EFFECTS OF SOWING DATE AND PLANT POPULATION ON YIELD AND YIELD COMPONENTS OF SESAME (Sesamum lndicum L.)

BY

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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.

PETER DUNIYA KATUNG

Date: 3rd May 1988

The above declaration is confirmed.

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CERTIFICATION

This thesis entitled "EFFECTS OF SOWING DATE AND PLANT POPULATION ON YIELD AND YIELD COMPONENTS OF SESAME (*Sesamum indicum* L.)" by Peter Duniya Katung meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific knowledge and literary presentation.

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"To accomplish great things,
We must not only act,
But also dream,
Not only plan,
But also believe"

- Anatole France

And ----------

"The great thing
In this world
Is not so much
Where we are,
But in what direction
We are moving"

- Oliver Wendel Holmes

DEDICATION

This work is dedicated to my mother, Mrs. A'AMANTA KATUNG and my father, late Mr. KATUNG DUNIYA.

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ABSTRACT

Investigation was carried out at Samaru during the 1966 wet season to observe the effects of three plant populations (100,000; 250,000 and 400,000 plants/ha), three Bowing datea (2k June, 15 July and 5 August, 1986) and two varieties (Pb-till$_1$ and E$_8$) on seed yield and yield components of sesame.

Increasing plant population from 100,000 to 250,000/ha increased seed yield by 27%. Further increase in plant population from 250,000 to M30,000/ha resulted in no significant increase in seed yield.

Although the effect of plant population on number of pods, seed yield/plant and number of seeds/plant was not significant, these characters decreaBed with increasing plant population. Number of seeds/pod, length of pods and 1,000 seed weight were also not significantly affected by plant population.

The earliest sown sesame with a mean seed yield of 319.00 kg/ha, outyielded the second and third sowinga by averages of 37.80% and 55.20%, respectively. Seed yield reduction with delay in sowing were caused mainly by decreases in the number of pods/plant, seed yield/plant, number of seeds/plant and number of seeds/pos.

The variety E$_8$ excelled Pb-till in yield and yield components. All possible treatment lnteractions had significant effect8 on one parameter or the other. However,

none of the treatment interactions influenced seed yield.

There were positive and significant correlations between seed yield and yield components measured.

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Chapter 1

INTRODUCTION

Sesame (Sesamum indicum L.) is probably the most ancient oilseed used by man (Smilde, 1960; Weiss, 1971; Anonymous, 1980). It is a crop of great antiquity, whose origin cannot now be traced with any certainty (Tribe, 1967; Weiss, 1971). The crop is widespread in tropical and sub-tropical regions especially in India and China, where it is considered one of the most important oil crops. In the Western hemisphere the expansion of the culture was hampered because this crop is not adapted to completely mechanized harvest owing to the dehiscense of the capsules at maturity.

Sesame is a crop of the tropics and warm temperate regions (Tribe, 1967). It normally requires fairly warm conditions during growth to produce maximum yields, and the average daily temperature required during the critical three to four months growth period is 23 to 30^{o}C (Weiss, 1971). A temperature of 25 - 27^{o}C encourages rapid germination, initial growth and flower formation (Weiss, 1971). Sesame is usually grown in areas with an annual rainfall of 625 - 2,250 mm. Once established, it can tolerate short periods of drought (Purseglove, 1968). Sesame grows in the plains and at elevations up to 1,200 m (Tribe, 1967; Anonymous, 1980). It cannot stand frost, continued heavy rainfall or prolonged drought.

Sesame is adapted to many types of soil but does best

on well drained fertile soils of loamy texture and neutral reactions (Anonymous, 1958; Tribe, 1967; Anonymous, 1980). It can also grow on permeable clays or dark alluvial soils, where moisture is not limiting and water-logging not pronounced.

The importance of seasame in international trade has diminished in favour of other more easily, and, therefore, cheaply produced oilseeds which are mainly used for industrial purposes (Weiss, 1971). Weiss (1971) reported that the decline in sesame production is not only due to increased production of other local oil seeds but also the deliberate introduction of alternatives. In Burma, for instance, the introduction of groundnut into the local cropping programme, where it actively competed with sesame, effectively reduced the rate of expansion of sesame. When the two are grown under similar conditions, however, and the newly developed high yielding, high oil content, indehiscent varieties of sesame sown then a very different relationship emerges (Weiss, 1971). In U.S.A., for instance, the overall average yield of oil for seven varieties grown at eight locations was quoted as 387 kg/ha compared with average in the same area of 193, 190, 230 and 79 kg/ha of oil from linseed, soybean, groundnuts and cotton, respectively. In these circumstances, the growing of sesame would be profitable. Profitability will, however, depend on local conditions and the relative incentives given to producers of the various oilseeds. What is obvious is that much higher yields of sesame seed and oil/ha are possible than are presently obtained.

The demand for sesame on a world wide basis is frequently greater than world production, and except where sesame is grown as a cash crop for export, there are seldom any large quantities available to world trade (Weiss, 1971). Another factor restricting its wider usage is a higher price than alternative oilseeds (Weiss, 1971). The main reason for this is the basic difficulty of growing the crop and the generally low yields of seed or oil/ha.

The decline in the production of groundnut as reported by Yayock (1978) and oil palm, which are the two main sources of vegetable oil in Nigeria, coupled with the recent ban on importation of vegetable oils have all made sesame a potentially important alternative oilseed crop. In view of the prospect which this crop holds for the agro-allied industries in Nigeria, this study was proposed to investigate:

1) The growth and development of two sesame varieties at various plant populations on different sowing dates.

2) An optimum plant population for sesame production, and

3) The interactive effects of sowing date and plant population on yield and yield components.

Chapter 2

LITERATURE REVIEW

2.1 Production of Sesame

Estimates of the world sesame production must always take into consideration the fact that in many of the countries where there is a substantial area planted to the crop, a high proportion is consumed by the local farmers themselves and not marketed (Weiss, 1971). The main sesame producing countries are India, China, Mexico and Sudan. India ranks first both in the area and production of sesame in the world (Van Rheenen, 1973; Anonymous, 1980). The total world production which varies considerably from year to year has not shown any consistent increase or decrease since 1950/51. For instance, Van Rheenen (1973) reported that the world production was about 1.8 million tons both in 1950/51 and 1969/70 while FAO production figure for 1979/80 was 1.97 million tons (FAO, 1980).

In Nigeria, all the sesame is grown mainly in the Savanna region and there are two different sowing periods. In Kwara State (Southern Guinea Savanna), sowing is done after the end of the dry season and with the onset of the rains. Thus, called "early sesame". In Plateau and Niger States, it is sown two or three months before the rainy season ends and thus, called "late sesame" (Van Rheenen, 1973).

Sesame is often sown alone or mixed with other crops

(Anonymous, 1966 and 1974). Desai and Goyal (1980) reported that intercropping increased the total oil production as well as the economic return. Sesame can be grown on either flat by broadcasting or on ridges. Weiss (1971) showed the superiority of row planting over broadcasting to control weeds, and this factor alone has resulted in considerable yield increases.

Sowing methods and planting densities vary in the different sesame growing areas. Weiss (1971) reported that the seed rates for broadcasting sesame in eighteen different countries, varied from 2-15 kg/ha with average of about 5 - 8 kg/ha. High seed rates may compensate for often substantial losses of seeds and plants during the period from sowing to harvesting. Good yields of 1000 kg/ha can be obtained with close spacing or planting of new varieties which have been screened and developed at Mokwa (Anonymous, 1977).

Exports from Nigeria rose annually following the second world war up to a peak of 27,000 tons in 1960, fell slightly in the mid-sixties but have increased since then to over 24,000 tons (Weiss, 1971). Weiss (1971) reported that over 70% of the world exports originate in Africa which grows less than 80% of the world's total. There is no large scale mechanized system of growing sesame in Nigeria. It is produced on small peasant farms.

2.2 Economic Importance

The marketable sesame products are the whole seeds, the oil and the meal. The whole seed is used in making a variety of breads, cakes and candies (Harper, 1950). The whole seed may be eaten roasted. The seed contains about 50% of an excellent, edible semi-drying oil (Tribe, 1967). The oil from sesame resembles that of groundnut and sunflower but in some respects it is of better quality than these other vegetable oils (Harper, 1950).

