EFFECT OF SOWING DATE AND MOISTURE STRESS ON DRY SEASON MAIZE (Zea mays L.)

BY

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DEPARTMENT OF AGRONOMY
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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated and the sources of information are specifically acknowledged by means of references.

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CERTIFICATION

This thesis entitled 'EFFECT OF SOWING DATE AND MOISTURE STRESS ON DRY SEASON MAIZE (Zea mays L.)' by Yakubu TSALA 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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ABSTRACT

A field experiment was conducted at the Irrigation Research Station, Ahmadu Bello University, Kadawa, during the 1983/84 dry seaabn (September - May) to study the Effect of Sowing Date and Moisture Streee at various growth periods of maize. The treatments consisted of six sowing dates starting from 23 September 1903 at monthly interval, ending 23 February, 1904 and three moisture stress treatments consisting of unstressed (normal irrigation of 65mm depth of water was applied at weekly interval), moisture stress at flowering and moisture stress at grain development.

Earlier sowings i.e. September and October were superior to late sowings. The maximum groin yield of 71G7 kg/ha was produced when maize was sown on 23 October- Delaying sowing until December, January and February reduced grain yield by 27.6, 33.0, 72.1 and 42.0%, especially compared to October sowing.

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INTRODUCTION

Maize (Zea mays L.) is an important grain crop of the world. In production of total grain crops, it ranks second in the world as well as in Nigeria (Anonymous, 1983). It is grown in more countries than any other cereal, and has produced the highest grain yield per hectare of any cereal.

The traditional areas for maize grain production in Nigeria have been those approximately south of latitude 8^{o}N mainly the forest zone, but now the production potential of maize has increased from south to north up to 11^{o}N in the northern Guinea savanna where according to Kassam and Kowal (1972) maize has its greatest yield potential attributed mainly to higher solar radiation and other favourable growth factors for the crop. Kassam et al. (1975) have reported the climatic yield potential of a single crop of maize in the savanna areas is considerably higher than in the forest and derived savanna areas. They reported a yield potential of 8,000 - 10.000 kg/ha in the Guinea savanna areas.

Because of its world-wide distribution and the relatively lower price of the grain, maize is used directly as human food, for industrially processed food, for industrial production of starch, oil and alcohol, and as a livestock feed.

Especially as human and livestock feed there has been an increasing demand for maize in the country and the Government had to import maize to meet the demand. For example, in 1977,

about 90,000 tonnes of maize was imported into Nigeria at a cost of over 18 million dollars; while 293,000 and 345,000 tonnes were imported in 1981 and 1982, respectively (Annoymous, 1983). This is inspite of the production figure of 1.6 million tonnes recorded for 1982 (Annoymous, 1983). Because of the strain of importation on foreign exchange, Government is determined to produce enough maize to meet its requirement.

To meet the ever increasing demand, efforts have to be made mainly in two directions - increase in yield per hectare and increase in hectarage. The incursion of maize into the savanna in the last few years is an effort in this direction. Further increase in hectarage can be made by the utilization of irrigation facilities, being developed by the River Basin and Rural Development Authorities, during the dry season. Singleton et al. (1950) reported maize to be one of the best grain crops for irrigation because of the high yields that can be obtained from it.

In Nigeria however, little or no work has been reported on the growing of dry season maize under irrigation. Most of the work reported on maize production covers rainfed cultivation. There is, therefore, the need for a thorough research into the aspect of maize production in the dry season under irrigated condition.

The present study, therefore, was undertaken with the objective: to study the effect of sowing date and moisture

stress at different growth stages on the growth, yield components and yield of dry season maize.

Chapter 2

LITERATURE REVIEW

The available literature on the effect of sowing date and moisture stress on the growth, yield components and yields of maize are reviewed in this chapter. Most of the literatures reviewed cover mainly the rainfed maize as very little work has been reported on dry season maize.

2.1 Effect of Sowing Date

2.1.1 On plant growth

The growth and development of a crop plant can be influenced by agronomic practices. These practices may also affect the yield and quality of the crop. Time of sowing either under rainfed or irrigated condition is one of such an important agronomic practices. Time of sowing of a crop mainly depends on the prevailing weather condition.

The dry season (October - May) in northern Nigeria is characterised by wide fluctuations of day and night temperatures. The temperatures decrease from October to January and increase from February to April or May. The abrupt rise of temperature in March or April limits the growing season of maize and the crop yield decrease in relation to sowing dates (Kumar *et al.*, 1982). They further reported that very high temperatures 35^{o}C or above and low humidity during tasselling and silking stage of maize may result in

floret sterility in spite of frequent irrigation. According to them, the ideal temperature requirement for maize grain growth and development is 24 - 30°C.

