 0-30-30-60kg N/ha had significant effect on leaf area.

4.5 Days to first flowering

The number of days to first flowering as affected by treatments is shown in Table 5.

The application of nitrogen fertilizer had no significant effect on the number of days to first flowering of water melon plants. Varying the intra-rowspacings between 1.0 to 2.5m also did not significantly affect the number of days to first flowering.

There was no significant interaction between nitrogen levels and intra-row spacing on the number of days to first flowering.

Table 3: Effect of Nitrogen level and Intra-row spacing on the leaf area cm/plant at 4 and 8 WAS at Kadawa

Treatments	4 WAS	8 WAS
Nitrogen (KgN/ha		
0	49.9c	99.8b
30	53.1a	106.3a
60	50.1b	99.9b
SE±	1.10	6.29
Intra - row spacing (M)		
1.0	44.3c	82.7b
1.5	49.6b	99.2b
2.0	50.2b	100.3b
2.5	62.8a	125.7a
SE±	1.21	7.27
Interaction		
N x S	NS	*

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT.

Table 4: Interaction between Nitrogen level and Intra-row spacing on the leaf area (8 WAS) of Water melon at Kadawa.

Intra-row spacing (M)	Nitrogen 0	30	60
1.[redacted]	70.0c	110.7abc	99.7b
1.5	91.3bc	105.3abc	95.7ab
2.0	102.0abc	125.3ab	73.7c
2.5	135.7a	110.7abc	130.7ab
SE±	12.59		

Means followed by the same letter (s) are not significant statistically at 5% level using DMRT.

4.6 Days to 50 percent flowering

Table 5 shows the effect of treatments on the number of days to 50% flowering. Increase in nitrogen level from 0 to 30kgN/ha did not affect the days to 50% flowering significantly; but further increase in nitrogen to 60kgN/ha increased the days to 50 percent flowering. Changes in intra-row spacing did not significantly affect the number of days to 50% flowering.

None of the interactions was significant.

4.7 Number of flowers per vine

Neither nitrogen nor intra-row spacing had any significant effect on the number of flowers per vine of water melon (Table 5).

Also the interactions were not significant.

4.8 Number of days to Maturity

Table 6 showed the effect of nitrogen and intra-row spacing on number of days to maturity.

The application of nitrogen had no significant effect on the number of days to maturity of water melon fruits.

The intra-row spacing was observed to significantly influenced the number of days to maturity. Increased in intra-row spacing from 1 - 1.5m increased the number of days to maturity; further increase in intra-row spacing from 1.5 to 2.5 did not affect the day to maturity.

The interaction between nitrogen levels and intra-row spacings was not significant statistically.

Table 5: Effect of nitrogen level and intra-row spacings on the days to first flowering days to 50% flowering and on the number of flowers per vine of watermelon at Kadawa.

Treatment	Days to first flowering	Days to 50% flowering	No of flowers per vine
N-levels (kg/ha)			
0	45.75	55.00b	4.75b
30	44.92	54.83b	4.92a
60	44.92	57.08a	4.42b
S.E ±	1.06	0.58	0.43
Intra-row spacings (m)			
1.0	44.89	56.44	5.33
1.5	43.56	55.89	5.22
2.0	47.22	54.89	3.67
2.5	45.11	55.33	4.56
S.E ±	1.23	0.67	4.50
Interaction			
N x S	NS	NS	NS

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT.

Table 6: Effect of nitrogen levels and intra-row spacings on number of days to maturity and mean yield/plant of watermelon fruits at Kadawa.

Treatments	Days to maturity	Mean yield/ plant (kg)
N-levels (kg/ha)		
0	82.00	14.1
30	81.80	16.3
60	80.60	21.8
S.E ±	1.06	2.54
Intra-row spacings (m)		
1.0	76.30c	6.6c
1.5	81.20b	8.20c
2.0	83.10a	19.30b
2.5	85.30a	35.50a
S.E. ±	1.29	2.93
Interaction	NS	NS

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT.

4.9 Mean fruit yield per plant

The effect of nitrogen and intra-row spacing on the mean fruit yield/plant is shown in Table 6.

The application of nitrogen had no significant effect on the mean fruit yield/plant.

