GROWTH AND DEVELOPMENT STUDIES OF SUNFLOWER (*Helianthus annuus* L.) AS INFLUENCED BY PLANT DENSITY AND SOWING DATE

By

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I.A

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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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(Name and Signature of Candidate)

Date: ...7th September, 1988...

The above declaration is confirmed.

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(Name and Signature of Major Supervisor)

Date: ...7th September 1988...

DEDICATION

For their very supportive and understanding roles during very trying periods, this thesis is dedicated to my wife, Ladi S. ATUK, and our children - James Jiyo, Joana Kaliyat, Rowland Swanta, Labock Peter, and Bihiyai John ATUK.

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ABSTRACT

Investigation was carried out at Samaru, Zaria, Nigeria, during the 1986 cropping season to study the effects of four plant populations (30,000; 60,000; 120,000 and 240,000 plants/ha), three sowing dates (July 2, 16 and 30) and two varieties (isaanka and Funtua) on growth characters, yield and yield components and seed quality of sunflower.

Increasing the population density from 30,000 to 2l}.0,000 plants/ha, decreased stand establishment and survival rate from 53 to 35% and from 46 to 23%, respectively. Similarly, stem and head diameters, dry weight/head and weight of 1000 seeds decreased, but the number of seeds/head and seed yield/plant showed a significant decrease only at populations of 120,000 and 240,000 plants/ha There was no clear trend in oil content with increase in plant population. However, crude protein content, decreased with increase in population only from 30,000 to 120,000 plants/ha. Number of days to 50% flowering, days to maturity, lodging percentage, percent empty seeds and seed yield were not significantly affected by plant population.

The July 16 sown sunflower with a mean seed yield of 1434.O kg/ha, out-yielded that sown on July 2 and July 30 by 18 and 24%, respectively. Delay in

sowing date decreased dry weight/head, number of seeds/ head and seed yield/plant. The percent oil content of the seed increased from 44.1 to 47.2% when sowing was delayed from July 2 to July 16.

Of the two varieties tested, Funtua excelled in almost all the parameters except in oil content and plant count.

Significant treatment interactions were observed on yield parameters«

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Chapter 1

INTRODUCTION

Sunflower (*Helianthus annuus* L.), a member of the compositae family is a dicotyledonous plant which is believed to be a native of the Americas. It is adapted to both tropical and temperate regions where rainfall is below 3,500 mm (Weiss, 1966). It is grown primarily for its oil content which ranges from 41.6-47.2%.

The World production as at 1980 was 13,174,000 metric tons from 12,374,000 hectares while the production in Africa stood at 478,000 metric tons from 506,000 hectares (Anonymous, 1980). The major producers of sunflower are Union of Soviet Socialist Republics, Rumania, United States of America and South and Central America.

Though there has been no official recorded hectarage figures in Nigeria, the crop was once cultivated rather widely in the semi-arid Sudan zone and it is known to be tolerant to drought. However, high as the potential of sunflower is as a crop for the drought-prone areas of Nigeria, sunflower has so far received little research attention (Yayock *et al.*, 1986). In order to meet the world's oil seed needs, sunflower must rank at or near the top of any priority for research attention. Unlike most agricultural crops,

sunflower is blessed with a considerable level of unexplored genetic variability, thus allowing sunflower breeders to tailor-make varieties for particular climatic zones and environments. Since sunflower is a relatively new crop, the genetic potentials for growth, yield and other characteristics have been lightly tapped (Gandy, 1977).

In Nigeria, the need for obtaining another oil seed crop to complement groundnut and oil palm, has motivated research into sunflower production (Yayock et al., 1986). Since the drought of 1971 which affected most of the West African region, Nigeria has had to relinquish her position as the third largest producer of groundnuts after India and China and as the world's largest exporter of the crop. In addition to the problems of shortage and uneven distribution of rainfall, other factors responsible for the decline in groundnut production in the country include diseases, problems of guaranteed producer prices and the poor monetary arrangements for purchases by the buying agents. As a result of these and other considerations, farmers have become discouraged from growing groundnuts (Tanimu et al., 1986a). The decline in groundnut and oil palm production, coupled with the recent ban on the importation of vegetable oil, has necessitated the search for

alternative oil seeds. Sunflower, one of the most important edible oil seeds is a potential alternative source of vegetable oil in Nigeria (Kinman, 1963).

Sunflower is good for human consumption since it is known to contain appreciable quantities of protein. For instance it is used for shortening and making of cooking and salad oils. Industrially, it is used in the manufacture of margerine, soaps and paints. The cake is used mainly as livestock feed but some is used as fertilizers in crop production (Martin et al., 1976). In recognition of these high potentials of the crop, it has become necessary to explore the possibility of its cultivation in Nigeria.

Research into sunflower cultivation as an arable crop began in Nigeria in the early sixties to find out if it could possibly be grown on a large scale to supplement the shortfall in edible oil and meal, (Ogunremi, 1978). Though studies have been carried out on the effects of sowing dates on sunflower in South Western Nigeria, effects of environmental factors on its growth and development have not been studied. Several factors that constrain production of sunflower have not yet been identified. In Nigeria, agronomic knowledge on the crop is very scanty, for example, time of sowing,

the correct plant populations, spacing and nutrients requirement have not been adequately worked out. There is a need for information on the agronomic practices for sunflower production that the existing and prospective sunflower growers in Nigeria could use in order to boost production and achieve the desired goal of increasing oil production.

This work was therefore undertaken with the following objectives:

1. To study the effects of sowing date on the growth and development of two varieties of contrasting maturity periods.
2. To determine the optimum population densities for these two varieties.
3. To study the growth characteristics of the two varieties and relate these to yield and yield components.

Chapter 2

LITERATURE REVIEW

Sunflower is cultivated on a large scale in the U.S.S.R., U.S.A., Rumania and South and Central America, but it is a relatively new crop to most other parts of the world. Published research work on the sunflower in Nigeria is rather limited, and as a result, literature on its growth and development is scanty particularly in this part of the world.

2.1 Effects of Plant Population

The literature on the influence of plant density on sunflower productivity has been thoroughly reviewed by Robinson (1978). Sunflower adapts to a range of plant populations by changes in yield and yield components. However, optimum population varies with environment.

2.1.1 Seed yield

Robinson *et al.* (1980) found that minimum populations for maximum yield varied from 25,000 to 62,000 plants/ha among six locations over two years in Minnesota. Alessi *et al.* (1977) and Radford (1978) achieved maximum seed yield with populations ranging from 25,000 to 100,000 plants/ha. In North Dakota,

Zubriski and Zimmerman (1974) reported that increasing the plant populations from 36,000 to 72,000 plants/ha significantly increased seed yield from 2258 to 3190 kg/ha. In Georgia, Massey (1971) reported significant increase in seed yield from 1667 to 2839 kg/ha by increasing the populations from 20,000 to 60,000 plants/ha.

In Minnesota, Robinson (1973) reported that increasing populations from 37,000 to 86,000 plants/ha increased yield at Waseca whereas yield at Morris was not affected. At Swift Current, Canada, Vijayalakshmi et al. (1975) found no yield differences between populations of 25,000 and 75,000 plants/ha, but yields were significantly reduced when the stand density was increased to 125,000 plants/ha. In North Dakota, Miller and Fick (1978) and Prunty (1981) reported that seed yields were not affected by increasing the plant populations. The inconsistent yield response of sunflower to increasing plant population may be due to great differences in the environment under which the trials were conducted (Robinson et al. 1976; 1980).