Nagase and Takemura (1965), Dechev (1974) and Balan (1977) Have reported that early sowing produced the highest dry matter yield of irrigated maize.

El-Sharkawy et al. (1975) working in Libya reported that vegetative growth, as measured by plant height, declined with late planting. Kamel et al. (1979) observed sowing date to have a significant effect on the perdentage of barren plants, number of ears per plant, weight of ear and grains per ear and grains per plant, shelling percentage and yield of grains.

2.1.2 On yield components and grain yield

It has been reported that high temperatures and low humidity at the time of pollination have adverse effects on pollination and fertilization of maize, causing a reduced seed set. It is the air temperature that causes the low grain yield of dry season maize in Nigeria. The environment with cool night (14 - 18°C) and moderate day temperature (25 - 30°C) is more favourable to maize grain development. Accordingly, sowing date has to be fixed in a way so that the growth of the plant coincides with the temperatures favourable to the plant especially during grain formation. Duncan et al. (1964), Benoit et al. (1965) reported that the late planting effect on yield was related to the high air temperature during

the ear formation period. Kumar et al. (1982) reported excessive high temperatures and low air humidity at the time of pollination have adverse effects on pollination and fertilization. Coligado and Brown (1975) observed a consistent decrease in the time to tassel initiation as temperature was increased from 15 - 25°C. Hunter et al. (1975) also observed decrease in the number of days to tassel with an increase in temperature. Briggs and Attinaw (1979) reported that sowing date (depending on the prevailing weather conditions) significantly affected the days to maturity. Balan (1977) observed longer cob having a mean length of 24cm with early sowing.

George (1943) found a reduction in the size of maize grains with delayed sowing. Kamel et al. (1979) also observed the effect of sowing date on the size of maize grains. Individual grain weight is the product of the duration of the effective grain filling period and the rate of grain growth, and both are affected by environmental factors, particularly temperature (Tollenaar, 1977; and Fischer and Palmer, 1980). A maximum grain size was achieved at a mean temperature of 24.8°C, with a kernel growth rate of 6.84 mg per day and a duration of effective grain filling of 31 days.

Balan (1977) reported early sowing gave higher mean 1000-grain weight of 330g as compared to late sowing.

Many workers have reported that date of sowing significantly

influences the yield of maize. The general consensus is in favour of early sowing. George (1943), El-Sharkewy et al. (1975), Balan (1977), Briggs and Attinaw (1979) and Kamel et al. (1979) observed that date of sowing significantly affected the grain yield. The highest grain yield was obtained from the earliest sowing dates. There was a continuous reduction in yield with delay in sowing dates.

Vernon (1953) reported a loss of about 25% in yield with each week's delay in sowing. Benoit et al. (1965) reported that yield decreased with late planting independent of the soil moisture level. Nagase and Takemura (1965) obtained the highest grain yield of maize on irrigated plots by early sowing. Farrel (1975) obtained a maximum grain yield of 11.9 t/ha with early sowing on October 25. Kumar et al. (1982) reported from a result obtained from Bakura (Nigeria) that highest maize yield was obtained from plots planted in mid-September and that the grain yield was reduced linearly with time as date of sowing was delayed uptill mid-February. Mayaki and Palmer[1] reported similar result from Kadawa in Nigeria. Farnworth and Said (1983) observed when they planted maize between February and April, that the highest yield of 7.23 t/ha were obtained by the earliest sowing date of February, and the lowest yield was obtained at the penultimate sowing date of 24 March. Yields generally decreased with late sowing. Pacheco (1983)

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[1]Personal Communication, W.C. Mayaki and J. L. Palmer, Irrigation Research Station, Ahmadu Bello University, Zaria, Nigeria.

observed, when maize was sown on 30 September, 16 October, 20 November and 22 December in the dry season, that the yield decreased with sowing date. Yields obtained were 4.81, 3.64, 3.64 and 3.55 t/ha, respectively.

2.2 Effect of Moisture Stress

2.2.1 On plant growth

In the past, investigations have been carried out on different aspects of moisture stress on the growth of maize. Short supply of water damage crop by limiting nutrient uptake and metabolic activities, thus leading to reduced crop growth and yield. It has been observed that water requirement of crops vary with the stage of their growth. When water supply is limited, it becomes necessary to know the critical stages of crop growth when the limited water can be utilized. The phenological stages of maize have been reported by Hanway (1971) and Egharevba (1974). These are listed in Appendix A. The stages are delineated into the following three periods:

i) vegetative

ii) reproductive (flowering) and

iii) grain-filling and development

The most critical stage at which the crop is susceptible to matter stress is flowering (Robins and Domingo, 1953).