A significant effect of intra-row spacing on fruit yield was observed. Increasing the intra-row spacing from 1 to 1.5m did not affect the fruit yield. However, further increase in intra-row spacing to 2 and 2.5m significantly increased the mean fruit yield.

The interaction of nitrogen and intra-row spacing was not significant statistically.

4.10 Total fruit yield (t/ha)

The effect of nitrogen and intra-row spacing on the total yield of fruits (t/ha) is shown in Table 8.

Increase in nitrogen level either from 0 to 30 or 30 to 60kgN/ha did not affect the total fruit yield; however the yield produced at 60kgN/ha was the highest.

Significant difference in fruit yield was observed in respect to varying intra-row spacings. The widest spacing (2.5m) produced the highest fruit yield, which was significantly greater than at other spacings except 2.0m spacing. The difference in yield produced at 1.0m and 1.5m were not significant statistically.

No significant interaction between nitrogen and intra-row spacing was

observed.

4.11 Marketable fruit yield (t/ha)

The effect of nitrogen and intra-row spacing on marketable yield of water melon fruits is shown in Table 7.

Application of nitrogen had no significant effect on the marketable fruit yield of water melon.

Increasing the intra-row spacings, from 1.0 to 1.5m did not affect the marketable fruit; however, further increase in spacing from 1.5 to 2 and 2.5m increase the marketable fruit yield. There was no significant interaction between nitrogen levels and intra-row spacing.

4.12 Mean fresh weight of fruits (kg)

The mean fresh weight of fruits of water melon was significantly increased by the application of nitrogen (Table 7).

The application of 60kgN/ha gave significantlly heavier fresh fruit when compared to plot that received 30kgN/ha and 0 nitrogen which were at par.

Changes in intra-row spacing significantly influenced fruit weight. There was a successive increase in mean fruit weight as spacing was increased from 1.5 to 2.0 and 2.5m. The increased in fresh weight, when the intra-row spacing was increased from 1.0 to 1.5m was however not significant.

None of the interactions was significant.

Table 7: Effect of nitrogen levels and intra-row spacings on the total and marketable fruit yield and mean fresh weight per fruit of watermelon at Kadawa.

Treatments	Total yield (t/ha) (t/ha)	Marketable fruit yield (kg)	Mean fresh weight/fruit
N-levels (kg/ha)			
0	34.9b	27.5	7.53b
30	43.8ab	33.4	8.25b
60	54.9a	40.0	9.83a
S.E ±	4.62	4.70	0.43
Intra-row spacings (m)			
1.0	25.9b	17.1c	3.81c
1.5	30.4b	20.7c	4.0c
2.0	53.1a	39.5b	9.39b
2.5	68.6a	57.3a	16.41a
S.E. ±	5.34	4.70	0.50
Interaction			
	NS	NS	NS

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 level using DMRT.

4.13 Fruit dry matter content (%)

Fruit dry matter content of water melon was significantly affected by nitrogen application Table 8.

Application of 60kgN/ha significantly increased fruit dry matter when compared to 30kgN/ha and control.

Changes in intra-row spacing significantly influenced the dry matter content. The increase in intra-row spacing from 1.0 to 1.5m produced no significant effect on dry matter, further increase of intra-row to 2.0 and 2.5m gave successively significant increase in dry matter content of fruit.

The interaction between nitrogen and intra-row spacing had no significant effect on the fruit dry matter.

4.14 Sugar content of fruits

The effect of nitrogen and intra-row spacing on fruit sugar content is shown in Table 8.

The application of 30kgN/ha significantly increased the sugar content of fruits over control. The difference in sugar content between the highest and medium rate (30 and 60kgN/ha) was not significant.

Changes in intra-row spacings and its interaction with nitrogen have no significant effect on the sugar content of water melon fruits.

4.15 Seeds yield per fruit

The effect of nitrogen and intra-row spacing on seed yield per furit is shown in Table 8.

Table 8: Effect of nitrogen levels and intra-row spacings on dry matter, Sugar content and Seed dry weight of watermelon fruit at Kadawa.