Zubriski (1975) compared plant populations of 37,000, 47,000 and 72,000 plants/ha and found that yields increased with increase in plant population being 2179, 2550 and 3113 kg/ha, respectively. Many other studies using various cultivars have shown no significant yield

differences between plant populations ranging from 25,000 to 99,000 plants/ha (Lofgreen, 1970; Swellers and Fick, 1973; Smith, 1975, Vijayalakshmi et al. 1975; and Robinson et al. 1976). Robinson et al. (1976), concluded that yields were affected more by soil type, temperature and rainfall at different locations than by populations. Optimum plant populations were shown to be in the range of 57,000 to 64,000 plants/ha in southern Manitoba, Canada (Enns and Giesbrecht, 1971); 54,000 plants/ha in Bangladesh (Main and Gaffer, 1971); and between 35,000 and 54,000 plants/ha in Spain (Lopez, 1972). Work by Pacucci and Scarascio Mugnozza (1972) in Italy showed that plant densities of 31,000 to 83,000 plants/ha did not influence grain yield. A new spacing of 30 cm is recommended in Manitoba (Enns and Giesbrecht, 1971), but Vijayalakshmi et al. (1975) suggested that the crop can be grown over a wide range of plant populations and row spacings without adversely affecting yields. Currotti and Rosania (1971) in Italy and Lopez (1972) in Spain, found that increasing the spacing between plants increased yields in Russian sunflower.

Research into sunflower plant populations in Canada was reported by Putt and Unrau (1943) and Putt and Fehr (1951). Their work showed that suitable population for the production of sunflower under rainfed conditions ranged from 48,000 to 72,000 plants/ha in 46 cm rows. At Saskatchewan, seed yields were highest at 25,000 plants/ha

with little effect from row spacing greater than 36 cm (Alessi et al; 1977). Putt and Fehr (1951) reported that decreasing row spacing from 91 to 46 cm increased seed yield, but that reducing spacing between plants in 46 cm rows from 16 to 15 cm reduced sunflower yield.

Thompson and Fenton (1979) conducted three experiments in the Murrumbidgee Irrigation area of south New South Wales and examined the influence of plant population on the yield and yield components of irrigated sunflower. Populations ranged from 25,000 to 140,000 plants/ha, furrow irrigation was employed with row spacing of 76 cm apart. In two of the experiments, plant population had little effect on seed yield while in the third experiment, insufficient total dry matter production without improved harvest index prevented the attainment of an acceptable seed yield. Chaudhari et al. (1978a) reported that sunflower seed yields were increased with increases in plant density from 28,000 to 148,000 plants/ ha, but there was no significant difference in yields (600-730 kg/ha) at densities of 56,000 to 148,000 plants/ha.

Holt and Campbell (1984) reported at Saskatchewan in the semi-arid prairies that at populations of 40,000 to 85,000 plants/ha, plant density had no significant effect on seed yield. Miller et al. (1984) reported that sunflower seed yields were not affected by plant populations ranging from 28,700 to 73,200 plants/ha. Establishing plant

populations between 43,600 and 59,600 plants/ha in the humid climate of the north central U.S.A. resulted in adequate seed yields (Miller et al; 1984). Moisture was a yield limiting factor in sunflower production on the sandy soils at Hancock and applied irrigation dramatically increased seed yields. (Miller et al., 1984).

Ogunremi (1978) reported that variations in plant densities of 36,000; 43,000; 55,000 and 75,000 plants/ha, had no effect on seed yield. Tanimu et al. (1986b) reported that close spacing of 15 cm between stands on ridges 75 cm apart produced the highest sunflower yield of about 2729 kg/ha.

2.1.2 Plant height

In North Dakota Miller and Fick (1978) found that plant height increased with increase in plant populations from 36,000 to 72,000 plants/ha. Robinson et al. (1976) reported increases in plant height as plant populations increased from 25,000 to 99,000 plants/ha. Currotti and Rosania (1971) in Italy and Lopez (1972) in Spain found that increasing the spacing between plants, produced shorter plants in Russian sunflower. Holt and Campbell (1984) reported in Saskatchewan that plant height increased with increase in plant populations from 40,000 to 85,000 plants/ha.

2.1.3 Stem and head diameters

In Georgia, Massey (1971) reported that when stand density was increased from 20,000 to 60,000 plants/ha, head diameter was significantly reduced at the high population. Robinson et al. (1976) reported that as plant populations increased from 25,000 to 99,000 plants/ha, heads became smaller. Currotti and Rosania (1971) and Lopez (1972) found that increasing the spacing between plants produced larger stalk diameter. Salam et al. (1978) found that closer spacing of 30 x 20 cm decreased head diameter in sunflower. Holt and Campbell (1984) reported in Saskatchewan that as plant density was increased from 40,000 to 85,000 plants/ha, head diameter decreased. Miller et al. (1984) reported that establishing plant populations between 43,600 and 59,600 plants/ha in the humid climate of the north central U.S.A. reduced head size which could allow for more rapid dry down of the head during a wet harvest season. In North Dakota, Zubriski and Zimmerman (1974) reported that increasing the plant populations from 36,000 to 72,000 plants/ha significantly reduced the head diameter.

2.1.4 Lodging percentage

Sunflower trials in Western Kenya showed a population of approximately 25,000 plants/ha appeared to be optimum and this depended mostly on soil fertility and climatic conditions during growth (Weiss, 1966).

Closer spacing ranging from 18 to 36 cm significantly increased the number of lodged plants. Robinson et al. (1976) reported that as plant populations increased, plants lodged more. Miller et al. (1984) reported that establishing plant populations between 43,600 and 59,600 at Arlington, U.S.A., resulted in minimal lodging.

2.1.5 Oil content

In Manitoba, plant densities of 40,000 to 49,000 plants/ha were recommended for oil type cultivars and hybrids (Manitoba Agriculture, 1983). In North Dakota, Miller and Fick (1978) found that oil content was not different for the three plant densities of 36,000; 48,000 and 72,000 plants/ha. In North Dakota, Zubriski and Zimmerman (1974) reported that increasing the plant population from 36,000 to 72,000 plants/ha, had no significant effect on oil concentration. Work by Pacucci and Scarascio Mugnozza (1972) in Italy showed that plant densities of 31,000 to 83,000 plants/ha did not influence oil content. In Canada, Putt and Unrau (1943) and Putt and Fehr (1951) showed that suitable populations for the production of oil under rainfed conditions ranged from 48,000 to 72,000 plants/ha in 46 cm row. Holt and Campbell (1984) reported at Saskatchewan that the increase in percentage oil content (44.3 to 45.6%) with increase in plant populations of 40,000 to 85,000 plants/ha was small but significant. At Arlington, U.S.A., Miller et al.

(1984) reported that oil concentration was consistently higher in populations between 43,800 and 70,700 plants/ha, but at Hancock and Spooner, oil concentration was not significantly influenced by increasing plant population.

2.2 Effects of Time of Sowing

Although sunflower produces good yields over a wide range of planting dates, higher yields and seed oil content have been achieved with early plantings.

2.2.1 Seed yield

In North Dakota under dryland conditions, Alessi *et al.* (1977) recommended planting sunflower before mid-June for high seed yield. In Minnesota, Robinson (1970) reported early May as the optimum planting time for maximum seed yield. Johnson and Jellum (1972) found that seed yield was highest in Geogia, U.S.A., when sunflower was planted between mid-March and April. In Texas, U.S.A., Unger (1980) reported no significant yield differences in planting dates from late March to mid- June, but yield declined with delayed planting between late May through August. Miller *et al.* (1984) reported that planting in early and mid- May at Arlington, U.S.A., and mid- May at Spooner U.S.A. maximized seed yield. Bhattacharya *et al.* (1975) reported seed yields of 1.93 and 1.81 t/ha in India with

sowing on November 28 and December 12, respectively. Jessop (1977) in Wimmera District of Victoria, Australia, observed that with mid- September, mid- October or mid-November sowings, highest seed yield was obtained from the November sowing.

Yadava et al. (1976) reported at Hayana, India, that sunflower cv "Armavirskij" sown at 15- day intervals throughout the year gave highest seed yields when sown between December 15 and February 15, the highest yield being in crops sown on January 15. Early May planting of sunflower generally produced higher seed yields and June planting resulted in low yields in Minnesota, U.S.A., (Johnson and Soine, 1967; Robinson, 1970) and in Canada (Putt, 1967).