Loomis (1934) reported that under low moisture condition maize plant growth was checked. According to him, the growth

of maize depends on a liberal supply of water at the growing point. Haynes (1948) also found that the vegetative growth of maize was markedly affected by the degree of availability of soil moisture. It has been reported by many workers that moisture stress causes reduction in plant height. Severe dwarfing of plant from soil moisture deficits during vegetative stages was reported by Robins and Domingo (1953). Similarly, Denmead and Shaw (1960) observed a reduction in the stem enlongation because of stress in the vegetative stage of growth. Claassen and Shaw (1964) reported a reduction of 10.2cm in the height because of stress at vegetative period. Gardner et al. (1981) reported an average height differences of 50cm between fully irrigated and UN-irrigated plants. Increasing irrigation increased plant height (Nnadi, 1975).

Mallet and de Jager (1971) reported that moisture stress prior to silking produced a smaller final leaf area; whereas according to Nnadi (1975) frequent irrigations reduced leaf area of maize.

It has been reported that moisture stress causes dry matter reduction in maize, severity depends upon the timing of stress. Water deficits approximately 3 weeks before 75% silking reduced total dry matter by 15 - 17%. (Claassen and Shaw, 1967). Soil moisture stress during 50 - 60 days after maize emergence caused a reduction in total dry matter (Vivekanandan et al., 1974). According to Wilson and Allison (1978) a mild stress during grain filling reduced total dry

matter yield. Gregersen (1979) obtained highest stem dry matter yields with frequent irrigation before flowering and less frequent at other stages.

Other effect of moisture stress on the growth of maize is delaying in tasselling and silking emergence (Kemper et al., 1961). Robins and Domingo (1953) reported delay in tasselling and silking by about 4 to 5 days because of moisture stress. Claassen and Shaw (1964) also observed delay in silking by 2 to 5 days under moisture stress. Barnes and Woolley (1964) found a delay in silk emergence with stress imposed at the silking-pollination stage. Arnon (1975a) reported that when the plants are close to wilting or actually wilted, the extension of the silks out of husks is slowed down and complete silking is delayed. Kumar et al. (1982) reported that the exertion of the silks is delayed under low moisture conditions at the time of pollination.

2.2.2 On yield components

The yield components of maize include ear size (length and diameter), weight of grains per ear, number of grains per ear, kernel depth, 1000-grain weight and shelling percentage. Moisture stress causes reduction in these components. The percentage of reduction depends on the timing of moisture stress.

Robins and Domingo (1953) and Vivekanandan et al. (1974) reported reduction in ear size because of moisture stress.

Kiesselbach (1950) reported that drought following fertilization shortened the ears by drying back from the tip. Denmead and Shaw (1960) found reduced cob length because of stress at flowering. Reduction in ear size due to moisture stress has also been reported by Claassen and Shaw (1967). They reported that stress at 75% silking reduced ear size.

Loomis (1934) observed that stress near tasselling produced sterile tassels and large percentage of barren stalks. Moisture stress at tasseling caused reduction in fertilization due to non-receptive silks which resulted to poor grain filling (Robins and Domingo, 1953). Kemper et al. (1961) have reported that moisture stress during tasselling, earing and pollination may cause the tassels and upper leaves to dry up, tassels may fail to shed viable pollen causing partial fertilization. According to them, the silking period which normally is not much longer than ten days can extend over a period of four weeks or more, Claassen and Shaw (1967) observed significant reduction in kernel numbers with stress before or during silking pollination. Vivekanandan et al. (1974) reported moisture stress at 50 - 60 days after emergence caused reduced number of grains per cob. Larson (1975) reported drought stress during anthesis and fertilization in maize provides for little to no fertilization of the ovules which result in ear void of grain because of the dehydration of pollen grains.

Robins and Domingo (1953) reported a reduction of 82.7-77.6% in shelling percentage when there was deficit of moisture at

tasselling.

Drought following fertilization reduced the kernel size due to destruction of the productive tissues (Kiesselbach, 1950). Claassen and Shaw (1964) also reported a reduction in kernel size due to stress at silking.