Treatments	Dry matter content (%)	Sugar content (%)	Seed dry weight (g)
N-levels (kg/ha)			
0	29.8b	0.81b	30.71b
30	33.4ab	0.93a	31.42b
60	39.3a	0.95a	36.54a
S.E ±	1.5	0.03	0.55
Intra-row spacings (m)			
1.0	14.2c	0.92	21.72c
1.5	17.8c	0.89	29.11b
2.0	40.6b	0.88	39.28a
2.5	64.10	0.89	41.44a
S.E. ±	1.7	0.04	0.63
Interaction			
N x S	NS	NS	*

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT. * Interaction is significant at P = 0.05

Increased in nitrogen applied from 0 to 30kgN/ha did not affect the seed yield; further increase to 60kgN/ha resulted in significantlly increased seed yield per fruit.

The seeds dry weight responded positively to increased intra-row spacing. Each increase in intra-row spacing from 1.0 to 2.0m resulted in significant increase in seed dry weight; however no significant difference was observed when the intra-row spacing was further increased from 2.0 to 2.5m.

The interaction between nitrogen and intra-row spacing was significant (Table 13). At the closest spacing 1.0m, the seed weight was not affected by nitrogen application. When the spacing was increased to 1.5 and 2.0m, each addition of nitrogen significantly increased the seed weight. At 2.5m spacing, both the control and 60kgN/ha gave similar seed weight, while application of 30kgN/ha reduced the seed weight. When each nitrogen level was examined in respect to varying intra-row spacing. At control, increase in intra-row spacing from 1 to 1.5m increased the seed weight significantly, further increase to 2.0m had no significant effect. At 30kgN/ha, the level of significance can be divided into 1.0 - 1.5, and 2.0 - 2.5m. While at 60kgN/ha, each increase in intra-row spacing from 1.0 to 2.0 significantly increase

Table 9: Interaction between Nitrogen level and Intra-row spacing on seed dry weight per plant of Water melon at Kadawa.

Intra-row spacing (M)	Nitrogen (kgN/ha) 0	30	60
1.0	19.50f	23.33e	22.31ef
1.5	29.67d	38.00c	32.33d
2.0	30.67d	25.33e	49.17a
2.5	43.00b	39.00c	42.33b
SE± 1.09			

Means followed by the same letter (s) are not significant statistically at 5% level using DMRT.

the seed weight, but further increase in intra row spacing to 2.5m reads to reduction of seed weight.

4.16 100 seed weight

The effect of nitrogen and intra-row spacing on 100 - seed weight of water melon is presented in Table 10.

Application of 30kgN/ha significantly increased the 100 - seed weight when compared to the control. The difference between application of 30 and 60kgN/ha was not significant.

The effect of intra-row spacing was significant. Each increased intra-row spacing led to reduction of 100-seed weight.

The interaction between nitrogen and intra-row spacing was significant (Table 11). When the intra-row were considered spacings at fixed nitrogen level, It was observed that, at control, the level of significances fall into 2 major groups; 1.0-1.5 and 1.5-2.5m. At 30kgN/ha, increasing the intra-row spacing from 1.0 to 1.5m significantly reduced the 100-seed weight, further increase in intra row spacing have no effect on the test weight. At 60kgN/ha, two levels of significance were observed, 1.0 - 1.5 and 2.0 and 2.5m. When the different levels of nitrogen were considered in respect to each intra-row spacing, at 1.0m, each increase in N-rate resulted in increased 100-seed weight; while at 1.5m, there was no significant difference in the test weight by increasing the level from 0 to 30, however further

Table 10: Effect of nitrogen levels and intra-row spacings on 100 seed weight of water melon at Kadawa

Treatments	Seed dry weight (g)
N-levels (kg/ha)	
0	4.86b
30	5.79a
60	6.11a
S.E ±	0.16
Intra-row spacings (m)	
1.0	6.89a
1.5	5.61b
2.0	5.22b
2.5	4.64c
S.E. ±	0.18
Interaction	
N x S	*

Means followed by the same letter(s) within a column and treatments are not significant statistically at P=0.05 using DMRT.
* Interaction is significant at P = 0.05

Table 11: Interaction between Nitrogen levels and Intra-row spacings on 100-seed weight of Water melon at Kadawa.