Kathiresan and Ramasedamy (1978) reported that highest seed yield was obtained in October sown sunflower followed by those sown in March and November and the lowest in the January sown crop in Tamil Nadu, India. Shaikh and Chaudhary (1976) reported in South Suid that sunflower seed yield was increased by 40-55% when the crop was sown between the last week of January and the 2nd week of February. Alessi et al. (1977) reported that when sunflower cv. "Peredovik" was sown in mid-May or early to late June at Mandan, North Dakota, yield increased with increasing delay in sowing. Anderson et al. (1978) at Armidale, New South Wales, examined

the relationship between yield of sunflower cv "Peredovik" and variations in the thermal and radiation environments of the crops. Yields declined with later sowings and were associated with a reduced mean temperature regime during the vegetative stages of growth and lower levels of radiation during the development. Chaudhari et al. (1978b) reported that the optimum dates for sowing two sunflower cultivars were early July for the kharif (monsoon) season, mid- October for the winter season and early February for the summer season in Maharashtra. Average seed yield during the three seasons were 1.09, 0.9 and 0.45 t/ha respectively.

Ogunremi (1979) reported that early season crops at Ibadan gave highest yields of 2079 kg/ha in 1975 and 2312 kg/ha in 1976 when cv. Russian Giant was sown during the 3rd week of May. Tanimu et al. (1986b) found that early planting (as soon as rains have established) produced the best crop in terms of crop establishment and yield at Samaru, Zaria.

2.2.2 Oil content

In North Dakota, Alessi et al. (1977) recommended planting sunflower before mid- June for high oil concentration. In Minnesota, Robinson (1970) reported early May as the optimum planting time for maximum oil content. Johnson and Jellum (1972) found that oil concentration was highest in Georgia, U.S.A. when

planted between mid- March and April. Under irrigated conditions in Texas, Unger (1980) reported that oil content declined irregularly from late March to mid- June. Putt and Unrau (1943) reported no significant differences in oil concentration of seed from different dates of harvest ranging from September 1 to October 20. Miller et al. (1984) reported that planting in early and mid- May at Arlington, and mid- May at Spooner, U.S.A., maximized seed oil concentration.

The oil percentage of sunflower seed decreased from early May to late June plantings in Minnesota (Robinson, 1970) or when the crop was grown in temperatures either lower or higher than 21°C (Canvin, 1964). Kinman and Earle (1964) found that the linoleic acid composition of sunflower oil was influenced more by environmental conditions than by the genotype. They concluded that high linoleic acid oil might be produced in the southern states of the U.S.A. by late summer plantings. Alessi et al. (1977) reported that seed oil yield was always greater with late than with early sowing and accounted for 80% of the variation in seed oil content, which was in the range of 28-47%. Simpson and Radford (1976) reported that seeds of cv. "Isaanka" and "Sunfola 68-2" were sown at Biloela, Queensland on five dates between August, 1973 and January, 1974. Plants from the later sowings showed slower rates of moisture content loss and

nitrogen and oil accumulation in their seeds than those from earlier sowings. Nitrogen and oil content of the seed reached final value at 70% seed moisture content. Low temperature during seed maturation encouraged production of linoleic acid.

2.2.3 Other yield components

In Minnesota, Robinson (1970) reported early May as the optimum planting time for maximum test weight. Miller *et al.* (1984) reported that planting in early and mid- May at Arlington, and mid- May at Spooner, U.S.A. maximized seed weight, seeds/head, oil yield and test weight. Bhattacharya *et al.* (1975) reported oil yields of 726 and 768 kg/ha in India with sowing on November 28 and December 12, respectively. Shaikh and Chaudhary (1976) reported that plant height was unaffected by sowing date. Tanimu *et al.* (1986c) showed that the date of sowing had significantly affected the number of stands per unit area such that the earlier you plant the more stands that are likely to survive.

Chapter 3

MATERIALS AND METHODS

3.1 Location

The experiment was conducted during the 1986 cropping season at the Institute for Agricultural Research (I.A.R.) farm, Ahmadu Bello University, Samaru ($11^{o}11'N$ and $7^{o}38'E$; 686 meters above sea level) in the Northern Guinea Savanna ecological zone. The soil of the experimental site is a well drained sandy loam and the field was cropped to cotton the previous year. Details of the physio-chemical composition of the soil at the experimental site are shown in Appendix 1. A total of 968.3 mm of rainfall was received in Samaru during the 1986 cropping season. Data on distribution of rainfall, relative humidity, sunshine and temperature at Samaru during the experimental period are shown in Appendix 2.

3.2 Treatments and Experimental Design

Treatments consisted of two sunflower varieties (Isaanka and Funtua), three sowing dates spaced at two weeks intervals (July 2, 16 and 30, 1986), and four plant populations (30,000; 60,000; 120,000 and 240,000 plants/ha).

Isaanka is one of the 31 varieties brought in from Canada. One variety was obtained from Funtua Agricultural Development Project without much information as to its origin, hence it was named "Funtua".

The two cultivars used were the only ones obtainable in enough quantity for planting at the time the experiment started.

The populations were chosen to include all the range of populations reported in the literature as giving maximum yield in various parts of the world including Nigeria, so as to enable us determine the optimum plant density for sunflower production in the Nigerian Savanna.

The 24 treatment combinations were laid out in a randomized complete block design with four replications.

3.3 Plot Size

The gross plot size was six ridges, 75 cm apart (4.5 m wide) and 6 meters long (27.0 m^2) and the net plot size was four ridges (3 meters wide) and 6 meters long (18.0 m^2).

3.4 Agronomic Practices

3.4.1 Land preparation

The experimental area was disked at the end of June, harrowed twice and ridges were constructed at 75 cm apart. The area was marked out into 96 plots.

3.4.2 Sowing

Sowing was done manually on July 2, 16 and 30 by planting 3 seeds/hole on 75 cm ridges at spacings of 44.4, 22.2, 11.1 and 5.6 cm apart to give the desired populations of 30,000, 60,000, 120,000 and 240,000 plants/ha, after thinning to two plants per stand. Supplying of missing stands was done at the time of thinning.

3.4.3 Weeding and fertilizer application

The first weeding for each sowing date was carried out manually two weeks after germination. Fertilizer rates of 100 kg N/ha, 60 kg P_2O_5/ha and 30 kg K_2O/ha were applied in shallow trenches along one side of each row. The second weeding was done as soon as weeds emerged and a general moulding up was done to all plots as the last weeding operation at the end of August, 1986.

3.5 Harvesting

The crop was harvested manually by cutting the heads with knives when the crop matured. At maturity the back of the heads turned yellow and the outer bracts turned brown. The dates of harvesting were September 30, for the first sowing, October 14, for the second sowing and October 28, for the third sowing.

3.5.1 Drying and threshing

The sunflower heads were sun dried and the dried heads were threshed by putting the heads in a sack and using sticks to beat the sack. This was done to avoid the loss of seeds through being blown away by the wind. A local sieve (matangadi) was used in winnowing the seeds.

3.6 Data Collection

Total number of stands in each plot were counted soon after thinning (21 days after sowing) and at harvest to determine the actual populations that were established. Five plants were randomly selected and tagged in each plot for various observations and measurements.

The height of the main stem of each of the five plants was measured from the ridge top to the growing point of each plant fort-nightly. The dates of first flowering and 50% flowering were observed for each sowing date.

The heads of the five tagged plants were harvested in each plot and the five heads were measured and the mean head diameter was determined. The heads were then dried and weighed to obtain the mean head weight per plant.

The number of plants that lodged in each net plot was counted and expressed as a percentage of the total number of plants per plot. The number of plants in each

net plot was counted during harvest to determine the survival rate.

The five heads from the tagged plants were dried on small sacks, threshed as in 3.5.1 above and the number of seeds counted. This was then divided by five to obtain the average number of seeds per head. The seed yield/head was also obtained by weighing the seeds from each set of five heads and determining the mean.

The heads from the net plots were harvested, sun dried, threshed by beating with sticks in big sacks, winnowed by using local sieve and the seeds weighed. The weight of the seeds from the five heads was added to the weight of the net plot to obtain the seed yield per plot. This was converted to seed yield in kg/ha.