The oil is used as a cooking oil, for the manufacture of margarine, cosmetics, medicines, insecticides, paints and soap. For instance, sesame oil is characterised by the presence of the compounds sesamol and sesamolin which were shown to be active synergists for pyrethrins in fly sprays (Tribe, 1967). Approximately, 500,000 tons of sesame oil has been produced annually in recent years, which is about 4% of the estimated world production of liquid edible vegetable oils (Weiss, 1971).

The meal left after the oil extraction is of high nutritional value and it is a good source of methionine which is deficient in many cakes of leguminous origin (Tribe, 1967). Thus, it is used as poultry and livestock feed. Tribe (1967) for instance, reported that mixtures of sesame and groundnut cakes gave better rat growth rates than groundnut cake alone, the sesame/soybean meal was superior to soybean meal alone in

chick diets. In recent years considerable interest has been shown in the use of sesame meal to supplement human protein deficient diets (Tribe, 1967; Weiss, 1971). Sesame stalks serve as a source of fuel in arid and savanna areas of the world. In Nigeria, the leaves either fresh or dry are used for soup making as "Karkashi".

2.3 Effects of Plant Population on Yield and Yield Components

Yield of any crop is a very complex quantitative character resulting from different factors, the most important of them being the yield per plant and number of plants per unit area (Menon, 1967). The yield per plant is controlled by many factors such as nutrients taken by the plants, its genetic potentials and the environmental conditions. Under wide spacing the individual plant is subjected to lesser degree of competition from its counterparts due to more available space, but the plant population per unit area is much reduced. For instance, Ogunremi (1982) reported that dry matter accumulation per plant increased with increase in inter-row spacing.

Menon (1967) found that the increased production from individual plant by providing it with lesser competitive field for growth and performance giving it wider spacing, was not compensative to make good the reduction in yield due to the decrease in the number of plants in a unit area. Bleasdale

(1966) and Gupta (1982) reported that if a crop is grown at a range of plant densities, and all the plants are harvested at one time, it is generally supposed that the total dry matter yield per unit area will increase with increasing density until a level of yield is reached which is barely exceeded as density increases further. This constant yield over a wide range of high densities is thought of as representing the maximum fixation of energy that crop can achieve in the time between sowing and harvest.

Delgado and Yermanos (1975) reported that seed yield per unit area of sesame increased by increasing population density from 80,000 plants/ha to 160,000 plants/ha. Further increases in density were counter productive and a population density of 200,000 plants/ha was as productive as that of 80,000 plants/ha. This finding is in agreement with those of Bleasdale (1966), Menon (1967), Gerakis and Tsangarakis (1969) and Gupta (1982) who also reported that yield/ha increases with increasing plant density until a level is reached which is hardly exceeded as density increases further. However, varying population density did not affect seed size (Menon, 1967; Delgado and Yermanos, 1975).

Kermel et al. (1983) reported that sesame grown in rows 20, 30, 40 or 50 cm apart, with spacing of 2.5, 12.5 or 22.5 cm and given 0, 36 or 72 kg N/ha gave highest seed and oil yields with 72 kg N/ha and the closest spacings. Smith et al. (1981) using three cultivars, sown in rows 41, 61 and 91 cm

apart as densities of 4 - 12 plants/m^2 reported that the highest seed yields (2.75 t/ha) were obtained from crops grown at 8 plants/m^2. Seed yields increased by an average of 167 kg for each increase of 1 plant/m^2 between 4 and 8 plants/m^2.

Several researchers have suggested a positive correlation between yield in sesame and yield components. Weiss (1971) and Nadi and Lazim (1974) reported that increase in plant density increased seed yield, which was positively correlated with the number of capsules per plant, number of seeds per capsule, 1000-seed weight, plant height and number of nodes/plant. Increases in between-plant spacings, thus decreasing plant population, progressively delayed flowering and maturation and increased the number of branches and capsules/plant. This is probably due to the fact that under wider spacing the individual plants are subjected to lesser degree of competition for space, soil nutrients, soil moisture and light from their counterparts due to more available space (Gupta, 1982). Effects on plant heights were inconsistent. Considerable research has been carried out on optimum plant population for sesame in other parts of the world. There is a basic difference between branched and unbranched varieties of sesame (Weiss, 1971), but high yields are correlated with high plant populations. Weiss (1971) working on both branched and unbranched varieties of sesame, reported that growth characters such as number of branches, height of the plants and height of the first capsule from the ground varied little with the different densities. This result

is in close agreement with that reported by Mazzani and Cobo (1956). Van Rheenen (1973) reported that the branched cultivars of sesame showed a high stand tolerance and relatively small yield differences occured between densities of 25,000 and 500,000 plants/ha. This is in agreement with the findings of Mazzani and Cobo (1956) and Karmel et al. (1983).

Weiss (1971) reported that when an unbranched type of sesame was sown at various plant populations from 71,400 to 660,000 plants/ha in Venezuela, the height of the plant was little affected, but the height of the first capsule was greatest at the highest population. He thus, recommended that non-branching varieties should be planted at densities of at least 300,000 plants/ha, but the branched varieties were little affected as regards the number of branches produced over a wide range of populations. The highest population produced the greatest seed yield as reported by Menon (1967) and Van Rheenen (1973).

Daulay and Singh (1982) in rainfed trials with sesame grown at 25,000 to 50,000 plants/ha and given N and P at 0 - 60 kg/ha, reported that plant densities in the good rainfall year did not significantly affect seed yield but in the below normal year, yield was highest with lowest plant density. This finding is at variance with those of Mazzani and Cobo (1956), Bleasdale (1966), Menon (1967), Weiss (1971), Van Rheenen (1973), Nadi and Lazim (1974), Delgado and

Yermanos (1975), Gupta (1982) and Karmal et al. (1983). The difference could probably be due to the effect of rainfall in those years.

2.4 Effects of Sowing Date on Yield and Yield Components of Sesame

The climate favourable for sesame is characterized by high temperatures and abundant sunshine. Through variance analysis it has been shown that the main meteorological factor that significantly influences the yield of sesame is precipitation at flowering. Ding (1983) reported that when the annual precipitation was more than 1500 mm, the yield of sesame decreased markedly. Low annual yields caused by summer waterlogging accounted for 89% of the total low yield years. The average temperature required by sesame is 26^{o}C (Weiss, 1971; Ding, 1983). In order to utilize the heat and light resources sufficiently it is important to sow as early as possible with the optimum sowing date.

The optimum sowing date obviously affects the yield and other characters of any crop (Baluch et al., 1965; Weiss, 1971). If sown late, the yield suffers due to the limited period that the crop gets for its vegetative growth. Narayanan and Reddy (1982) working on three early and three late sesame cultivars grown in a field trial at Hyderabad, India, during the Monsoon season reported that the early cultivars were shorter and flowered earlier than the late cultivars. Maximum leaf production occured during the 3 - 4 week period following

flower bud appearance in both types and there was maximum leaf retention on both cultivars. The yield potentials of all cultivars was low but maximum yield was associated with higher number of capsules and seeds per capsule.

Johnson and Jellum (1972) in a 3- year trial, reported that highest seed yields were obtained in the early sowing dates (March and April) during the years of investigation. May, June and July planting dates resulted in significantly lower yields in all the years. This finding is in agreement with those of Weiss (1971), Abdel-Rahman *et al.* (1980) and Schiller *et al.* (1981) who reported that the highest seed yield and yield components were obtained when plants were sown early.

The decrease in seed yield associated with delay in sowing sesame is probably as a result of decrease in the number of branches and capsules per plant, Baluch *et al.* (1965), Tilak *et al.* (1971), Van Rheenen (1973), Johnson and Jellum (1972), Bhattacharya *et al.* (1975), Mandal and Rao (1976) and Ogunremi (1979). Another probable reason is the limited period that the crop gets for its vegetative growth as reported by Baluch *et al.* (1965).

Weiss (1971) using the variety Venezuela 51 varied times of planting from early May to early September in El-Salvador and showed that there was a reduction in plant height from 235 cm to 170 cm between May and June planting, no appreciable

change in height between June and August plantings but a major depression to 50 cm in the September planting. The yield, however, decreased drastically from 1770 kg/ha in May to 330 kg/ha in September and was not related to plant height. Over the period June to August when height remained almost constant there was a substantial reduction in yield. Early planting dates were also found to increase seed oil content.