Intra-row spacing (M)	Nitrogen (kgN/ha) 0	30	60
1.0	4.00ef	7.17b	9.50a
1.5	4.83e	5.67cd	3.43f
2.0	5.50d	4.83d	6.50bc
2.5	5.17d	5.50de	5.00d
SE± 0.32			

Means followed by the same letter (s) not significant statistically at 5% level using DMRT.

increase to 60kgN/ha reduced the test weight. At 2.0m, the 100-seed weight was not affected by increase in N-rate from o to 30kgN/ha but further increase in N to 60 kgN/ha increase the test weight. Nitrogen had no significant effect on 100-seed weight at 2.5m.

4.17 Correlation studies

Correlation studies between total yield, yield components and other parameters of water melon is presented in Table 12.

Simple correlation coefficient showed that there was no significant correlation between total yield, leaf area and days to maturity; while a very strong positive correlation was observed between total yield and mean fruit weight, marketable fruit yield, dry matter content and seed yield/fruit.

Table 12: Matrix of correlation (r) between total fruit yield, yield components and growth parameters of water melon at Kadawa.

	1	2	3	4	5	6	7	8	9
1	1.0000								
2	-0.1593Ns	1.0000							
3	0.3599NS	0.1815NS	1.0000						
4	0.8324**	0.2895NS	0.4064NS	1.0000					
5	0.9646**	0.1134NS	0.4049NS	0.8350*	1.0000				
6	0.8333**	0.2895NS	0.4113NS	0.9938**	0.8340**	1.0000			
7	0.4273NS	-0.4431NS	0.2214NS	0.5347*	0.4010NS	0.5133*	1.0000		
8	0.9439**	-0.1870NS	0.3915NS	0.8915**	0.9408**	0.8798**	0.4424NS	1.0000	
9	0.0444NS	0.1659NS	-0.1955NS	-0.0020NS	0.0430NS	0.0352NS	-0.1350NS	0.0068NS	1.0000

1. Total fruit yield. 2 length of vine (8 WAS) 3 leaf area (4 WAS) 4. Mean fruit weight
5. Marketable fruit yield 6. fruit dry matter control (8). seed yield/fruit.
8. Mean yield/plant 9. Sugar content.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Effect of nitrogen fertilization.

Leaf area per plant at 8 weeks after sowing as well as leaf number at 8 weeks after sowing were increased by nitrogen application at the rate of 30kgN/ha. A further increase in fertilizer rate at 60kgN/ha did not significantly increase the leaf number and leaf area per plant. The positive response shown by leaf area and number of N-application up to 30kgN/ha would be expected in view of the role of nitrogen in photosynthesis especially when initial soil N-content is low. Nitrogen is an essential constituent of chlorophyll, amino acids, enzymes and proteins that are all vital in growth processes, particularly of vegetative growth such as leaf production and expansion. Mccollum (1980) and Rice et al (1987) also reported enhanced vegetative growth in watermelon when nitrogenous fertilizers were applied. It is apparent that the optimum nitrogen requirement for vegetative growth in this experiment lie between 0 and 30kgN/ha since the effect of the higher rate did not significantly differ from that of the lower rate.

Application of 60kgN/ha resulted in the maximum number of days to 50%flowering compared with 30kgN/ha and control. This indicates that the enhancement of vegetative growth by nitrogen application consequently led to a delay in the days to 50% flowering by watermelon plants. The higher nitrogen level prolonged the vegetative growth phase relative to that of the reproductive stage. Similar observations have been reported by (Knysh and Vakulenko, 1976; McCollum (1980) and Rice et al (1987).

Despite the delay in rate of flowering, the day to first flower appearance and

the total number of flowers per vine recorded at 42 days after sowing were not significantly affected by the N-treatments. This indicates that the delay in the rate of flowering may not necessarily influence the final outcome of the reproductive phase. This is confirmed by the fact that total fruit yield/ha, mean fresh and dry weight of fruits were significantly increased by the application of nitrogen. The increase in watermelon fruit yield/ha with increased nitrogen fertilization was due to better vegetative growth which increased the production and translocation of assimilates for fruit growth. Strong postive correlations was found between leaf area and fruit growth. Similar observations of higher yields of watermelon in response to nitrogen application were reported by Knysh and Vakulenko (1976) Mahakel et al 1977), Bhosale et al (1978) and Ogunremi (1978). These workers reported increased fruit size of watermelon with increasing levels of nitrogen. In the present study, nitrogen application at the rate of 60kgN/ha produced the maximum yield of fruits/ha but the effect of nitrogen on the marketable fruit yield and the mean fruit yield per plant were not significant.