Five hundred seeds from each net plot were sampled for determining percent empty seeds. All hulls without seeds were counted and expressed as a percentage of the total to obtain the percent empty seeds. Three batches of one thousand seeds were counted from each plot. This was done to obtain a true representative sample of the seeds from each plot. These were weighed to obtain the mean 1000-seed weight.

The diameter of the main stems of the five tagged plants in each plot was measured just before harvest. The mean stem diameter for each plot was obtained from these measurements.

Chapter 4

RESULTS

4.1 Growth Characters

4.1.1 Plant count at thinning and at harvest

Appendices 3A and 3B show the effects of plant population on plant establishment at thinning and plant survival at harvest, respectively.

When averaged over the two varieties and expressed as a percentage of the intended populations, both stand establishment and plant survival rate were highest for the lowest population and decreased with each successive increase in plant population from 30,000 to 240,000 plants/ha. Stand establishment decreased from 53% to about 35% and survival rate from 46% to 23% when population increased from 30,000 to 240,000 plants/ha. Both stand establishment and survival rate were higher for Isaanka than Funtua at all plant populations and sowing dates. For Isaanka, percent stand establishment decreased with delay in sowing, but plant survival rate was higher for the second sowing date than either the first or third sowing dates. For Funtua, stand establishment was lowest for the first sowing date while the second and third sowing dates had comparable percent stand establishment. Plant survival rate in this

variety was also highest for the second sowing date than for either the first or third sowing dates.

4.1.2 Days to 50% flowering/maturity

The number of days from seedling emergence to first flowering, to 50% flowering and to maturity are given in Appendix 4.

The two varieties were similar in their days to flowering and days to maturity. Sowing date and plant population had no influence on days to flowering and maturity.

4.1.3 Plant height

At 5 weeks after sowing (WAS), plants sown on July 2 were significantly shorter than plants sown two and four weeks later on July 16 and July 30, respectively (Table 1). Plant height at 5 WAS increased with each increase in population from 30,000 to 240,000 plants/ha, but the differences in height between 30,000 and 60,000 and between 120,000 and 240,000 plants/ha were not significant.

Isaanka produced significantly taller plants than Funtua at 5 WAS, but there were no significant differences in their heights at harvest.

Table 1: Effects of sowing date, plant population and variety on plant height (cm) at Samaru, 1986.

Treatment	Plant height (cm)	
	5 WAS	At harvest
Sowing date		
July 2	44.44b*	149.04a
July 16	52.65a	149.81a
July 30	51.46a	127.78b
SE(±)	1.54	2.28
Plant population x 000/ha		
30	44.95c	139.69
60	46.34bc	139.98
120	51.37ab	145.94
240	55.42a	143.23
SE(±)	1.78	NS
Variety		
Isaanka	52.55a	142.25
Funtua	46.49b	142.17
SE(±)	1.26	NS

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

Sowing date significantly influenced plant height at harvest. The third sowing date (July 30) produced significantly shorter plant than the first two sowing dates (July 2 and July 16).

Variety and plant population had no significant influence on plant height at harvest.

4.1.4 Stem diameter

Stem diameter decreased with increase in plant populations but there was no significant difference in stem diameter between populations of 60,000 and 120,000 plants/ha (Table 2).

The second sowing date (July 16) produced plants with smaller stem diameter than either first (July 2) or third (July 30) sowing dates.

Funtua produced plants with significantly thicker stems than Isaanka.

Interactions between sowing dates and plant populations indicated that at the highest population of 240,000 plants/ha sowing date had no significant effect on stem diameter. At all other plant populations, the first (July 2) and third (July 30) sowing dates produced plants with significantly thicker stems than those from the second (July 16) sowing date.

Table 2: Effects of sowing date, plant population and variety on stem diamter (cm) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	16	30	Mean
Population x 000/ha				
30	2.08a*	1.74b	2.12a	1.98a
60	1.69bc	1.46c	1.91ab	1.69b
120	1.77b	1.37c	1.69b	1.61b
240	1.24c	1.26c	1.23c	1.24c
Mean	1.70a	1.46b	1.74a	
SE(±)	0.08			0.05
Variety				
Isaanka	1.48c	1.42c	1.75ab	1.55b
Funtua	1.91a	1.49c	1.72b	1.71a
SE(±)	0.06			0.03

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

Interaction between variety and sowing date was also significant. In the first sowing date (July 2); Funtua had significantly thicker stems than Isaanka. There were no significant differences in stem diameter between the two varieties in the second (July 16) and third (July 30) sowing dates.

4.1.5 Lodging percentage

Sowing date, interactions between population x date and variety x date had significant influence on lodging in sunflower (Table 3).

Increasing plant population from 30,000 to 240,000 plants/ha significantly increased lodging in the first two sowing dates, but this trend was reversed in the third sowing date. The highest lodging percentage was obtained at a plant population of 240,000 plants/ha in the first sowing date. Except at the lowest plant population of 30,000 plants/ha, lodging percentage generally declined with delayed sowing.

Of the two sunflower varieties (Isaanka and Funtua) tested, Isaanka lodged significantly more than Funtua in the first sowing date. The difference in lodging percentage between the two varieties was not statistically significant in the two later sowing dates.

Table 3: Effects of sowing date, plant population and variety on lodging percentage at Samaru, 1986.

Treatment	Sowing Date		
	July 2	16	30
Population x 000/ha			
30	16.21bcde*	15.60bcde	20.94bcde
60	31.39bc	9.05e	13.69cde
120	33.46b	15.85bcde	14.20cde
240	49.38a	25.44bcd	10.99de
Mean	32.61a	16.49b	14.95b
SE(±)	5.56		
Variety			
Isaanka	41.70a	17.39b	13.44b
Funtua	23.51b	15.58b	16.46b
SE(±)	3.93		

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

4.1.6 Head diameter

Plants from early sowing produced significantly larger heads than those from late planting (Table 4.)

Funtua produced larger heads than Isaanka.

Head diameter decreased with increase in plant populations. Population of 30,000 plants/ha produced the largest heads. However, the differences in head diameter between plant populations of 30,000 and 60,000 plants/ha and between 60,000 and 120,000 plants/ha were not significant.

There was a significant variety x sowing date interaction on head diameter. In Isaanka, the first and third sowing dates produced heads with significantly larger diameter than the second sowing date, but in Funtua head diameter decreased with each delay in sowing date from July 2 to July 30.

4.2 Yield Components and Yield

4.2.1 Dry weight per head

Sowing date, variety, plant population and interaction between sowing date and variety had significant influence on dry weight/head (Table 5).

Table 4: Effects of variety, sowing date and plant population on head diameter (cm) at Samaru, 1986.

Treatment	Variety		
	Isaanka	Funtua	Mean
Date			
July 2	14.14b*	17.25a	15.69a
July 16	11.77c	13.53b	12.65b
July 30	13.36b	12.63c	12.99b
Mean	13.09b	14.47a	

SE(±) Variety = 0.31 Sowing date = 0.38; Variety x date = 0.53

Population x 000/ha	30	60	120	240	SE(±)
Head diameter (cm)	15.61a	14.82ab	13.66b	11.02c	0.43

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

Table 5: Effects of variety, sowing date and plant population on dry weight per head (g) at Samaru, 1986.

Treatment	Variety		
	Isaanka	Funtua	Mean
Date			
July 2	61.51b*	79.14a	70.33a
July 16	50.31c	66.24ab	58.28b
July 30	54.78bc	46.09c	50.44b
Mean	55.53b	63.82a	

SE(±) Variety = 2.77; sowing date = 3.39; variety x Date = 4.79

Plant population x 000/ha	30	60	120	240	SE±
Dry weight/head(g)	72.4a	64.72a	59.11b	42.48b	3.91

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

Dry weight/head significantly decreased (by 17%) when sowing date was delayed from July 2 to July 16. Further delay in sowing to July 30 caused a further 13.5% decrease in dry weight/head, but this decrease was not significant.