2.5 Correlation of Yield of Sesame and Yield Components

It has been shown that there is a positive correlation between some yield components and yield while some other characters are not correlated to seed yield. Yadava et al. (1980) reported that seed yield/plant in 22 sesame cultivars was positively correlated with number of capsules and primary branches/plant and 1000-seed weight. Through Path-coefficient analysis, he showed that capsules/plant, 1000-seed weight, days to 50% flowering and primary branches/plant had high direct effect on yield. However, Ibrahim et al. (1983) observed that seed yield/plant was negatively correlated with 1000-seed weight and seed yield per capsule. This finding is at variance with the findings of Yadava et al. (1980). This could be due to varietal differences, plant population and/or sowing date. Shukla and Verma (1976) found that there was a negative relationship between days to flowering and seed yield indicating the possibility of selecting early flowering types

for rainfed areas. This is not in agreement with what was reported by Yadava et al. (1980) and Ibrahim et al. (1983). This could probably be due to differences in date of sowing plant population and/or varieties used. Yadava et al. (1980) and Ibrahim et al. (1983) reported the number of secondary branches, capsules/branch and capsule/plant as contributing to seed yield. Path. co-efficient analysis showed that the number of capsules/plant had the highest direct effect on seed yield (Ibrahim et al., 1983). This result is in agreement with the findings of Naphade and Kolte (1974), Delgado and Yermanos (1975), Elahman and Serry (1977), Choudhary et al. (1977) Khidir and Osman (1970) and Uzo et al. (1985). Naphade and Kolte (1974) and Choudhary et al. (1977) reported that seed yield/plant was negatively correlated with capsule length. This may probably be due to early sowings which tend to produce excessive vegetative growth and the incidence of phyllody may be very high as reported by Weiss (1971). Seed yield was also found to be positively and significantly correlated with plant height (Uzo et al., 1985).

Oil content was correlated positively with number of fruiting branches, seed yield/capsule and 1000-seed weight (Ibrahim et al., 1983).

Chapter 3

MATERIALS AND METHODS

3.1 Experimental Site and Soil

A field experiment involving sesame (*Sesamum indicum* L.) was conducted in 1986 rainy season at the Agronomy Research Farm of the Institute for Agricultural Research, Samaru, Zaria (11^{0} $11^{'}$ N and 7^{0} $38^{'}$ E, 650 m above mean sea level) in the Northern Guinea Savanna ecological zone. The soil of the experimental site is sandy loam. Details of the physical and chemical composition of the soil at the experimental site are contained in Table 1, , while details of the distribution of rainfall, relative humidity, sunshine and temperature at Samaru during the period of the trial are shown in Table 2.

3.2 Treatments

Treatments investigated involved two varieties of sesame, three plant populations and three sowing dates. The sesame varieties were Pb-Till$_1$ and E$_8$. Variety Pb-Till$_1$ matures early and has little branching while E$_8$ is late maturing and heavily branched. The three plant populations tested were 100,000, 250,000 and 400,000 plants/ha. The three sowing dates spaced at three-week intervals, with sowing commencing soon after the establishment of rains, were 24 June, 15 July and 5 August, 1986.

Table 1: Physico-Chemical analysis of soil at the experimental site at Samaru

	Soil Depth (cm)	
Soil Composition	0-15	15-30
Texture %		
Sand	62.80	55.60
Silt	27.60	26.40
Clay	9.60	18.00
pH in water	5.3	5.40
pH in 0.01M $CaCl_2$	4.9	5.00
Organic carbon (%)	0.324	0.292
Total Nitrogen (%)	0.256	0.264
Available P (ppm)	3.36	0.80
Exchangeable cations (meq/100g of soil)		
Sodium Na	0.05	0.05
Potassium K	0.18	0.19
Calcium Ca	2.84	2.85
Magnesium Mg	0.88	0.88
Cation Exchange Capacity (meq/100 g of soil)	5.44	7.04

Table 2: Mean temperature, relative humidity, sunshine hours and total rainfall at 10-day interval during the period of the trial in 1986 wet season at Samaru.

Month	Days	Total Rainfall (mm)	Mean Temperature (°C)	Relative Humidity (%)	Sun-shine (hours)
June	1-10	35.30	25.30	64.10	7.00
	11-20	23.00	25.40	74.40	9.10
	21-30	24.00	25.05	75.30	7.40
July	1-10	52.90	24.50	79.80	7.00
	11-20	49.40	23.65	83.40	6.50
	21-30	165.00	23.30	83.10	5.20
August	1-10	51.00	23.70	83.00	5.80
	11-20	95.00	24.10	84.30	7.00
	21-30	177.00	24.25	78.30	7.70
September	1-10	56.40	23.75	77.80	7.10
	11-20	81.20	23-95	72.60	8.60
	21-30	75.30	24.20	76.40	7.80
October	1-10	0.00	24.75	67.50	7.90
	11-20	0.00	23.65	45.40	9.60
	21-30	0.00	24.65	57.40	8.10
November	1-10	0.00	25.40	49.80	9.00
	11-20	0.00	21.00	24.90	8.50
	21-30	0.00	22.00	33.70	8.10

Source: Meteorological Station, I.A.R., Samaru, Zaria, Nigeria, 1986.

3.3 Design and Plot Size

The experiment was laid out in a Randomized Complete Block Design with four replications. The plot size was 4.0 x 3.75 m (15.0 m^2) while the total experimental area was 30.0 m long and 58.0 m wide (1740 m^2 of 0.174 ha). Each plot contained five ridges of which the outer two rows were used for observations and data collection.

3.4 Cultural Practices

3.4.1 Land preparation

The land was ploughed and harrowed two times to a fine tilth. These operations were followed by ridging. The field was then marked out into 72 plots each 15.0m^2 in area.

3.4.2 Sowing

Sowing was done by hand drilling the seeds on ridges 75 cm apart. The plants were later thinned to the desired populations at three weeks after sowing.

3.4.3 Application of fertilizers

Calcium ammonium nitrate (CAN) and single superphosphate (SSP) fertilizers were applied at the rates of 50 kg N and 40 kg P_2O_5/ha, respectively. These fertilizers were band applied along the rows about 8.0 cm away from the plants at two weeks after each of the sowings.

3.4.4 Weed control

A pre-emergence herbicide "Lasso", was applied at the rate of 2.08 l/ha. The experiment was weeded using hand hoes at three and nine weeks after emergence. Earthing-up was done during weeding to minimize lodging of the plants.

3.4.5 Harvesting

The crop was harvested when the leaves and stems changed colour from green to yellow. In the first sowing date (24 June, 1986) the variety Pb-Till$_1$ was harvested on the 23 September, while E$_8$ was harvested on the 2 October, 1986. In the second sowing date (15 July, 1986) Pb-Till$_1$ was harvested on the 11 October, while E$_8$ was harvested on the 18 October, 1986. In the third sowing date (5 August, 1986), Pb-Till$_1$ was harvested on the 29 October, while E$_8$ on the 8 November, 1986. Harvesting was done manually with knives by cutting the plants at the base and putting them in sacks. They were allowed to dry inside the sacks so as to minimize the loss of seeds when the pods shattered. When the plants were thoroughly dried the sacks were gently beaten with sticks in order to release all seed from the pods. Large debris were removed from the sacks by hand while the smaller debris were removed by winnowing.

3.5 Data Collection

Five plants were randomly selected and tagged in each plot for the measurement of various plant parameters. These

included plant height, number of primary and secondary branches and number of pods/plant, length of pods, 1000-seed weight, seed yield per plant, number of seeds per plant, number of seeds per pod and dry matter production at harvest.

3.5.1 Plant height

Heights of the five plants were measured at maturity just before harvest from the ground level to the tips of the main stems.

3.5.2 Number of primary and secondary branches and number of pods/plant

The number of primary branches, secondary branches and number of pods per plant were obtained by counting these parameters from the five selected plants at harvest and their averages calculated.

3.5.3 Length of pods (cm)

Length of pods from the five plants were measured and the mean length of pods was calculated.