The fruit sugar content was significantly increased with nitrogen application upto 30kgN/ha. Naturally, watermelon store much of its photosynthetic carbohydrate as simple sugars in the fruit. The improvement in general crop growth in response to nitrogen application led to more efficient and higher rate of photosynthate production. The higher production of carbohydrate is expected to lead to a relatively higher amount of sugars being translocated and stored in the fruits as observed in this study. However, this result is not in conformity with the findings of Knysh and Vakulenko (1976) who reported that nitrogen application had no significant effect on fruit sugar and Vitamin C contents. In the work of the above authors, it is most likely that increase in fruit size in response to better N-nutrition reduced the concentration

of accumulated sugar such that the net effect of the sugar content appear unaffected if not lowered. In this present study, although the application of nitrogen had increased sugar content, applying more than 30kgN/ha had no further significant influence on the sugar content.

The increase in seed weight per fruit by increasing N from 30 to 60 could be associated with better nutritional status of the crop. Application of nitrogen enhances efficient and higher rate of photosynthate production leading to subsequent translocation and storage of the photosynthate in the fruits and seeds of watermelon.

5.2 Effect of Intra-row spacing.

The vegetative growth of watermelon was significantly influenced by intra-row spacings. The stem length leaf number, leaf area per plant, days to fruits maturity, as well as fruit weight were all significantly increased by increase in intra-row spacing. This significant increase could be associated with the increase in the rate of photosynthesis. Watermelon planted at closer intra-row spacings tends to cover the soil surface very easily thereby ensuring maximum light interception by the leaves for rapid formation of carbohydrates, which are subsequently used in tissue formation and growth. Belik and Veselovskii (1973) also reported a similar increase in leaf area and photosynthesis with decrease in intra-row spacings. Halsey (1960) and Ogunremi ((1978) also observed similar trends of increase in leaf area per plant with decrease in intra-row spacing.

The number of days to maturity of watermelon was, however, found to increase significantly with increase in the intra-row spacings. Wider intra-row spacing meant less intra-plant competition for nutrient, water and light. Thus, it appears that the larger fruits from wider spaced plants took longer to mature (Table 6).

Fruit yield (both total and marketable) per ha, fresh and dry weight per fruit as well as the seed yield per fruit were significantly increased with increasing intra-row spacings. These increases may be associated with the level of inter plant competition. Increasing intra-row spacings reduced the pressure due to competition for space and nutrients and contributed towards greater crop vigour and yield. Therefore higher yields of large fruit and seed from the wider than closer intra-row spacing is to be expected. Reports from some workers, however, showed that maximum yield/ha was obtained at the closer rather than wider spacing (Petkov, 1973 and Khristov. 1973). In these findings, the closer spacing increased the average number of fruits obtained per ha. However, with a widening intra-row spacing, the individual fruit weight and yield/plant were increased. This increase in fruit weight and yield/plant was also reported by Halsey, (1960), Khristov, (1975) and Brinen et al (1979).

Watermelon seed yield was increased with the increase in intra-row spacing, which was a reflection of the general improvement in the growth of plants under wider spacing. There was a strong positive correlation between fruit size and seed yield. Gadzonov (1970) also reported highest melon seed yield from closely spaced plants.

5.3 Interaction between nitrogen level and intra-row spacing.

Significant interactions between nitrogen level and intra-row spacing were observed on number of branches per plant, leaf area per plant and seed weight per fruit. Plants spaced at intra-row spacing of 1.0m and supplied with 30kgN/ha produced the highest number of branches per plant. Planting of watermelon at a spacing of 2.0m and 30kgN/ha gave the highest leaf area per plant. However, this result was statistically at par with that of 2.5m and 60kgN/ha.

The significant interaction observed between nitrogen level and intra-row spacing when seed weight/fruit was considered showed that 2.0m and 60kgN/ha produced the highest seed weight per fruit. This significant increase in seed weight with nitrogen application has been explained earlier. For 100 seeds dry weight, however, a spacing of 1.0m and 60kgN/ha was found to have the greatest weight of 100 seeds per fruit. This was in conformity with the report of Gadhzonov (1970).