Of the two varieties tested, Funtua had a significantly higher dry weight/head than Isaanka.

Dry weight per head decreased with each successive increase in plant population from 30,000 to 240,000 plants/ha, but the differences between 30,000 and 60,000 plants/ha and between 120,000 and 240,000 plants/ha were not significant.

Interaction between variety and sowing dates had a significant effect on dry weight/head. In Funtua, dry weight/head decreased with each delay in sowing date whereas Isaanka in the two later sowing dates, had less dry weight/head than in the first sowing date.

4.2.2 Number of seeds per head

Number of seeds/head was significantly decreased (by 35.3%) when sowing date was delayed from July 2 to July 16. A further two weeks delay in sowing date to July 30 caused no significant decrease in the number of seeds/head (Table 6).

The highest plant population of 240,000 plants/ha gave the lowest number of seeds/head, though this was not significantly different from that at 120,000 plants/ha. Differences in number of seeds/head between populations of 30,000; 60,000 and 120,000 plants/ha were also not significant.

4.2.3 Seed yield per plant

Two weeks delay in sowing from July 2 to July 16 caused a 27.3% decrease in seed yield/plant (Table 7). A further delay in sowing by two weeks to July 30, had no influence on average seed yield/plant.

Mean seed yield per plant was significantly higher (by 13.7%) in Funtua than in Isaanka.

Seed yield per plant decreased with each increase in plant population from 30,000 to 240,000 plants/ha, but the differencesin yield per plant between 30,000; 60,000 and 120,000 plants/ha were not significant.

4.2.4 Weight of 1000 seeds

The mean 1000-seed weight increased by 13.7% when sowing date was delayed by two weeks from July 2 to July 16 (Table 8). Further delay of sowing date by two weeks to July 30 caused no change in the weight of 1000 seeds.

Table 6: Effects of variety, sowing date and plant population on number of seeds per head at Samaru, 1986.

Treatment	Variety		
	Isaanka	Funtua	Mean
Sowing Date			
July 2	892b*	1153a	1022a
July 16	600c	723bc	661b
July 30	686c	568c	627b
SE(±)	59.11		

Plant Population x 000/ha	30	60	120	240	SE(±)
No of seeds/head	812a	859a	798ab	612b	48.3

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

Table 7: Effects of variety, sowing date and plant population on seed yield per plant (g) at Samaru, 1986.

Treatment	Variety		
	Isaanka	Funtua	Mean
Sowing Date			
July 2	37.36b*	52.35a	44.86a
July 16	29.21b	36.05b	32.63b
July 30	34.80b	29.03b	31.91b
Mean	33.79b	39.14a	

SE(±)=Variety 1.73; Sowing date 2.11; VarietyxDate 2.99

Population x 000/ha	30	60	120	240	SE(±)
Seed Yield/plant	43.07a	40.95a	36.28a	25.58b	2.44

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

Table 8: Effects of sowing date and plant population on weight of 1000 seeds (g) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	July 16	July 30	Mean
Population (x000/ha)				
30	52.5ab*	54.06a	53.68a	53.41a
60	43.91cde	49.64abc	51.88ab	48.23b
120	39.63de	47.49abc	52.55ab	46.55b
240	37.84e	45.7bcd	37.75e	40.43c
Mean	43.29b	49.22a	48.96a	
SE(±)	2.29			1.32

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

Weight of 1000-seeds decreased with each increase in plant population from 30,000 to 240,000 plants/ha, but the difference in the weight of 1000 seeds between populations of 60,000 and 120,000 plants/ha was not significant.

Interaction between sowing date and plant population had significant influence on 1000 seed weight. At the lowest population of 30,000 plants/ha, sowing date had no significant influence on 1000-seed weight. At populations of 60,000 and 120,000 plants/ha, the second and third sowing dates produced siginficantly heavier seeds than the first sowing date, while at the highest population of 240,000 plants/ha, the second sowing date produced significantly heavier seeds than both the first and the third sowing dates.

Variety had no significant influence on 1000-seed weight.

4.2.5 Percent empty seeds

Sowing date significantly influenced percentage empty seeds (Table 9).

The mean percentage empty seeds was highest in the first sowing date and showed a significant decrease when sowing date was delayed by two weeks to July 16. A further two weeks delay in sowing date to July 30 caused no significant decrease in the percentage of empty seeds.

Table 9: Effects of sowing date on percentage empty seeds at Samaru, 1986.

Treatment	Empty seeds (%)
Sowing Date	
July 2	1.87a*
July 16	1.18b
July 30	1.10b
SE(±)	0.19

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

Variety and plant population had no significant influence on percentage empty seeds.

4.2.6 Seed yield (kg/ha)

Seed yield was significantly influenced by sowing date (Table 10). The mean seed yield in the second sowing date was 18 and 24% higher than the first and third sowing dates respectively. The difference in seed yield between the first and third sowing dates was not significant.

Variety and plant population had no significant influence on seed yield.

4.3 Seed Quality (Chemical Composition)

4.3.1 Oil content

Sowing date significantly influenced the oil content of sunflower seeds. Two weeks delay in sowing from July 2 to July 16 caused oil content of the seed to increase from 44.1% to 47.2%. A further two weeks delay in sowing caused oil content to decline to 41.6% (Table 11).

Plant population significantly affected the oil content of the seeds. A population of 60,000 plants/ha gave the highest percent oil content (45.02%) in the seed, with seed oil content decreasing when plant population was increased or decreased beyond this level.

Table 10: Effects of sowing date on seed yield (kg/ha) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	July 16	July 30	Mean
Plant Population x (000/ha)				
30	1112*	1367	982	1154
60	1146	1470	1162	1259
120	1293	1439	1141	1291
240	1148	1461	1083	1230
Mean	1175b	1434a	1092b	

SE(±) Date = 47.85; Population = 55.26

Variety				
Isaanka	1231	1355	1092	1226
Funtua	1119	1513	1092	1241

SE(±) variety = 39.07

Variety	Plant Population			
	30	60	120	240
Isaanka	1216	1237	1280	1170
Funtua	1092	1281	1301	1291

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

Table 11: Effects of sowing date, plant population and variety on oil content (%) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	July 16	July 30	Mean
Plant Population x (000/ha)				
30	42.50g*	46.20c	43.07f	43.92c
60	45.36d	48.3a	41.41h	45.02a
120	43.68e	47.71b	40.89i	44.09bc
240	45.00d	46.54c	41.08i	44.20b
Mean	44.13b	47.18a	41.61c	
SE(±)	0.13			0.08

Plant Population x 000/ha	Variety	
	Isaanka	Funtua
30	44.75c	43.08f
60	45.64a	44.40d
120	45.21b	42.96f
240	44.42d	43.97e
Mean	45.01a	43.60b
SE(±)	0.11	

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

The difference in seed oil content between populations of 120,000 and 240,000 plants/ha and between 30,000 and 120,000 plants/ha was not significant.

Isaanka had a significantly higher oil content than Funtua.

There was a significant variety x plant population interaction effect on percent oil content of the seed. In Isaanka, the highest oil content was obtained at a population of 60,000 plants/ha, with oil content declining when plant population was increased or decreased from this level. In Funtua, there was no clear trend in oil content when plant population increased from 30,000 to 240,000 plants/ha.

4.3.2 Crude protein content

Crude protein content of the seed decreased significantly with each successive increase in plant population from 30,000 to 120,000 plants/ha. The decrease in crude protein content when plant population was further increased from 120,000 to 240,000 plants/ha was not significant (Table 12).

Two weeks delay in sowing from July 2 to July 16 caused a significant decline in the protein content of the seed. A further two weeks delay in sowing date to July 30 caused seed protein content to increase significantly above that sown on July 2.