Moisture stress at silking adversely affected the assimilation rate causing reduction in grain weight (Denmead and Shaw, 1960). Claassen and Shaw (1967) reported stress at ear development and silking to cause decreased kernel weight. Arnon (1975b) reported that moisture stress during flowering largely determines the number of kernels to be produced. Moisture stress during kernel enlargement during which considerable amounts of nutrient reserves are transported into the kernel affect the weight of the kernel resulting to small and shrivelled grains.

2.2.3 <u>On grain yield</u>

Efficiency of water use is judged by the crop yield obtained per unit volume of water. (Failure to apply water at right stages of growth causes reduction in yield, severity depends on the timing of failure). Nnadi (1975) reported grain yields to be positively related with frequency and quantity of water applied during the growing season. The detrimental effect of moisture stress on grain yield varies depending on its duration and the stage of plant development during which water stress has occured.

Withholding irrigation at different growth stages differ in their effects on grain yield. Denmead and Shaw (1960) reported from Iowa (U.S.A.) that moisture stress during vegetative growth, silking and grain development of maize reduced yield by 25, 50 and 21%, respectively. Stress at silking caused higher decrease in grain yield. Claassen and Shaw (1967) observed a grain reduction of 12 - 15% after stress during the vegetative development and 53% grain yield reduction associated with stress at 75% of silking.

Miller and Duley (1925) had reported that grain production was dependent on an adequate water supply from tasselling to maturity. They found that plants, which were suffering from water deficiency during their early growth were able to recover and produce good yields if optimum available soil water was restored in root zone during the reproductive stages. After long experience in irrigated maize, Leonard et al. (1940) concluded that if only one irrigation is possible, it should be applied at tasselling stage to get the maximum grain yield.

Robins and Domingo (1953) reported that soil water deficit maintained for one or two days during tasselling or silking reduced grain yield by 22% and a soil water deficit for 6 or 8 days during this stage reduced yield by 50%. Howe and Rhoades (1955) found that maize irrigated just before tasselling and during silking yielded almost as high (9.0 t/ha) and not significantly different from maize irrigated throughout the season (9.6 t/ha). Kemper et al. (1961) got lower grain yield

when water was not applied during tasselling, earing and pollination period. Henckel (1964) reported that the critical period in cereals begins with the appearance of pollen mother cells and ends of pollination. Aspinall et al (1964) reported even short period of water stress at anthesis to markedly reduce the number of flowers that set seed. Go'mez and McClug (1968) reported that irrigation was most effective during the 15 - 20 days before earing. According to them maximum yield can be obtained from preventing moisture stress during the period from tasselling to silking. Mallet and de Jager (1971) by subjecting maize plants to moisture stress prior to silking observed a smaller grain yield than those which did not suffer from moisture stress.

Moisture stress imposed at the pollination and blister kernel stages significantly reduced yield (Barnes and Woolley, 1964). Campbell (1964) also reported stress at late silking and at very early ear stages resulted in decrease in grain yield. Drought during grain filling has been shown to reduce translocation of photosynthate from the leaves. This response in addition to reduced photosynthesis contributes to lower grain yield (Larson, 1975). Wilson and Allison (1978) observed mild stress during grain filling had little effect on grain yield. Gardner et al. (1981) reported yield reductions were greatest when water stress occured during the pollination or grain filling period. Harder et al. (1982) reported that moisture stress occuring within 2 weeks after silking reduced grain

number by 15% with little effect on final weight of grains. Further stress had little effect on grain number, but inhibited further apical grain development.

2.2.4 On harvest index

Loomis (1934) reported drought near tasselling resulted in a large percentage of barren or nearly barren stalks. Dobbell (1964) reported stress at late silking and very early ear stages resulted in marked increase in stalk weight. These increase corresponded with grain yield decrease. Claassen and Shaw (1964) also reported significant increase in stalk weight as a result of stress at late silking and very early ear stages.

Chapter 3

MATERIALS AND METHODS

The experiment was conducted under irrigation during the dry season (end of September to May) of 1983-84, on the farm of Ahmadu Bello University, Irrigation Research Station, Kadawa ($11^{0}39^{'}$N, $08^{0}02^{'}$E and 500m above mean sea level) in the Sudan savanna zone. The data on temperature during the period of experimentation, recorded from meteorological laboratory, Kadawa, are presented in Table 3.1.

The soil at Kadawa are moderately deep, sandy loam with loamy sand tops. The physical and chemical properties of soils of the experimental plot are presented in Table 3.2.