CHAPTER SIX

6.0 SUMMARY AND CONCLUSION.

A field experiment to investigate the effects of varying levels of nitrogen (0,30 and 60kgN/ha) and intra-row spacings (1.0,1.5,2.0 and 2.5m) on the yield of watermelon (var. Sugar Baby) was carried out at Kadawa (11°39"N,8°02"E in the northern Guinea savanna ecological zone) during the 1992 - 1993 dry season.

The results of this study revealed that application of nitrogen significantly increased the plant leaf number, leaf area, days to 50% flowering. Number of branches, number of flowers and the days to first floweing were not significantly affected by nitrogen application. Total fruit yield, mean fruit weight and seed weight per fruit were all significantly increased with nitrogen application.

Intra-row spacings also significantly increased number of leaves, leaf area, days to fruit maturity and well as fruit size. Fruit (total and marketable) as well as seed weights were also significantly increased with increased intra-row spacings. The highest fruit yield of 68.6t/ha was obtained from the widest spacing of 2.5m and highest rates of 60kgN/ha.

The interaction of nitrogen levels and intra-row spacings were also found to be statistically significant interms of number of branches per vine, leaf area/plant and seed weight per fruit. Watermelon meant for seed production should therefore be planted at a spacing of 1.5m and be given 60kgN/ha.

Going by the results of this investigation. It can be deduced that intra-row spacings and nitrogen fertilization are of paramount importance in the cultivation of watermelon either for the edible fruits or seed production. The application of 60kgN/ha and intra-row spacings of 2.0m could be used for higher yields of better

quality fruits. Further increase in intra-row spacing from 2.0 to 2.5m no doubt give heavier fruits and thus more yield, but such fruits cannot easily be tansported to distant markets (personnel communication).

REFERENCES

Amans, E.; Cecilia, C.; Lacruz, G.; Masaoa, A; Moss, R and Schouten, C (1992). Analysis of the farming systems in the Hadejia Jama'are Flood plain of Northern Nigeria. Aworking Document series: 20, 113pp.

Anonymous (1987). Guide to the production of melon National Horticultural Research Institute, Ibadan, Nigeria.

Anonymous (1988). Annual Report on vegetable programme National Horticultural Research Institute, Ibadan, Nigeria.

Amonymous (1989). Annual Report on vegetable programme National Horticultural Research Institute, Ibadan, Nigeria.

Belik, V.F.; Veselovskii, M. YA. (1973). The effect of planting density on photosynthesis in irrigated water melon. Referativnyl Zhurnal, (Hort. Abstr.)

Belik, V.P and Koleboshina, T.G. (1989). The productivity of water melon in relation to fertilizer rates and plant density. Referativnyl Zhurnal, 5.5. 360

Bhella, H.S. (1988). Effect of Trickle irrigation and Black mulch on growth, yield and mineral composition of water melon Horticultural Science Journal. 23 (1), 1988

Bhosale, R.J.; Khanvilkar, S.A.; Andhale, R.K. (1979). Yield performance of water melon (Citrullus Vulgaries schard) variety sugar Baby under graded levels of Nitrogen, phosphorus and potassium Journal of Maharashtra Agric. University, (1978) 3.

Brinen, G.H.; Locascio, S.E and Elmstrom, G.W. (1979). Plant and row spacing, mulch and fertilizer rates effects on water melon production. J. Horticultural science Journal. 104: 724-726.

Elmstrom, G.W.; (1973). Water melon root development affected the direct seedling and transplanting Horticultural Science Journal. 8: 134-136

Gadzhonov, I. (1970). The effect of the nutrient area on the yield and quality of water melon seeds. Gradinastro 12 (7): 18 - 21

Greensill, T.M. (1976). Growing better vegetables. 4th Impression pub. Evens Brothers Ltd. London 157p.

Grubben. G.F.H. (1976). Tropical vegetables and their genetic resources. Publication of the International Board for plant genetic Resources. pp. 40 - 44

Halsey, L.H. (1960). Water melon spacing and fertilization on yield, quality, N-uptake and water use efficiency of water melon (Citrullus lanatus) Indian Journal of Agric. Science. 58. 444 - 446.

Herklots, G.A.C. (1972). Vegetables in south-East Asia Published by London George Allen and Unwin Ltd. P. 314 - 318.