Table 12: Effects of sowing date, plant population and variety on crude protein (%) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	July 16	July 30	Mean
Plant Population x (000/ha)				
30	25.44c*	23.19e	27.74a	25.45a
60	23.88d	21.55h	26.82b	24.08b
120	21.62h	21.73h	27.02b	23.45c
240	22.74f	22.13g	25.27c	23.38c
Mean	23.42b	22.15c	26.71a	

SE(±) Date = 0.04; Population = 0.05; Date x Pop. = 0.08

Variety				
Isaanka	23.27d	21.13e	27.60a	23.99b
Funtua	23.57c	23.16d	25.82b	24.18a

SE(±) Variety = 0.03; Variety x Date = 0.06

Variety	Plant Population			
	30	60	120	240
Isaanka	24.78b	23.58e	23.99d	23.64e
Funtua	26.13a	24.58c	22.91g	23.11f
SE(±)	0.07			

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

Funtua had a significantly higher crude protein content than Isaanka.

All two-way treatment interactions significantly influenced seed oil content. At the lower populations of 30,000 and 60,000 plants/ha, Funtua had a significantly higher seed crude protein content than Isaanka, but at the higher populations of 120,000 and 240,000 plants/ha, Isaanka had a higher seed crude protein content. Similarly, Funtua had a higher seed crude protein content in the first two sowing dates, but Isaanka had a higher seed crude protein content when sowing date was delayed to July 30.

4.3.3 Crude fibre content

Crude fibre content increased with increase in plant population from 30,000 to 240,000 plants/ha but differences between the populations were not significant (Table 13).

Funtua had a higher fibre content that Isaanka, but the difference was not significant. Delay in sowing from July 2 to July 16 had no influence on crude fibre content, but when sowing date was further delayed to July 30, crude fibre content of the seed decreased significantly.

Table 13: Effects of variety, plant population and sowing date on crude fibre (%) at Samaru, 1986.

Treatment	Variety		
	Isaanka	Funtua	Mean
Plant Population x (000/ha)			
30	1.09b*	0.98c	1.03
60	1.07b	1.10b	1.09
120	1.03bc	1.28a	1.15
240	1.17ab	1.22a	1.20
Mean	1.09	1.15	
SE(±)	0.05		
Sowing Date			
July 2	1.06b	1.31a	1.18a
July 16	1.22a	1.04b	1.13a
July 30	0.99b	1.09b	1.04b
SE(±)	0.04		

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

In Funtua, crude fibre content of the seed increased significantly with each increase in plant populations from 30,000 to 120,000 plants/ha, but further increase in population to 240,000 plants/ha caused no further increase in crude fibre content. In Isaanka, the differences in crude fibre content between the four populations tested were not significant. Isaanka had a significantly lower crude fibre content in its seeds when sown on July 2 and July 30, than when sown on July 16. Funtua had the highest seed crude fibre content when sown on July 2, and crude fibre content significantly declined when sowing was delayed by two weeks to July 16. A further two weeks delay in sowing to July 30, caused no further decline in the crude fibre content of the seeds in Funtua.

4.3.4 Ash content

Ash content of sunflower seed decreased significantly when sowing date was delayed by two weeks from July 2 to July 16, but increased again when sowing date was further delayed by two weeks to July 30 (Table 14). Ash content of the seed was significantly higher at plant populations of 30,000 and 120,000 plants/ha than at 60,000 and 240,000 plants/ha.

Table 14: Effects of sowing date, plant population and variety on ash content (%) at Samaru, 1986.

Treatment	Sowing Date			
	July 2	July 16	July 30	Mean
Plant Population x (000/ha)				
30	3.86a*	3.42d	3.55c	3.61a
60	3.63b	3.39d	3.43d	3.48b
120	3.60b	3.56bc	3.55c	3.57a
240	3.65b	3.37d	3.53c	3.51b
Mean	3.68a	3.43c	3.51b	
SE(±)		0.03		
Variety				
Isaanka	3.63b	3.44d	3.54c	3.53
Funtua	3.74a	3.43d	3.49cd	3.55
SE(±)		0.01		

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

The highest ash content of the seed was obtained with the earliest sowing on July 2, but four weeks delay in sowing to July 30 caused ash content to increase significantly above that of the second sowing on July 16.

Funtua in the first sowing date had a higher ash content than Isaanka, but the two varieties did not differ significantly in their seed ash content in the two later sowing dates.

Chapter 5

DISCUSSION

5.1 Effects of Variety

5.1.1 Growth characters

Among the characters assessed, Isaanka excelled Funtua in plant count both at thinning and at harvest. This may be attributed to better seed quality and therefore better percentage germination for Isaanka. Though the two varieties used in this study were chosen as being of two different maturity periods, they did not differ in their days to 50% flowering and days to maturity. This may be due to out-crossing arising from their being grown without adequate isolation distances. The growth and development pattern of the two varieties were similar, but Funtua was superior to Isaanka in stem diameter in the first sowing date and head diameter though it produced shorter plants at 5 WAS.

Possibly because of the sturdier stem, Funtua lodged significantly less than Isaanka in the first sowing date. In the second and third sowing dates where the two varieties did not significantly differ in their stem diameter, their lodging percentages were also similar.

5.1.2 Yield components and yield

Observations showed that Funtua was superior to Isaanka in dry weight/head, number of seeds/head and seed yield/plant.

Though variety had no significant effects on 1000-seed weight, percent empty seeds and seed yield, in this study, recent work by Ado (1987), showed that Isaanka outyielded Funtua by 34%.

5.1.3 Seed quality

The analysis carried out on seed quality after the harvest, showed that seeds from Funtua had less oil content than seeds from Isaanka, but had higher crude fibre content and ash content. This may be due to genetic differences in the two varieties.

The optained interaction of variety x plant population result indicated significant variations in varietal responses to increasing plant population. Lofgreen (1970) reported similar variations is varietal responses to varied plant population. These variable responses especially with respect to crude protein , crude fibre and oil content of seed could be occasioned by differences in genetic constitution and climatic factors at the time of sowing and during growth period.

5.2 Effects of Sowing Date

5.2.1 Growth characters

A relatively higher plant count was recorded for the first and second sowing dates at thinning. This could be explained by the fact that the plants sown during the first and second sowing dates might have had the advantage of utilizing the initial flush of soil nitrate which encouraged faster growth and therefore better plant establishment. At harvest, a relatively high plant count was recorded for the second sowing date as against the first and third sowing dates. This might have been due to optimum soil moisture conditions at the time the second sowing date was planted compared to the first sowing. The third sowing date might have suffered due to excessive moisture. The constant rains in the late part of August 1986 washed away the young seedlings that had not yet established an extensive root system.

During the development stage of the c rop, it was observed that plants grown on July 2 were significantly shorter than plants grown two and four weeks later. This might be due to changes in the atmospheric temperatures, relative humidity and hours of sunshine during the month (Appendix 2). Early in the month, the temperature and the sunshine hours were higher and the

relative humidity was lower. Rise and fall in temperatures accelerate and retard the growth of plants respectively. A similar observation was made on maize by Hunter et al. (1974), who reported that low and high temperatures retarded and accelerated the formation of reproductive organs of the plant. At harvest, however, the July 30 sowing produced shorter plants. This could be attributed to the fall in solar radiation and the relative humidity being high.

The July 16 sowing produced plants with thin stems. This might be due to shortage of nitrogen caused by leaching. The excessive rains after the second sowing date might have caused most of the nitrogen to be leached away and this might have resulted in less vigorous seedlings from the second sowing date.

The highest percentage lodging was observed in the July 2 sowing. This was likely because being earliest sown, it had the tallest plants at the time of the excessive rains in late July and August. Their height made them more susceptible to lodging than the later sown plants. This observation is in agreement with Tanimu et al. (1986c), who reported a similar observation.

Head diameter was larger in the first sowing date than in the two later sowing dates. This result however, disagrees with that of Tanimu et al. (1986b), who

reported that time of sowing had no effect on head diameter. The result obtained in this trial showed that early planting had the advantage of utilizing the nitrogen, thus resulting in vigorous growth and head development.

The differences in growth and yield performance between sunflower varieties sown at different or at the same time often depend on the extent of varietal adaptation to a particular environment and time lag between the sowing dates (Ogunremi, 1978). This explains the result of interaction of variety x sowing date that was obtained. The result of interaction of variety x sowing date also, seems to suggest that Funtua may be a more adapted variety than Isaanka to the Samaru ecological area.