3.1 Experimental Design and Plot Size

The experiment was laid out using the split-plot design with 18 treatments. Six sowing dates and three irrigation treatments were allocated at random in the main plots and sub-plots, respectively. The treatments were replicated three times, giving a total of 54 plots. The size of each sub-plot was 6 x 6m. To prevent seepage from the adjoining plots complete bund was made around each plot and a border 2m wide was left around each irrigation plot. Yield data were collected from the net plots measuring 6 x 1.5m, while other observations were carried out on the remaining stands within each plot.

Table 3.1. Maximum, minimum and mean temperatures and relative humidity in 10-days period covering the experimental period at Kadawa.

Months/Period	Temperature °C Max.	Min.	Mean	Relative humidity (%)
21-30 Sept.	30.6	25.2	27.9	No record taken
1-10 Oct.	30.9	23.0	27.0	"
11-20 "	31.4	20.4	25.9	"
21-31 "	31.3	19.0	25.0	"
1-10 Nov.	31.8	18.8	25.3	"
11.20 "	31.7	19.5	25.6	"
21-30 "	29.7	17.9	23.8	"
1-10 Dec.	31.2	14.2	22.7	30.8
11-20 "	32.5	11.8	22.2	29.6
21-31 "	28.4	12.2	20.3	32.0
1-10 Jan.	26.6	12.2	19.4	33.8
11-20 "	25.9	12.1	19.0	27.1
21-31 "	26.9	12.3	19.6	24.8
1-10 Feb.	27.9	11.9	19.9	26.5
11-20 "	30.8	14.9	22.9	28.8
21-29 "	32.1	17.6	24.9	21.9
1-10 Mar.	35.1	17.6	26.4	34.0
11-20 "	37.1	19.3	28.2	28.6
21.31 "	36.4	21.4	28.9	27.1
1-10 Apr.	36.8	21.5	29.0	23.0
11-20 "	38.3	23.3	30.8	23.2
21-30 "	36.9	23.3	30.1	34.4
1-10 May	35.4	23.4	29.4	45.5
11-20 "	34.8	23.3	29.0	56.2
21-31 "	33.9	22.7	28.3	41.8
1-10 June	34.9	22.6	28.8	No record taken
11-20 "	33.2	23.2	28.2	"

Table 3.2. The physical and chemical properties of the soil collected up to a depth of 30cm from the experimental site at Kadawo.

Soil properties	Characteristics
Physical properties:	
Sand (%)	53.3
Silt "	38.6
Clay "	8.1
Textural class	Sandy loam
Chemical properties:	
pH in H_2O	6.5
pH in 0.01M $CaCl_2$	5.8
Exchangeable cations:	
Na (meq/100g soil)	0.155
K "	0.114
Ca "	3.350
Mg "	0.990
Total P(ppm)	100.940
Total N (%)	0.022
CEC	5.82
Soil Moisture relation: (cm/25m)	
Field capacity	7.05
Available soil moisture at - 15 bar	3.61
Available soil moisture at - 3 bar	4.24

3.2 Treatments

Main plot treatment (sowing date):

September 23, 1983

October 22, 1983 (23 being a Sunday)

November 23, 1983

December 23, 1983

January 23, 1984

February 23, 1984

Sub-plot treatment (moisture stress):

No moisture stress (control) - irrigation of 65mm depth of water was given to the crop at 7 day interval through crop growth.

Moisture stress at flowering

Moisture stress at grain filling

Irrigation water was delivered to the plots by gravitational method using siphon. After sowing a light irrigation of 40mm depth of water was given to ensure good germination and establishment. Normal irrigation of 65mm depth of water was given to the crop at 7 days interval until tasselling stage when differential irrigation as per treatment was started. At all the stress treatments the crop was denied water until the total cummulative pan evaporation (CPE) over a period of time reached 200mm. This was measured using the USWB 'class A' pan-evaporimeter at the station. The irrigation

schedule are shown in Table 3.3. The first irrigation after moisture stress was 100mm depth of water in all cases.

3.3 Agronomic Practices

The experimental area was thoroughly ploughed, harrowed and ridged at 75cm apart. Final bunding of 54 plots was done manually.

Fertilizer rate of 150kg N + 60kg P_2O_5 and 40kg K_2O/ha was applied as per the recommendation of Institute for Agricultural Research, Ahmadu Bello University, Zaria. Nitrogen was applied in two splits. Half of the nitrogen and all phosphate and potash were applied at the time of sowing and other half of nitrogen was side-dressed six weeks after sowing.