3.5.4 1000-seed weight (gms)

1000-seeds for each of the plots were counted and weighed. This was repeated five times and a mean 1000-seed weight was obtained.

3.5.5 Seed yield (gm) and number of seeds/plant

The selected five plants were harvested, dried, threshed and winnowed to obtain clean seeds which were then weighed. The weight was then divided by five to give the mean yield per plant.

In determining the number of seeds per plant, the weight of the seed yield per plant was used. Using the 1000-seed weight relationship, the number of seeds per plant was estimated.

3.5.6 Number of seeds/pod

The number of pods in the five plants were counted. They were then dried, threshed, winnowed and the seeds were weighed. The weight so obtained was divided by the number of pods which gave the weight of seeds per pod. Using the 1000-seed weight relationship again, the number of seeds per pod was estimated.

3.5.7 Dry matter production

Five plant samples were randomly taken in each of the sampling operations, oven dried and weighed.

3.5.8 Leaf area (cm^2)

Five plants were sampled from each plot and their leaves detached. The leaves were then traced on square

graph sheets as described by Evans (1972). These were then oven-dried and weighed. The leaf area of the five plants was determined using leaf area - dry weight relationship.

3.5.9 Oil content of sesame seeds

The percentage of oil content of harvested seeds was determined as described by the Association of Analytical Chemists (AOAC, 1980).

3.6 Data Analysis

The data were subjected to statistical analysis with all the factorial arrangements as described by Leclerg *et al.* (1962). Where F values showed statistically significant differences, the means of such treatments were compared using the Duncan Multiple Range Test (DMRT) (Duncan, 1955) at five per cent level of probability. Correlation analysis was also done.

Chapter 4

RESULTS

4.1 Effect of Plant Population and Sowing Date on Growth Characters of Sesame

4.1.1 Plant height at harvest

Plant population, sowing date and variety significantly affected plant height at harvest (Table 3). Plant height increased with increase in plant population but the height recorded at 250,000 plants/ha was not significantly different from that at either 100,000 or 400,000 plants/ha.

Plant heights at harvest decreased with delayed sowing but the difference between the last two sowings was not significant.

Variety E_8 produced significantly taller plants than variety Pb-$Till_1$.

Table 4 shows the interaction effect between plant population, sowing date and variety on plant height at harvest. Variety Pb-$Till_1$, showed a significant decrease in plant height with delayed sowing from 24 June to 5 August at each of the three populations tested. The same trend was observed in variety E_8 but these decreases in height were not significant except at 250,000 plants/ha.

Table 3: Effect of plant population, sowing date and variety on plant height (cm) of sesame at harvest at Samaru, Zaria, 1986.

Treatment	Plant height (cm)
Plant population (plants/ha)	
100,000	85.52b
250,000	89.80ab
400,000	93.59a
SE±	2.19
Sowing Date	
24 June	101.34 a
15 July	86.71b
5 August	80.86b
SE ±	2.19
Variety	
$Pbtill_1$	78.63b
E_8	100.64a
SE ±	1.79

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

Table 4: Interaction between plant population, variety and sowing date on plant height (cm) of sesame at harveat at Samaru, Zaria, 1986.

Variety	Population (Plants/ha)	Sowing Dates		
		24 June	15 July	5 August
Pb-till$_1$	100,000	90.20cdef	73.15fg	65.80g
	250,000	94.73bcd	69.40g	75.88efg
	400,000	90.45cdef	79.85defg	68.20g
E_B	100,000	105.14abc	91.13bcde	87.64cdef
	250,000	113.93a	105.35abc	79.50defg
	400,000	113.54a	101.35abc	108.15ab
SE ±	(Interaction)	5.36		

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

4.1.2 Number of primary branches per plant

Plant population and sowing date had no significant effect on number of primary branches/plant (Table 5). Variety E_8 had significantly more primary branches/plant at harvest than Pb-till$_1$ (Table 5).

The effect of interaction between plant population and sowing date on number of primary branches/plant is presented in Table 5. At plant populations of 100,000 and 250,000 plants/ha., the number of primary branches/ plant decreased with delayed sowing but this trend was reversed at the population of 400,000 plants/ha.

4.1.3 Number of secondary branches per plant

Both plant population and variety affected number of secondary branches/plant (Table 6). Plants sown at 100,000 plants/ha. had more secondary branches/plant than those sown at 250,000 and 400,000 plants/ha. Variety E_8 produced significantly more secondary branches than variety Pb-till$_1$.

4.1.4 Leaf area

Leaf area at flowering (5 weeks after sowing) was significantly influenced by sowing date, variety and their interactions (Table 7). In both varieties, leaf area increased when sowing was delayed from 15 July to 5 August. Variety E_8 had more leaf area than variety Pb_till$_1$. Plant

population had no significant effect on leaf area at flowering.

Table 5: Effect of variety and interaction of plant population and sowing date on the number of primary branches/plant of sesame at harvest at Samaru, Zaria, 1986.

Variety	Number of primary branches/plant			
Pb-till$_1$	2.14b			
E_8	2.64a			
SE ±	0.11			
	Population (plants/ha)			
Sowing date	100,000	250,000	400,000	Mean
24 June	3.08a	2.50abc	1.80c	2.46
15 July	2.43abc	2.25bc	2.80ab	2.49
5 August	2.10bc	1.93c	2.53abc	2.19
Mean	2.54	2.23	2.38	
SE ± (Interaction)	0.22			

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

Table 6: Effect of plant population, sowing date and variety on the number of secondary branches/ plant of sesame at harvest at Samaru, Zaria, 1986.

Plant Population (plants/ha)	
100,000	1.12a
250,000	0.28b
400,000	0.43b
SE ±	0.15
Sowing Date	
24 June	0.84
15 July	0.46
5 August	0.53
SE ±	0.15
Variety	
$Pb\text{-}till_1$	0.44b
E_8	0.78a
SE ±	0.12

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

Table 7: Effect of sowing date, variety and their interaction on leaf area/plant $(cm)^2$ of sesame at flowering stage at Samaru, Zaria, 1986.

Variety	Sowing Date		Mean
	15 July	5 August	
Pb-till$_1$	174.96c	506.71b	340.84b
E_8	179.52c	694.22a	436.80a
Mean	177.24b	600.47a	

SE ± Sowing date = 30.55

Variety = 30.55

Sowing date x Variety = 43.21

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

At the pod formation stage (9 weeks after sowing), interaction between sowing date and variety on leaf area was also significant (Table 8). In all the sowings, varietal effect on leaf area at pod formation stage was inconsistent.

Table 8: Interaction between sowing date and variety on leaf area/plant $(cm)^2$ of sesame at pod formation stage at Samaru, Zaria, 1986.

Variety	Sowing Date			Mean
	24 June	15 July	5 August	
Pb-till$_1$	648.16a	418.92b	548.76ab	538.61
E$_8$	449.55b	566.18ab	531.29ab	515.67
SE ± (Interaction)	62.94			

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

4.2 Effect of Plant Population and Sowing Date on Dry Matter Production per Plant

Dry matter production/plant was higher in variety Pb-till$_1$ than variety E$_8$ both before and at flowering (Table 9). Plant population, sowing date and treatment interactions had no significant effect on this parameter.

At harvest, sowing date, variety and their interaction significantly influenced dry matter production/plant (Table 10). Dry matter production increased when sowing was delayed from 24 June to 15 July, after which, there was a reduction with further delay in sowing to 5 August. The dry matter produced

Table 9: Effect of variety on dry weight/plant (gm) of sesame before and at flowering at Samaru, Zaria, 1986.

Variety	Before flowering (3 weeks after planting)	At flowering (5 weeks after planting)
Pb-till$_1$	0.58a	1.84a
E$_8$	0.45b	1.45b
SE ±	0.04	0.10

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

at harvest was more in variety E$_8$ than in variety Pb-till$_1$. With respect to the interaction between variety and sowing date there were no significant differences in dry matter/plant between the three sowings in variety Pb-till$_1$ but in variety E$_8$, the last two sowings gave significantly higher dry matter/plant than the first sowing. Plant population had no significant effect on dry matter production/plant at harvest (Table 10). Dry matter/plant for variety E$_8$ was 99% and 59% greater in the second and third sowings, respectively, than in the first sowing.