Sowing date did not markedly affect days to 50% flowering and days to maturity.

5.2.2 Yield components and yield

Delay in sowing from July 2 to July 16, decreased the dry weight per head by 17% and delay in sowing to July 30, caused a further 13.5% decrease in dry weight per head. Number of seeds per head and seed yield per plant followed a similar trend with decrease of 35.3% and 27.3% respectively. The mean 1000-seed weight increased by 13.7% when sowing date was delayed by two weeks from July 2 to July 16.

This increase in the 1000 - seed weight could be attributed to the fact that the first sowing date contained more empty seeds than the two later sowing dates. The greater number of empty seeds in the first sowing date might have been due to intra-plant competition for assimilates. The first sowing date had significantly more seeds per head than the two other sowing dates. This resulted in some of the seeds not being well filled.

Previous studies of sunflower sowing date effects on yield have lacked agreement. In this trial however, the mean seed yield in the July 16 sowing date was 18 and 24% higher than the July 2 and July 30 sowing dates respectively. This result varies from the findings of Ogunremi (1979) who reported that highest yields of 2079 kg/ha and 2312 kg/ha were obtained in 1975 and 1976 respectively in Ibadan when CV. Russian Gaint was sown during the 3rd week of May. The differences in sowing dates might be due to differences in ecological conditions. However, Tanimu et al. (1986b and 1987), reported that early sowing as soon as the rains have established produced the best crops in terms of yield (2729 kg/ha) and planting on the 1st, 8th 15th and 22nd July gave yields of 687 kg/ha, 1237 kg/ha, 1007 kg/ha and 1173 kg/ha respectively. The differences in yield in this trial might be due to poor pollination and execessive rainfall in 1986 resulting in breakages, lodging and thus loss of seeds.

5.2.3 Seed quality

When sowing was delayed by two weeks, the oil content of the seed increased from 44.1% to 47.2% and a further delay in sowing by two weeks caused the oil content to decline to 41.6%. This might be attributed to the optimum environmental conditions coinciding with the July 16 sowing date and thus, proper seed development, thereby resulting in higher oil content. A similar trend was observed in the seed yield where the July 16 sowing date recorded the highest seed yield. This result agrees with the findings of several workers (Robinson, 1970, Johnson and Jellum 1972, Alessi *et al*. 1977, Murphy 1978 and Unger and Thompson 1982) who all reported different sowing dates that gave higher seed oil content.

The decline in the crude protein content of the seed when sowing was delayed by two weeks from July 2 to July 16 and its increase above that sown on July 2 by further delaying sowing date to July 30, might be explained by the fact that the excessive rains in the first two weeks of August might have caused the nitrogen fertilizers to leach, thus making the nitrogen unavailable to the plants.

5.3 Effects of Plant Population

The total rainfall of 968.3 mm that was available during the growing season was deemed adequate for the production of sunflower, though the excessive rains in the late part of August, 1986 affected the third sowing

date. There was no incidence of pests and diseases throughout the crop growing period, though one could not rule out the possibility of birds being hidden in the high plant population, thus causing some losses in seed yield.

5.3.1 Growth characters

Plant count at thinning and at harvest indicated that both percent stand establishment and survival rate decreased with increase in plant population from 30,000 to 240,000 plants/ha. This might be as a result of intense competition at the higher populations resulting in the death of weaker and slow growing seedlings.

Plant height at 5 WAS increased with each increase in plant populations. This result agrees with an earlier finding by Robinson *et al*. (1976), who reported that as plant populations increased, plants were taller. A similar result obtained by Nasr *et al*. (1978), working with safflower in Lebanon, showed that increasing population rates, increased plant height. This result in this trial is probably due to the fact that under high populations, the plants were subjected to greater degree of competition for light which induced etiolation resulting in tall spindly plants.

Stem and head diameters decreased with increase in plant populations. This result is in conformity with the results obtained by Curotti and Rosania, (1971) and Lopez

(1972) who found that increasing the spacing between plants produced bigger stems and larger head diameters in Russian sunflower. This observation again is due to less competition for space, nutrients, light and moisture in the lower populations. The taller plants, thinner stems and smaller heads produced by the higher plant populations were therefore due to the intense competition for the growth factors enumerated.

Plant populations had no significant effects on number of days to 50% flowering, days to maturity and lodging percentage.

5.3.2 Yield components and yield

Dry weight per head decreased with each successive increase in plant populations. This result is in agreement with the findings of Curotti and Rosania (1971) and Lopez (1972) who reported that increasing plant populations decreased dry weight per head.

Number of seeds per head and seed yield per plant, showed a significant decrease only where plant population increased from 120,000 to 240,000 plants/ha. This is a direct effect of the smaller heads produced by the tall and spindly plants with small heads that were obtained at the high plant populations.

Weight of 1000- seed was found to decrease with each increase in plant populations. The highest (53.41g) and the lowest (40.43g) 1000- seed weight were produced in populations of 30,000 and 240,000 plants/ha respectively. This could be attributed to intraplant competition for assimilates. The high shading of plants in the highest populations may have resulted in poor light interception by the foliage. This could reduce the total amount of assimilates available for partitioning to the seeds. Since the decrease in the number of seeds per plant with increase in plant population (Table 6) is not in proportion with the decrease in the general size of the plant, this would mean greater intra plant competition for assimilates with a resultant decrease in the size of individual seeds at the high plant populations.

Percent empty seeds and seed yield/ha were not significantly affected by plant populations. This indicates that even the highest plant population used in this study was not high enough to influence seed yield.

5.3.3 Seed quality

The effect of plant population on seed oil content was inconsistent. This result is in conformity with a report by Miller and Fick (1978) who reported that oil content was not different for the three plant populations of 36,000; 48,000 and 72,000 plants/ha.

A similar result was reported by Nasr et al. (1978), that percent oil in safflower seeds was not affected by the three plant populations of 133,333; 266,667 and 533,333 plants/ha.

The crude protein content of the seed significantly decreased with each successive increase in plant population from 30,000 to 120,000 plants/ha, but not when population increased from 120,000 to 240,000 plants/ha. This could be due to less competion for nitrogen in the soil among the lower plant populations. The least crude protein content in the high populations of 120,000 and 240,000 plants/ha was probably as a result of high competition for soil nitrogen at these high populations.

Crude fibre content of the seed decreased with each increase in plant population from 30,000 to 240,000 plants/ha, but the differences were not significant. Since most of the crude fibre is in the hull, this may be because the other components of the seed decreased when seed weight decreased with increase in plant population, while the hull was not much affected. This might thus result in the increase in crude fibre content of the seed concomitant with the decreases in the crude protein content.

The significant interaction of plant population x sowing date on stem diameter, percentage lodging, 1000-seed weight and oil content observed in this investigation might be explained by Alessi et al. (1977) and Anderson

et al. (1978) inferences. According to them, the differences in climatic factors during crop establishment requires changes in plant population in order to obtain the best of the prevailing climatic factors.

Chapter 6

SUMMARY AND CONCLUSION

The experiment was conducted during the 1986 cropping season at the Institute for Agricultural Research Farm at Samaru, Zaria. Treatments consisted of two sunflower varieties, three sowing dates and four plant populations. There were 24 treatment combinations replicated four times and laid out in a randomized complete block design with factorial arrangement.

Plant population had significant effects on growth characters, yield and yield components and seed quality of sunflower. Plant height increased with each increase in plant population while stem and head diameters decreased with increase in plant population. Plant population had no significant effects on number of days to 50% flowering, days to maturity and lodging percentage.

Dry weight/head and weight of 1000-seed were found to decrease with each increase in plant population, whereas number of seeds/head and seed yield/plant showed a significant decrease only when plant population increased from 120,000 to 240,000 plants/ha. Seed yield (kg/ha) and percent empty seeds were not significantly affected by plant population.