Maize variety 'TZB' was sown at monthly interval starting from 23 September, 1983, and ending on 23 February, 1984. Sowing was done on ridges 75cm apart and 25cm within row. Before sowing the seeds were dressed with Aldrex T at 20g per 10kg seed.

The maize crop was harvested from a net plot of 6m x 1.5m after physiological maturity. The date of harvest and crop duration in the field are shown in Table 3.4.

The harvesting, shelling and cleaning of seeds were done manually.

Table 3.3. Irrigation schedule of dry season maize as affected by sowing date and irrigation treatment at Kadawa, 1983-84.

Treatments		Number of Irrigations					
		Initial irrigation after sowing	Before imposing Moisture Stress	After moisture stress stage	Water stress period, days	Total number of irrigations	Total Amount of water supplied (mm)
Sept.	I_0	1	16	-	-	17	1080
	I_1	1	9	4	26	14	885
	I_2	1	12	-	28	13	820
Oct.	I_0	1	19	-	-	20	1275
	I_1	1	10	6	30	17	1115
	I_2	1	13	2	29	16	1050
Nov.	I_0	1	19	-	-	20	1275
	I_1	1	11	5	27	17	1115
	I_2	1	14	-	29	15	950
Dec.	I_0	1	18	-	-	18	1145
	I_1	1	12	3	24	16	1050
	I_2	1	14	-	22	14	950
Jan.	I_0	1	15	-	-	16	1015
	I_1	1	9	4	18	14	885
	I_2	1	12	-	16	13	820
Feb.	I_0	1	13	-	-	14	885
	I_1	1	7	4	17	12	790
	I_2	1	10	-	14	11	690

I_0 = No moisture stress
I_1 = Stress at flowering
I_2 = Stress at grain filling

Table 3.4. Date of sowing and harvesting and total duration of maize in the field.

Date of sowing	Date of harvest	Crop duration (days)
Sept. 1983	Feb. 2, 1984	123
Oct. 1983	Mar. 26, 1984	157
Nov. 1983	Apr. 23, 1984	152
Dec. 1983	May 15, 1984	144
Jan. 1983	May 29, 1984	127
Feb. 1984	Jun. 11, 1984	108

3.4 Assessment of Growth, Yield Components and Grain Yield

3.4.1 Emergence count

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

3.4.2 Growth characters

For the purpose of determining the following growth characters, samples of ten plants were taken from each plot.

Plant height: The length of the shoot was measured from the ground level to the base of the top most leaves to determine the plant height. The height of the plants was recorded at 3 and 6 weeks after sowing and at tasselling stage.

Leaf area index: During tasselling fresh leaves from

10 plants, were removed from their base. Their number, length and breadth (from the widest point) were measured with a ruler. The product of length and breadth was multiplied by a factor of 0.75 in calculating the leaf area (Duncan and Hesketh, 1960). To find the leaf area index (LAI), the leaf area per plant in cm^2 was multiplied by the number of plants per m^2 and divided by 10,000.

Ear height: The length of stems was measured from the ground level to the base of the lower ear to determine the ear height.

Dry matter production: At physiological maturity, the whole plant including even dried leaves and ears from each plot were oven dried at 60^0C for 40 hours and weighed. The dry matter per m^2 was determined.

3.4.3 Yield components

For the purpose of determining the following yield components, samples were taken from ten plants in each plot after harvesting.

Number of ears per plot: The number of ears from the net plot area (6 x 1.5m) was recorded.

Ear length: The average ear length from ten plants was recorded.

Ear diameter: The average ear diameter from ten plants was recorded.

Cob diameter: The average cob diameter from ten plants was recorded.

Kernel depth: This was obtained by substracting the cob diameter from the ear diameter and dividing by two (Olagunde, 1983[1].

Shelling percentage: For the purpose of determining the shelling percentage, ears from ten plants were weighed. The ears were threshed and grains cleaned and weighed. The weight of the grains was divided by the weight of the unshelled ears and multiplied by 100 to get the shelling percentage.

Grain weight per ear: The weight of grains per ear of ten plants was recorded.

1000-grain weight: From the sample of ten plants, 1000-grain weight (in grams) was determined.

Harvest index: Harvest index (HI) was obtained by taking the ratio of grain over total dry matter.

3.4.4 Grain yield

Grain yield was obtained after threshing and cleaning the seeds harvested from the net plot area (6 x 1.5m) and from this the grain yield per hectare was determined (at 15% moisture).

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[1]Personal communication, O. O. Olagunde, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria.

3.5. Statistical Analysis

The data collected were subjected to statistical analysis of variance as described by Snedecor and Cochran (1967). Main and sub plot treatments means were compared using the least significant difference at 5% level of probability.