Table 10: Effect of plant population, sowing date, variety and interaction between sowing date and variety on dry weight/plant (gm) of sesame at harvest at Samaru, Zaria, 1986.

Population (plants/ha)	
100,000	15.91
250,000	14.00
400,000	15.41

	Variety		
Sowing Date	Pb-till$_1$	E$_8$	Mean
24 June	12.46c	11.64c	12.05b
15 July	14.59bc	22.76a	18.68a
5 August	10.67c	18.52ab	14.59bc
Mean	12.57b	17.64a	

SE ±	Plant population	=	1.12
	Sowing date	=	1.12
	Variety	=	0.92
	Sowing date x Variety	=	1.59

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

Dry matter production/plant was also affected by the interaction between plant population, sowing date and variety (Table 11). In variety Pb-till$_1$, at all the populations, dry matter production/plant was not different as sowing was delayed from 24 June to 5 August. But in variety E$_8$, at all the plant populations, dry matter production/plant increased as sowing was delayed from 24 June to 15 July after which, further delay to 5 August decreased dry matter production/plant at populations 100,000 and 250,000 plants/ha.

Table 11: Interaction between plant population, sowing date and variety on dry weight/plant (gm) of sesame at harvest at Samaru, Zaria, 1986.

Variety	Population (plants/ha)	Sowing Date		
		24 June	15 July	5 August
Pb-till$_1$	100,000	14.51bcde	16.67bcde	9.43e
	250,000	11.51cde	13.27bcde	14.13bcde
	400,000	11.36cde	13.83bcde	8.44e
E$_8$	100,000	15.67bcde	20.17abc	19.01abcd
	250,000	9.04e	26.66a	9.49e
	400,000	10.22de	21.59ab	27.05a
SE ±		2.75		

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

4.3 Effect of Plant Population and Sowing Date on per cent Stand Count at Harvest

Per cent stand count at harvest was significantly influenced by sowing date, plant population and variety (Table 12). Per cent stand count at harvest decreased significantly with delay in sowing. The average per cent stand count decreased with increase in populations from 100,000 to 400,000 plants/ha. but stand establishment at 250,000 plants/ha. was not significantly different from that at either 100,000 or 400,000 plants/ha. The average per cent stand count recorded in variety E_8 was higher than that of Pb-till$_1$.

Table 12: Effect of plant population, sowing date, variety and their interactions on per cent stand count of sesame at harvest at Samaru, Zaria, 1986.

	Population (plants/ha)			
Sowing Date	100,000	250,000	400,000	Mean
24 June	99.44a	76.78abc	74.93abc	83.72a
15 July	97.78a	85.55ab	56.39bcd	79.91b
5 August	36.99cd	41.22cd	30.94d	36.38c
SE ± (Interaction)		12.77		7.37
Variety				
Pb-till$_1$	76.42	69.07	47.87	64.45b
E_8	79.72	66.63	60.30	68.88a
Mean	78.07a	67.85ab	54.09b	
SE ±		7.37		

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

4.4 Effect of Plant Population and Sowing Date on Yield Components of Sesame

4.4.1 Number of pods per plant

Sowing date and variety had significant effects on number of pods/plant (Table 13). The number of pods/plant decreased with successive delay in sowing but the difference between the first two sowings was not significant. Although number of pods/plant were not significantly affected by plant population, it was observed that the number of pods/plant decreased with increase in plant population from 100,000 to 400,000/ha (Table 13).

The number of pods/plant produced by variety E_8 was higher than that of variety Ph-till$_1$.

The interaction between plant population and sowing date on number of pods/plant was significant (Table 13). In the first sowing date, number of pods/plant decreased with increased in population, whereas for the last two dates similar number of pods/plant was recorded for the different populations.

The interaction between plant population, variety and sowing date on number of pods/plant was also significant (Table 14). In both varieties, in the first sowing date, the number of pods/plant decreased with increase in plant population whereas in the last two dates, the number of

pods/plant in both varieties was not significantly affected by increase in plant population.

Table 13: Effects of sowing date, variety and interaction between plant population and sowing date on the number of pods/plant of sesame at Samaru, Zaria, 1986.

	Populations (plants/ha)			
Sowing date	100,000	250,000	400,000	Mean
24 June	67.73a	50.65b	38.08bcde	52.15a
15 July	43.63bcd	46.63bcd	49.98bc	46.74a
5 August	32.93de	27.18e	35.63cde	31.91b
SE ±		4.68		
Varieties				
Pb-till$_1$		37.87b		
E$_8$		49.33a		
SE ±		2.20		

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

Table 14: Interaction between plant population, variety and sowing date on number of pods/plant of sesame at Samaru, Zaria, 1986.

Variety	Population (plants/ha)	Sowing Date		
		24 June	15 July	5 August
Pb-till$_1$	100,000	61.75ab	39.65cd	24.47d
	250,000	49.35bc	31.40cd	32.25cd
	400,000	32.20cd	47.45bc	22.35d
E_8	100,000	73.70a	47.60bc	41.40bcd
	250,000	51.95bc	61.85ab	22.10d
	400,000	45.95bcd	52.50bc	48.70bc
SE ± (Interaction)		6.61		

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

4.4.2 Number of seeds per pod

The number of seeds/pod decreased with delay in sowing but the difference between the first two sowings was not significant. Variety E_8 had more seeds/pod than Pb-till$_1$ (Table 15). In variety E_8, number of seeds/pod was not affected as sowing was delayed from 24 June to 5 August 1986, but in variety Pb-till$_1$ the number of seeds/pod decreased as sowing was delayed from 24 June to 5 August.

Table 15 also shows the interaction effect of variety and plant population on the number of seeds/pod. In variety Pb-till$_1$, number of seeds/pod showed a 20% decrease when plant populations increased from 100,000 to 250,000 plants/ha. with no further decrease when the population was increase to 400,000/ha. With variety E_8 on the other hand, increasing plant population from 100,000 to 250,000/ha. resulted in a 17.5% increase in the number of seeds/pod but no further increase was observed when population was increased to 400,000 plants/ha. Variety E_8 had more seeds/pod than variety Pb-till$_1$ at all plant populations.

4.4.3 Length of pod

Of the factors tested, only variety had significant effect on length of pod (Table 16). Variety E_8 had significantly longer pods than variety Pb-till$_1$.

4.4.4 Seed yield per plant

Table 17 shows the effect of plant population, sowing

date and variety on seed yield/plant. Plant population had no significant effect on seed yield/plant.

Table 15: Effects of sowing date, plant population, variety and their interactions on number of seeds/pod of sesame at Samaru, Zaria, 1986.

Treatment	Variety		Mean
	Pb-till$_1$	E$_8$	
Sowing date			
24 June	31.77ab	38.24a	34.01a
15 July	26.80b	35.45a	31.13a
5 August	13.03c	35.78a	24.40b
Mean	23.87b	35.82a	
Populations (plants/ha)			
100,000	27.07bc	32.48ab	29.78
250,000	21.68c	38.16a	29.92
400,000	22.86c	36.83a	29.85

SE ± Sowing date = 1.43
Plant population = 1.43
Variety = 1.17
Sowing date x variety = 2.03
Plant population x Variety = 2.03

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

Table 16: Effect of plant population, sowing date and variety on the length of pod (cm) of sesame at Samaru, Zaria, 1986.

Treatments	Length of pod (cm)
Plant population (plants/ha)	
100,000	2.71
250,000	2.64
400,000	2.68
SE ±	0.03
Sowing date	
24 June	2.73
15 July	2.66
5 August	2.64
SE ±	0.03
Variety	
Pb-till$_1$	2.56b
E_8	2.80a
Se ±	0.03

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

Seed yield/plant decreased with delayed sowing but the difference between the first two sowings was not significant.

Variety E_8 gave significantly higher seed yield/plant than Pb-till$_1$. Seed yield/plant was also affected by the interation between plant population and sowing date (Table 17). In the first sowing, there were significant decreases in seed yield/plant with increase in plant population. Differences in seed yield/plant between the three populations tested were not significant in the second sowing while seed yield/plant at 250,000 plants/ha. was significantly lower than that of either 100,000 or 400,000 plants/ha. in the third sowing.