There was no clear trend in oil content with increase in plant population. The crude protein content of the seed significantly decreased with each successive increase in plant populations only from 30,000 to 120,000 plants/ha, but crude fibre content of the seed decreased with each increase in plant population from 30,000 to 240,000 plants/ha.

Among the sowing dates tested, higher plant count was recorded for the July 2 and July 16 sowing dates at thinning. At harvest, the July 16 sowing date recorded the highest plant count. At 5 WAS plants from July 2 sowing date were significantly shorter than those from the July 16 and July 30 sowing date but the reverse was true at harvest when July 30 sowing produced the shorter plants. Highest percentage lodging and thin stems were observed with the July 2 and July 16 sowing dates respectively.

Sunflower sown on July 16, out yielded that sown on July 2 and July 30 by 18 and 24% respectively. This was probably due to high survival rate of plants in July 16 sowing date. Dry weight/head, number of seeds/head and seed yield/plant all decreased with each delay in sowing date.

The percent oil content of the seed increased with each delay in sowing date and the crude protein content

of the seed declined when sowing was delayed from July 2 to July 16.

Variety had significant effects on growth parameters, yield and yield components and seed quality. Funtua excelled Isaanka in many parameters studied, such as stem and head diameters, height at 5 WAS, dry weight/head, number of seeds/head, seed yield/plant and crude protein content of the seed, while Isaanka variety was only superior in plant count and in oil content.

In conclusion, the mid-July sowing (July 16) in this trial was the most suitable for the highest seed yield and oil content of sunflower under the soil and climatic conditions at Samaru, Zaria. Plant populations had no effect on seed yield.

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Appendix 1: Physio-Chemical analysis of soil samples from the experimental site at Samaru, 1986.

Soil characteristics	Soil depth in cm	
	0-15cm	15-30cm
Sand (%)	62.8	55.6
clay (%)	9.6	18.0
Silt (%)	27.6	26.4
Class	Sandy loam	Loam
pH in H_2O	5.3	5.4
pH in 0.01m $CaCl_2$	4.9	5.0
Percent organic carbon	0.324	0.292
Percent Total Nitrogen	0.256	0.264
Available P (ppm)	1.63	0.98
C.E.C. (meq/100g soil)	5.44	7.04
Exchanges Bases (meq/100g soil)		
Na	0.05	0.05
K	0.18	0.19
Ca	2.84	2.85
Mg	0.88	0.88

Appendix 2: Climatological Data at 10 days intervals Experienced during the experiment in 1986 cropping season at Samaru, Zaria.

Months and Days	Total Rainfall mm	Mean Temperature (^{o}C) max	min	Relative Humidity (%) a.m	p.m	Sunshine (hrs)
April						
21-30	5.8	35.8	21.2	59.1	37.8	7.8
May						
1-10	11.2	30.1	20.4	57.0	31.7	8.0
11-20	18.4	27.7	21.7	62.9	42.2	7.0
21-31	29.5	28.6	20.2	55.0	38.3	8.0
June						
1-10	35.3	29.8	20.0	75.6	64.1	7.0
11-20	22.6	30.2	20.6	74.3	55.8	9.1
21-30	24.1	30.0	20.1	75.3	59.0	7.4
July						
1-10	52.9	29.0	20.0	79.8	62.1	7.0
11-20	49.4	27.8	19.5	83.4	67.3	6.5
21-31	191.3	27.0	19.6	83.1	73.1	5.2
August						
1-10	50.6	28.1	19.3	83.0	76.9	5.8
11-20	94.9	28.5	19.7	84.3	66.0	7.1
21-31	176.6	29.1	19.4	78.3	70.5	7.7
September						
1-10	56.4	28.0	19.5	77.5	68.9	7.1
11-20	74.0	29.3	18.6	72.6	64.2	8.6
21-30	75.3	29.3	19.1	76.4	69.2	7.8
October						
1-10	-	30.4	19.1	67.5	56.3	7.9
11-20	-	31.5	15.8	45.4	45.3	9.6
21-30	-	31.4	17.9	57.4	48.4	8.1
November						
1-10	-	33.0	17.8	49.8	31.0	9.0
11-20	-	30.0	30.0	12.0	24.9	8.5
21-30	-	31.1	13.9	33.7	25.8	7.8
December						
1-10	-	26.4	13.0	28.6	22.7	6.7
11-20	-	27.0	12.4	24.3	20.4	8.6
21-31	-	27.6	12.4	22.4	22.5	6.5

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

Appendix 3A: Plant count of Sunflower at thinning as influenced by sowing date, plant population and variety at Samaru, 1986.

		P_1	P_2	P_3	P_4	Mean
V_1 Isaanka	D_1	82.75	133.00	264.25	453.75	233.44
	D_2	78.00	148.75	227.50	391.00	211.31
	D_3	75.00	111.50	198.00	338.50	180.75
	Mean	78.58	131.08	229.92	394.42	208.50
		(65.5)*	(54.2)	(47.9)	(41.1)	
V_2 Funtua	D_1	46.50	87.00	174.50	259.25	141.81
	D_2	65.00	118.25	191.25	224.50	149.75
	D_3	35.00	89.50	139.25	329.25	148.25
	Mean	48.83	98.25	168.33	271.00	146.60
		(40.7)	(40.9)	(35.1)	(28.2)	
	Mean	63.70	114.67	199.12	332.71	
		(53.1)	(47.5)	(41.5)	(34.6)	

*Numbers in parantheses represent plant count expressed as a percentage of the intended population.

Appendix 3B: Plant count of Sunflower at Harvest as influenced by sowing date, plant population and variety at Samaru, 1986.

		P_1	P_2	P_3	P_4	Mean
V_1 Isaanka	D_1	70.00	100.25	160.75	202.25	133.31
	D_2	64.00	125.00	194.50	288.00	167.88
	D_3	66.25	100.00	149.25	275.75	147.81
	Mean	66.75	108.42	168.17	255.33	149.67
		(55.6)*	(45.2)	(35.0)	(26.6)	
V_2 Funtua	D_1	38.75	62.00	102.50	109.25	78.13
	D_2	60.50	107.00	154.25	187.25	127.25
	D_3	31.25	69.25	113.25	275.25	122.25
	Mean	43.50	79.42	123.33	190.58	109.21
		(36.2)	(33.1)	(25.7)	(19.9)	
	Mean	55.12	93.92	145.75	222.95	
		(45.9)	(39.1)	(30.3)	(23.2)	

*Numbers in parentheses represent plant count expressed as a percentage of the intended population.

Appendix 4: Effects of sowing date, plant population and variety on time to 50% flowering (days) of Sunflower at Samaru, 1986.

Date of sowing	Date flowering/maturity observed		Days after sowing
July 2	1st flowering	16/8/86	45
	50% flowering	25/8/86	54
	Maturity	23/9/86	83
July 16	1st flowering	31/8/86	46
	50% flowering	8/9/86	54
	Maturity	10/10/86	86
July 30	1st flowering	17/9/86	48
	50% flowering	25/9/86	56
	Maturity	22/10/86	82

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Previous Qualifications

Institutions Attended	From	To	Cert./Diploma/Degree
Junior Primary School, Kafanchan	1953	56	Primary Four Cert.
Senior Primary School, Wamba	1957	59	Primary Seven Cert.
Govt. College, Keffi	1960	64	W.A.S.C.
School of Agriculture, Samaru, Zaria.	1965	66	Agric. Asst. Cert.
School of Agriculture, Kabba	1970	70	Asst. Agric. Supt. Cert.
School of Agriculture, Kabba	1973	73	Diploma in Gen. Agric
Fort Hays State University, Kansas, U.S.A.	1982	83	B.Sc. (Agric.)

Work Experience

Organization	From	To	Position
Kaduna State Min. of Agric.	1967	69	Agric. Assistant
Kaduna State Min. of Agric.	1970	72	Asst. Agric. Supt.
Kaduna State Min. of Agric.	1973	77	Agric. Supt.
Kaduna State A.P.D.C.	1978	81	Farm Manager
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