Chapter 4

RESULTS

4.1 Effect of Sowing Date and Moisture Stress

4.1.1 Plant growth

Plant height: The plant height was recorded at 3 and 6 weeks after sowing (WAS) and at tasselling. The data obtained are presented in Table 4.1.

At three weeks after sowing, the February sowing produced significantly taller plants (60.5cm) followed by October, September, November, December and January sowing. There was no significant difference between October and September; and also between December and January sowing dates.

At six weeks after sowing, the February and December sowing produced tallest (132.7cm) and shortest (66.3cm) plants, respectively. For other four sowing dates the trend was almost similar to that observed at three weeks after sowing.

At tasselling stage, the October sowing produced significantly taller (254.1cm) plants than all the other dates. The September sowing being statistically same to November and December sowing was found to be superior to February and January sowings. There was no significant differences between November, December, January and February sowings.

As the crop was not stressed before tasselling the

Table 4.1. Effect of sowing date and moisture stress at different stages of growth on height of maize at Kadawa, 1983/84.

Treatments	Plant height (cm)		
	3 WAS	6 WAS	Tasselling
Sowing date			
Sept. 1983	43.4	100.5	205.2
Oct. 1983	40.5	104.9	254.1
Nov. 1983	36.9	80.5	194.8
Dec. 1983	27.3	66.3	188.4
Jan. 1984	24.3	93.7	175.2
Feb. 1984	60.5	132.7	175.6
S.E. (±)	1.8	2.0	7.5
LSD (0.05)	5.6	8.9	23.6
Irrigation			
No moisture stress	40.1	97.9	201.9
Moisture stress at flowering	39.3	97.6	199.1
Moisture stress at grain filling	41.1	97.8	195.6
S.E. (±)	1.5	2.0	3.7
LSD (0.05)	NS	NS	NS
Interaction			
Irrigation x Date	NS	NS	*
S.E. (±)			9.2
LSD (0.05)			26.8

WAS = Weeks after sowing

NS = Not significant * = Significant at 5%

moisture stress, therefore, did not affect the height.

Interaction between sowing date and moisture stress was significant at tasselling stage. October sowing produced taller plants in all the irrigation treatments (Table 4.2). On the other hand January and February sowing produced significantly shorter plants under the two moisture stress conditions.

Leaf area index at tasselling: The leaf area index as affected by sowing date and moisture stress were measured at tasselling stage. The data are presented in Table 4.3.

The October and September sowing being statistically similar produced significantly higher LAI than all the other sowings. There was no significant difference between November to February sowing dates.

The moisture stress at grain filling and at flowering both being statistically similar with no stress produced the highest (5.0) and lowest (4.7) LAI.

The interaction between the two factors was significant. October sowing under all stress conditions produced higher LAI than others (Table 4.4). It was followed by September sowing which produced higher LAI under all stress conditions except January sowing with stress at grain filling.

Ear height: The October sowing being statistically similar with September sowing produced significantly tallest

Table 4.2. The interaction effect of sowing date and moisture stress on plant height at tasselling at Kadawa, 1983/84.

Treatments	Irrigation		
	I_0	I_1	I_2
Sowing date			
Sept. 1983	211.3	211.7	192.5
Oct. 1983	248.7	256.7	257.0
Nov. 1983	202.3	190.6	191.7
Dec. 1983	176.5	195.5	193.1
Jan. 1984	180.7	167.0	170.0
Feb. 1984	104.1	173.3	169.3
S.E. (±) (Irrigation)	9.2		
S.E. (±) (Sowing date)	12.9		
LSD (0.05) (Irrigation)	26.8		
LSD (0.05) (Sowing date)	40.9		

I_0 = No moisture stress

I_1 = Stress at flowering

I_2 = Stress at grain filling

Table 4.3. Effects of sowing date and moisture stress at different stages of growth on leaf area index, ear height and days to 50% tasselling and silking of dry season maize at Kadawa, 1983/84.