Table 18 shows the interaction effect of plant population, sowing date and variety on seed yield/plant. Variety Pb-till$_1$ at all the populations, seed yield/plant decreased with delay in sowing, whereas in variety E_8, seed yield/plant showed no consistent trend with delay in sowing.

4.4.5 Number of seeds per plant

Sowing date and variety effects significantly influenced number of seeds/plant (Table 19). The number of seeds/plant decreased with successive delay in sowing but the difference between the first two sowings was not significant. Although number of seeds/plant were not significantly affected by plant population, it was observed to decrease with increase in plant population from 100,000 to 400,000/ha (Table 19).

Table 17: Effect of plant population, sowing date, variety and interaction of plant population with sowing date on seed yield/plant (gm) of sesame at Samaru, Zaria, 1986.

	Population (plants/ha)			
Sowing date	100,000	250,000	400,000	Mean
24 June	5.70a	4.16b	3.53bc	4.46a
25 July	3.81bc	4.81a	3.68bc	3.90a
5 August	2.33cd	1.61d	3.06bc	2.33b
Mean	3.95a	3.33a	3.42a	
Variety				
Pb-till$_1$	1.35b			
E_8	4.78a			

SE ± Plant population = 0.27
Sowing date = 0.27
Variety = 0.22
Population x date = 0.47

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

Table 18: Interaction between plant population, sowing date and variety on seed yield/plant (gm) of sesame at Samaru, Zaria, 1986.

Variety	Population (plants/ha)	Sowing Date		
		24 June	15 July	5 August
Pb-till$_1$	100,000	4.40bcde	3.42cdef	0.98g
	250,000	3.54cdef	2.05fg	0.98g
	400,000	2.70defg	2.21efg	0.85g
E$_B$	100,000	7.00a	4.20cdef	3.67cdef
	250,000	4.78bcd	6.38ab	2.25efg
	400,000	4.35bcde	5.15abc	5.25abc

SE ± (Interaction) 0.67

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

Table 19: Effect of plant population, sowing date, variety and interaction of sowing date and plant population on the number of seeds/plant of sesame at Samaru, Zaria, 1986.

	Population (plants/ha)			
Sowing date	100,000	250,000	400,000	Mean
24 June	2208.67a	1762.08ab	1346.30bcd	1772.35a
15 July	1536.29bc	1564.20bc	1418.50bc	1506.33a
5 August	851.06de	622.17e	1105.06cde	859.43b
Mean	1532.01	1316.15	1289.95	
Variety				
Pb-till$_1$	959.47b			
E$_8$	1799.28a			

SE±	Plant population	=	101.38
	Sowing date	=	101.38
	Variety	=	82.78
	Population x date	=	175.60

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

Table 20: Interaction between sowing dates, plant population and variety on the number of seeds/ plant of sesame at Samaru, Zaria, 1986.

Variety	Population (plants/ha)	Sowing Dates		
		24 June	15 July	5 August
Pb-till$_1$	100,000	1757.36bc	1520.20cde	357.84f
	250,000	1559.34cde	747.71ef	379.61f
	400,000	1088.59def	928.02def	296.63f
E_8	100,000	2659.97a	1552.37cde	1344.28cde
	250,000	1964.83abc	2380.70ab	864.73def
	400,000	1604.02bcd	1908.99abc	1913.59abc
SE $\pm$ (Interaction)		248.34		

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

Table 21: Effect of plant population, sowing date and variety on 1000-seed weight (gm) of sesame at Samaru, Zaria, 1986.

Plant population (plants/ha)	
100,000	2.63
250,000	2.49
400,000	2.62
SE ±	0.05
Sowing date	
24 June	2.53
15 July	2.59
5 August	2.62
SE ±	0.05
Variety	
Pb-till$_1$	2.52b
E_8	2.64a
SE ±	0.04

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

4.5 Effect of Plant Population and Sowing Date on Seed Yield of Sesame

Seed yield of sesame was significantly influenced by plant population, sowing date and variety (Table 22). Increasing plant population from 100,000 to 250,000 plants/ha resulted in a 27% increase in yield. No further yield increase was obtained when the population was increased to 400,000 plants/ha.

Seed yield decreased by 37.80% when sowing was delayed from 24 June to 15 July. Further yield decrease of 55.20% was observed when sowing was delayed to 5 August.

Variety E_8 gave a 59.56% higher seed yield than Pb-till$_1$. The treatment interactions had no significant effects on seed yield of sesame.

4.6 Effect of Plant Population and Sowing Date on Oil Content

Effects of plant population, sowing date, variety and their interactions on oil content was significant statistically (Table 23). Increasing plant population from 100,000 to 250,000 plants/ha resulted in 0.06% increase in oil content but further increase in population to 400,000 plants/ha decreased oil content by 3.3%. The overall effect of sowing date on oil content was a significant increase in per cent oil in the seeds with delay in sowing (Table 23).

Table 22: Effect of plant population, sowing date and variety on seed yield (kg/ha) of sesame at Samaru, Zaria, 1986.

Treatments	Seed Yield (kg/ha)
Plant populations (plants/ha)	
100,000	185.54b
250,000	236.12a
400,000	238.21a
SE ±	16.45
Sowing date	
24 June	318.79a
15 July	198.28b
5 August	142.81c
SE ±	16.45
Varieties	
$Pb\text{-}till_1$	169.49b
E_8	270.43a
SE ±	13.43

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

Table 23: Effect of plant population, sowing date, variety and their interactions on oil content (%) of sesame seeds at Samaru, Zaria, 1986.

	Populations (plants/ha)			
Treatments	100,000	250,000	400,000	Mean
Sowing date				
24 June	49.33d	49.11e	47.14g	48.53c
15 July	49.60c	49.86b	49.72bc	49.73c
5 August	50.85a	50.91a	48.33f	50.03a
Variety				
Pb-till$_1$	48.86d	47.88e	46.36f	47.7b
E_8	50.99b	52.04a	50.43c	51.15a
Mean	49.93a	49.96a	48.40b	

SE ± Plant population = 0.05
Sowing date = 0.05
Variety = 0.04
Population x date = 0.08
Population x variety = 0.07

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

Variety E_8 had a higher seed oil content than variety Pb-till$_1$. Oil content of variety Pb-till$_1$, showed a significant decline with increase in plant population from 100,000 to 400,000 plants/ha. In variety E_8, oil content increased with increase in population up to 250,000 plants/ha thereafter, there was a decline. At plant populations of 100,000 and 250,000 plants/ha, oil content increased with delay in sowing, but at 400,000 plants/ha, it increased when sowing was delayed from 24 June to 15 July, thereafter a decline was recorded as sowing was delayed till 5 August (Table 23).

Oil content was also significantly influenced by the interaction between sowing date, plant population and variety (Table 24).

4.7 Correlation Analysis

Analysis of correlation coefficient between different growth characters, yield components and seed yield of sesame was done to determine their relationships (Table 25).

There were significant positive correlations between seed yield and number of pods, seed yield/plant, number of seeds and number of branches/plant, number of seeds/pod, length of pods, 1000-seed weight and stand count at harvest.

Table 24: Interaction between plant population, variety and sowing date on oil content (%) of sesame at Samaru, Zaria, 1986.

Variety	Population (plants/ha)	Sowing Date		
		24 June	15 July	5 August
Pb-till$_1$	100,000	47.74i	46.58k	52.27c
	250,000	45.87e	47.24j	50.52g
	400,000	47.63i	46.63k	44.81m
E_B	100,000	50.92f	52.63ab	47.43h
	250,000	52.35bc	52.48bc	51.29e
	400,000	46.64k	52.81a	51.85d
SE ±	(Interaction)	0.12		

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

Table 25: Correlation of seed yield of sesame and yield components.