James, E-simon; Gerald, E. Wilcox; Michael, S.; Osman, M.E. and Dennis, K.D. (1986). Identification of Managanese grown in Low P^H Soils. Horticultural Science Journal 21: 1383 - 1386.

Khristov, B. (1973). The suitable size and shape of nutrient area for mechanised sowing of early water melon cultivars. Gradinarska ilozarska 10. 89 - 95.

Knysh, A.N. and Vakulenko, R.I. (1976). Effect of mineral fertilizers on water melon yield and quality Agrokhimiya (1976) 2, 100-10 (RV) from Referatunyl Zhurnal. 6.55 - 67

Locascion S.J. and Halsey, L.H. (1962). Fertilizer requirements of water melon. Florida Agric. Experiment Station's Annual Report. pp. 194 - 5.

Locascion, S.J.; Fiskell, J.G.A; Elmostron, G.W. (1978). Comparison of sulfur coated and uncoated urea on water melons. Soil and Crop Science Society of Florida Proceedings. 37, 197 - 200

Malinina, M.I. (1971). Source material and methods of growing cuccurbits crops. Trady poprikladnoi Botanike Genetike T. Selektssi. 44: (2) 113 - 120.

McCollum, J.P. (1980). Producing vegetable crops 2nd Edition. Interestate printers and publishers - inc. Illinois. P.493-507

Melvin, R.H.; Suhas, R. Ghate, and sharad C. phatak (1988). Germinated seeds for field establishment of water melon University of Georgia coastal plain Experimental Station

Nichols, M.A. (1989). Growing for export: water melons and melons. Agribusness Worldwide (11 (3): 19 - 24.

Ogunremi, E.A. (1978). Effects of nitrogen on Melon (Citrullus lanatus Thumb.) at Ibadan 357 - 365.

Peterson, L.E. (1961). Get more water melon with smaller spacing. Iowa Farm Sci., 15: 631.

Peterson, L.E. (1962). Space close for water melon yields.

Petkov, M. (1970). The effect of the area of nutrition on yield and quality in water melon production. Gradinastro. 12:18 - 20 (Bulgarian).

Rice, R.P., Rice, L.W. Tindale, T.O. (1987). Fruits and vegetables production in Africa. (1st Edition) macmillan pub. Ltd.

Saddique, M.A. (1991). Production of water melon. A paper presented at the Bauchi State Agricultural Development Project, Monthly Technology Review Meeting (MTRM) held between 11 - 14 August, 1991. pp 9.

Singh, R.V. Naik, L.B. (1989). Reponse of water melon (Citrullus Danatus Thumb. Monsf.) to plant density, Nitrogen and phosphorus fertilization. India Journal of Horticulture: 46, 80 - 83.

Splittstoesser, W.E. (1979). Vegetable growing Handbook. The A.U publishing company. pp. 258 - 260.

Stucky, H.P. (1951). Southern Horticulture. pp. 311 - 340.

Thompson, H.C. (1939). Vegetable crops 3rd Edition. pp. 510 - 517.

Whitaker, T.W. and G.N. Davis (1962). Cucurbits:- Botany, Cultivation and Utilization. Pp. 250.

Appendix 1: Physical and chemical properties of soil from experimental sites at (Kadawa)

P^H in water (1:2.5)	6.50
P^H in 0.01M caclx (1:2.5)	5.80
Organic carbon (%)	0.76
Total Nitrogen (%)	0.70
Available P (ppm)	13.44
Exchangeable cations (meq/100g)	
K	0.41
Ca	7.38
Mg	1.47
Na	0.12
C.E.C	11.20
Extractable Micro nutrients (ppm)	
Cu	1.28
Mn	33.00
Zn	5.00
Fe	50.00
B	0.31
Particle size distribution	
Clay (%)	16
Silt (%)	28
Sand (%)	56
Textural class	Loam

Appendix 2: Meteorological data during the period of the Experiment (1992/93 dry season) at Kadawa

Period	Temperature (°C)		Relative Humidity 10.am Morning (%) 4.pm		Rainfall (mm)
	Max	Min			
OCT. 92	30	20	74	55	Total 39.9-3
NOV. 92	33	17	62	49	2.6-1
DEC. 92	28	11	28	24	NIL
JAN. 93	32	17	19	13	NIL
FEB. 93	32	14	16	26	NIL
MAR. 93	36	16	33	18	TRACE