	1	2	3	4	5	6	7	8	9	10	11
1	1.000										
2	0.572**	1.000									
3	0.320*	0.320**	1.000								
4	0.821**	0.872**	0.529**	1.000							
5	0.508**	0.149	0.247*	0.481**	1.000						
6	0.320**	0.775**	0.166	0.334**	0.033	1.000					
7	0.631**	0.586**	0.437**	0.738**	0.173	0.491**	1.000				
8	0.643**	0.819**	0.733**	0.735**	0.200	0.602**	0.699**	1.000			
9	0.651**	0.823**	0.748**	0.718**	0.209	0.596**	0.623**	0.983**	1.000		
10	0.250*	0.063	0.156	0.160	-0.015	0.113	0.325**	0.262*	0.142	1.000	
11	0.270*	0.653**	0.114	0.303	-0.137	0.529**	0.397**	0.516**	0.524**	0.009	1.000

Where 1 = Yield
2 = No. of pods/plant
3 = No. of seeds/pod
4 = Plant height
5 = Stand count at harvest
6 = No. of primary branches/plant
7 = Length of pods
8 = Seed yield/plant
9 = No. of seeds/plant
10 = 1000-seed weight
11 = No. of secondary branches per plant.

* Significant at 5% level of probability
** Significant at 1% level of probability

Chapter 5

DISCUSSION

5.1 Effect of Plant Population

5.1.1 Growth characters

The observed increase in plant height at harvest with increases in plant population from 100,000 to 400,000/ha agrees with reports by Mazzani and Cobo (1956), Weiss (1971). Van Rheenen (1973) and Delgado and Yermanos (1975). Donald (1963) ascribed increases in plant height with increase in plant population to competition among individual plants for light.

The non-significant difference in number of branches/plant, with increase in plant population is in agreement with report by Mazzani and Cobo (1956), Weiss (1971) and Gupta (1982). This could probably be due to the fact that increase in plant population tends to adversely affect the essential development of the buds from which the branches emerge due to high degree of competition among individual plants for available space.

5.1.2 Dry weight per plant

Dry weight/plant was not effected by increases in plant population. This result suggests that even the highest plant population used in this study was not high enough to cause

reduction especially in vegetative growth. This clearly indicates that even higher plant populations can be tried. This might equally account for the insignificant effect of plant population on leaf area/plant.

5.1.3 Yield components

Although the results indicated an insignificant effect of plant population on number of pods, seed yield and number of seeds/plant, it was observed that these characters decreased with increasing plant population. This can be attributed to intra and inter plant competition at the medium and high plant population, as the individual plants might have been subjected to some sort of competition for space, soil moisture, nutrients, light and assimilates. These results are in conformity with the findings of Delgado and Yermanos (1975) who reported increases in seed yield/plant as spacing between plants became wider. Similar trends were observed by Weiss (1971), Van Rheenen (1973), Nadi and Lazim (1974) and Gupta (1982). This shows that the increase in seed yield with increase in plant population must have been accounted for by the number of plants/ha as reported by Menon (1967).

The insignificant differences observed in the number of seeds/pod, length of pods and 1,000-seed weight with increasing plant population might be attributed to genetic and/or environmental factors. Westermann and Crothers (1977) reported that yield components' changes are said to be due to

plant's response to its environment which may or may not permit the full genetic expression of each component.

5.1.4 Seed yield

The results indicated that there was a 27% increase in seed yield when plant population was increased from 100,000 to 250,000/ha, whereas, no increase in seed yield was observed when the population was further increased to 400,000 plants/ha. This is similar to earlier findings by Mazzani and Cobo (1956), Bleasdale (1966), Menon (1967), Gerakis and Tsangarakis (1969), Harper and White (1970), Weiss (1971), Van Rheenen (1973), Nadi and Lazim (1974), Delgado and Yermanos (1975) and Gupta (1984) in which yield increase with increasing plant population up to a certain level was reported. This is probably because a population of 100,000/ha is low to produce good yields on per plant basis, but not high enough to compensate for the low number of plants per unit area as reported by Menon (1967). The non-significant difference in seed yield between the range of 250,000 to 400,000 plants/ha probably indicates that maximum fixation of energy by sesame crop in the time between sowing and harvesting (Bleasdale, 1966; Gupta, 1982) occurs within these two populations.

5.1.5 Stand count at harvest

The result showed that there was decline in per cent stand count with increase in plant population. This could probably be due to the high rate of plant mortality resulting

from close spacing and other stresses which are detrimental to plants' survival. Harper and White (1970) reported that self thinning is a well known phenomenon in high plant densities.

5.1.6 Oil content

The high inter and intra plant competition for soil moisture, nutrients, space, light and assimilates at high populations may account for the decrease in oil content with increase in population. This can lead to incomplete or improper development of the seeds thereby affecting the synthesis of fatty acids, which might result in low oil content (Gupta, 1987). It appears that the population used was high enough to affect the reproductive growth and seed yield but still low to stress the vegetative growth as evident from the dry weight/plant records.

5.2 Effect of Sowing Date

5.2.1 Growth characters

Plant height at harvest decreased with delay in sowing. This might be due to the inadequate rainfall and other favourable environmental factors necessary for the growth of plants. This decrease in plant height with delay in sowing might account for the decrease in number of pods/plant and thus, seed yield/plant as the plant height was found to be positively correlated to number of pods and seed yield/plant. The superiority in plant height of early sowing which was observed in this study is similar to that of Weiss (1971) in

which varying times of planting from early May to early September resulted in the reduction in plant height from 235 cm to 170 cm between May and June planting but a major depression to 50 cm in the September planting. Kaigama and Misari (1986) observed a similar depression in plant height when sowing date was delayed from early July to early August at Kadawa and Mallam Maduri.

At flowering, leaf area/plant increased when planting was delayed from 15 July to 5 August, 1986. This can probably be attributed to disease attack on the early sown crop which might have reduced the leaf area through reduction in the number of leaves. The plants later recovered and at pod formation stage, leaf area/plant was found to decrease with delay in sowing. This conforms with the findings of Van Rheenen (1973) who reported greater leaf area with early sowing. This decrease in leaf area at pod formation stage may account for the decrease in seed yield and yield components with delay in sowing as this is the main photosynthesising surface for assimilates which is eventually translocated and stored in the seeds (Evans, 1975).

Even though number of branches/plant was not significantly influenced by sowing date, it was observed that the number of branches tended to decrease with delay in sowing. This could be associated with the increasing inadequacy of rainfall with delay in sowing sesame.

5.2.2 Dry weight per plant

Dry weight/plant before and at flowering were not significantly affected by sowing date. At harvest, however, dry weight/plant increased by 55.02% when sowing was delayed from 24 June to 15 July and decreased by another 21.90% when sowing was further delayed to 5 August, 1986. This might be attributed to the optimum environmental conditions coinciding with the growth and thus, dry matter production of the plants sown on 15 July.

The insignificant difference in dry weight/plant, before and at flowering might probably be that at both stages and at all the sowing dates, moisture was probably still adequate but as the growth of plants continued towards maturity, moisture and other factors probably became inadequate to meet the requirement of the late sown-crop.

5.2.3 Yield components

The decrease in number of pods/plant, number of seeds/pod, seed yield/plant and number of seeds/plant with delay in sowing may account for the low seed yield of the crop. This is in conformity with the findings of Tilak *et al.* (1971), Weiss (1971), Van Rheenen (1973), Bhattacharya *et al.* (1975), Mandal and Rao (1976), Ogunremi (1979), Abdel-Rahman *et al.* (1980), Schiller *et al.* (1981), Ding (1983) and Kaigama and Misari (1986) who reported the highest yield components with early sown sesame. This might be attributed to the adequate moisture

and other environmental factors coinciding with the growth of the crop sown early, therefore, taking this advantage of adequate moisture to develop hence increasing the ability of these organs to compete for the synthesized assimilates.

The insignificant effect of sowing date on length of pods and 1,000-seed weight in this study seems to agree with the views of Westermann and Crothers (1977) who reported that yield components changes are said to emanate from the plant's response to its environment which may or may not permit the full genetic expression of each component.

5.2.4 Seed yield

The earliest sown sesame outyielded the second and third sowings by 37.80% and 55.20%, respectively. These findings are in line with those of Tilak et al. (1971), Weiss (1971), Van Rheenen (1973), Bhattacharya et al. (1975), Mandal and Rao (1976), Ogunremi (1979), Abdel-Rahman et al. (1980), Schiller et al., (1981), Ding (1983) and Kaigama and Misari (1986) who reported the highest seed yield with early sowing. This would be attributed to the differences in the length of the growing period as reported by Menon (1967) and Van Rheenen (1973) with the first sowing date having the longest growing period (95, 91 and 89 days for the first, second and third sowings, respectively) and, therefore, producing bigger and vigorous plants with better developed yield components such as number of pods, seed yield/plant, number of seeds/plant and number of seeds/pod thus,

resulting in high yields. Another possible reason for the low yield with delay in sowing is that most of the yield components formed from the late sown crop did not get the advantage of adequate moisture to develop. This coupled with decreased stand establishment must have accounted for the sharp decrease in seed yield as sowing was delayed.

5.2.5 Stand count at harvest

The result indicated decrease in stand count at harvest with delay in sowing. This significant decrease could be due to the increasing inadequacy of soil moisture to meet the plants requirements as reported by Hillel (1972) and Gupta (1984) thereby, causing low plant stand. This result also is quite similar to the findings of Weiss (1971) and Van Rheenen (1973) in which stand establishment was reported to have decreased with delay in sowing sesame. This decrease in stand count at harvest may have added to the decrease in seed yield with delay in sowing the crop.

5.2.6 Oil content

Oil content was found to increase with delay in sowing sesame from 24 June to 5 August. This result does not agree with Weiss (1971) who reported an increase in oil content with early sowing. This disparity might be due to varietal differences and/or the effect of moisture stress which probably enhanced fatty acid synthesis thereby, increasing the oil content.

5.3 Effects of Variety

The significant effect of variety on seed yield, yield components, growth characters, oil content and stand count at harvest tested may be explained by the fact that these characteristics are genetically controlled and they can also be influenced by environmental factors. Thus, variety E_8 performed better than variety Pb-till$_1$ in almost all the parameters measured except in dry matter production before and at flowering. The fact that variety E_8 out-yielded Pb-till$_1$ by 37.33% could be attributed to its higher yield potential as well as being more adapted to the environmental conditions at Samaru where the two varieties were tested.

5.4 Interactions

5.4.1 Interaction between plant population and sowing date

The interaction between plant population and sowing date was significant on number of pods, seed yield/plant, number of seeds and number of primary branches/plant, stand count at harvest and oil content. Early planting of sesame at populations of 100,000 and 250,000 plants/ha gave a higher number of pods, seed yield/plant, number of seeds and primary branches/plant and stand establishment than the last two sowings. These results may be explained with the views of Gupta (1984) that the difference in climatic factors under which plants are grown requires changes in plant population in order to get the best use of the prevailing climatic factors.

5.4.2 Interaction between plant population and variety

The main reason for the variety population interaction is that, in E_8 there were no significant differences in number of seeds/pod when population was varied from 100,000 to 400,000 while in Pb-till$_1$ the number of seeds/pod decreased such that beyond 100,000 plants/ha, E_8 had significantly higher seeds/pod than Pb-till$_1$.

Variety E_8 yielded more seeds/pod than variety Pb-till$_1$ at all the plant populations tested. This probably shows how better adapted variety E_8 is than variety Pb-till$_1$ and must have accounted for the higher yield in variety E_8 over Pb-till$_1$ at all populations tested.

Variety E_8 produced more oil than Pb-till$_1$ in all the populations tested. The result also indicated that variety E_8 when sown at a plant population of 250,000/ha, the oil content of this variety was increased. This further emphasises the superiority of this variety over variety Pb-till$_1$.

5.4.3 Interaction between sowing date and variety

The four traits, number of seeds/pod, leaf area at flowering and at pod formation, dry weight/plant at harvest and seed oil content showed significant sowing date x variety interaction. A higher number of seeds/pod and dry weight/plant at harvest was observed in variety E_8 in all the three sowings than variety Pb-till$_1$. This probably shows how better adapted

variety E_8 is over Pb-till$_1$. The interactive effect of sowing date and variety was inconsistent for leaf area at both flowering and at pod formation stage. In both varieties, dry weight/plant at harvest increased when sowing was delayed from 24 June to 15 July and then decreased when sowing was further delayed to 5 August, 1986. This result further emphasises the importance of planting sesame early in order to obtain more meaningful yield. This might be due to the fact that adequate amount of rainfall and other favourable environmental factors were optimum for the 15 July sowing.

In both varieties tested, oil content increased with delay in sowing the crop. An increase in oil content of sesame seed as a result of delay in sowing might have been caused by moisture stress which probably increased fatty acid synthesis.

5.4.4 Interaction between plant population, sowing date and variety

This three factor interaction was significant for number of pods, seed yield/plant, number of seeds and dry weight/plant at harvest, plant height and oil content. This was probably due to the highly significant effects of plant population and sowing date x variety interaction.

5.5 Correlation

The highly significant and positive correlation between number of pods/plant, number of seeds/pod, length of pods, seed

yield/plant, number of seeds/plant and 1000-seed weight with seed yield of sesame revealed these as important yield components and critical determinants of seed yield of sesame. The results are similar to the findings of Khidir and Osman (1970), Naphade and Kolte (1974) Delgado and Yermanos (1975), Shukla and Verma (1976), Choudhary et al. (1977), Osman (1980) Yadava et al. (1980) and Narayanan and Reddy (1982).

The significant positive correlations between seed yield of sesame and growth characters such as plant height number of primary and secondary branches/plant and leaf area/plant may be attributed to the fact that these vegetative characters directly determine the amount of photosynthates available for plant growth, development and seed yield. This agrees with the findings of Weiss (1971) and Van Rheenen (1973) in which a positive correlation between seed yield and plant height and number of branches/plant was obtained.

Chapter 6

SUMMARY AND CONCLUSION

Two varieties of sesame (Pb-till$_1$ and E$_8$) were seeded directly on the field at three different sowing dates (24 June, 15 July and 5 August, 1986) at three-week intervals between each date and at three plant populations (100,000; 250,000 and 400,000 plants/ha). The treatments were replicated four times in a Randomized Complete Block Design in a factorial arrangement.

The result indicated a 27% increase in seed yield when plant population was increased from 100,000 to 250,000/ha and no significant increase in seed yield when the population was further increased from 250,000 to 400,000 plants/ha.

The results showed a decrease in number of pods, seed yield/plant, number of seeds/plant and number of branches/plant with increase in plant population from 100,000 to 400,000/ha. Number of seeds/pod, length of pods, 1,000-seed weight, leaf area and dry weight/plant both at flowering and at harvest were not affected by plant population.

Plant height increased with increase in plant population from 100,000 to 400,000 plants/ha while per cent stand count at harvest decreased with increase in plant populations.

It was found that oil content decreased with increase in plant population.

Sesame sown earliest (24 June) out-yielded that sown on 15 July and 5 August, by 37.80% and 55.20%, respectively. The high seed yield in the early sown sesame was determined by the number of seeds/pod, number of pods/plant, seed yield/plant and number of seeds/plant which also declined with the successive sowing dates. Delay in sowing sesame resulted in decrease in plant height with each successive sowing. Sowing date had no significant effects on length of pods, 1,000-seed weight, dry weight/plant before and at flowering and on leaf area at pod formation. Dry weight/plant at harvest was increased when sowing was delayed from 24 June to 15 July. Further delay in sowing from 15 July to 5 August decreased dry weight/plant. Per cent stand count at harvest decreased with each successive sowing date. Oil content was found to increase with delay in sowing sesame.

Variety E_8 appeared to be superior to Pb-till$_1$ in terms of seed yield (it out-yielded Pb-till$_1$ by 37.33%) and all other traits measured.

The effects of interaction of plant population and variety on number of seeds/pod and oil content were significant. Number of pods, seed yield/plant, number of seeds and number of primary branches/plant, stand count at harvest and oil content were significantly affected by the interaction between plant population and sowing date. The four traits, number of seeds/pod, leaf area at flowering and at pod formation, dry weight/plant at harvest and oil content showed significant

plant population x sowing date interaction effects. The three factor interaction of plant population, sowing date and variety was significant for number of pods, seed yield, number of seeds, plant dry weight at harvest, plant height and oil content.

Correlation analysis indicated a significant and a positive correlation between seed yield of sesame and yield components tested.

Based on the results obtained in this study, it can be concluded that among the plant populations tried, 250,000 plants/ha was the most appropriate for optimum production of sesame in Samaru. It appears that the optimum or best time to sow sesame at Samaru is soon after the establishment of rains. Variety E_8 was superior to Pb-till$_1$ in almost all the characters studied.

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