Treatments	LAI at tasselling	Ear height (cm)	Days to 50% tasselling	Days to 50% silking
Sowing Date				
Sept. 1983	5.6	112.2	73	81
Oct. 1983	6.1	122.6	77	87
Nov. 1983	4.1	96.7	83	92
Dec. 1983	4.4	97.5	89	94
Jan. 1984	4.5	99.0	69	77
Feb. 1984	4.2	105.7	52	60
S.E. (±)	0.3	5.3	+	+
LSD (0.05)	0.9	16.6	+	+
Irrigation				
No water stress	4.9	100.6	94	81
Stress at flowering	4.7	100.1	94	83
Stress at grain filling	5.0	100.1	94	81
S.E. (±)	0.1	2.7	+	+
LSD (0.05)	0.2	7.0	+	+
Interaction				
Irrigation x Date	Sig	N.S.	N.S.	N.S.
S.E. (±)	0.2			
LSD (0.05)	0.6			

+ = All replications have the same number of days, therefore, no S.E. and LSD can be calculated.

N.S Not significant.

Table 4.4. The interaction effect of sowing date and moisture stress on leaf area index at tasselling of maize at Kadawa 1983/84.

Sowing date	Irrigation		
	I_0	I_1	I_2
Sept. 1983	5.9	5.3	5.5
Oct. 1983	6.1	6.3	6.0
Nov. 1983	4.3	3.8	4.3
Dec. 1983	4.0	4.6	4.6
Jan. 1984	4.6	3.8	5.0
Feb. 1984	4.1	4.2	4.2
S.E. (±) (Irrigation)	0.2		
S.E. (±) (Sowing date)	0.5		
LSD (0.05) (Irrigation)	0.6		
LSD (0.05) (Sowing date)	1.5		

I_0 = No moisture stress

I_1 = Stress at flowering

I_2 = Stress at grain filling

ear height than all other sowing dates (Table 4.3). The September sowing was statistically similar with all other sowing dates.

The effect of moisture stress on ear height showed that the no stress being statistically similar with stress at grain filling both produced significantly taller ear height than stress at flowering.

Days to 50% tasselling: The number of days to 50% tasselling was found to vary with sowing date (Table 4.3). The November and December sown crop took longer days to tassel (83 and 89 days, respectively) where as the January and February sown crop took shorter number of days to tassel (69 and 52 days, respectively).

Days to 50% silking: The effects of sowing dates and moisture stress on days to 50% silking was found to vary (Table 4.3). For sowing date the trends was similar as for number of days to 50% tasselling. Silking was found to be delayed by two days by moisture stress at flowering.

Dry matter production: The effect of sowing date and moisture stress on total dry matter production are shown in Table 4.5.

The September sowing being statistically similar with October, December and February sowings, produced significantly more dry matter than November and January sowings. December

Table 4.5. Effect of sowing date and moisture stress at different growth stages on total dry matter of dry season maize at Kadawa, 1983/84.

Treatments	Total dry matter production (t/ha)
Sowing date:	
Sept. 1983	28.8
Oct. 1983	26.1
Nov. 1983	20.7
Dec. 1983	25.1
Jan. 1984	15.8
Feb. 1984	24.1
SE (±)	1.8
LSD (0.05)	5.7
Irrigation:	
No water stress	25.3
Stress at flowering	21.7
Stress at grain filling	23.3
SE (±)	0.8
LSD (0.05)	2.8
Interaction	
Irrigation x Date	N.S.

N.S. = Not significant

and February sowing, both being statistically similar with November sowings produced more dry matter than January sowing. There was no significant difference between November and January sowing.

No moisture stress and moisture stress at flowering each being statistically similar with moisture stress at grain filling produced significantly highest (25.3 t/ha) and lowest (21.7 t/Ha) dry matter.

4.1.2 Yield components

Number of ears per plot: The data on the number of ears per plot as influenced by sowing date and moisture stress are presented in Table 4.6.

The October sowing produced significantly more number of ears (314) per plot than all the other sowing dates. This was followed by September and November sowings which were statistically similar with each other. The later sowing dates December, January and February and February which were statistically similar with each other, produced significantly lower number of ears per plot.

The interaction between sowing date and moisture stress was significant. October sowing irrespective of moisture stress treatments produced more number of ears per plot (Table 4.7). This was followed by September sowing which produced more number of ears per plot under all stress

Table 4.6. Effect of sowing date and moisture stress at different growth stages on the number of ears per plot of dry season maize at Kadawa, 1983/84.

Treatments	Number of ears/plot
Sowing date	
Sept. 1983	260.2
Oct. 1983	314.4
Nov. 1983	248.6
Dec. 1983	207.3
Jan. 1984	213.2
Feb. 1984	206.5
S.E. (±)	6.6
LSD (0.05)	20.6
Irrigation	
No water stress	246.4
Stress at flowering	239.2
Stress at grain filling	240.6
S.E. (±)	3.9
LSD (0.05)	11.3

Table 4.7. Interaction effect of sowing date and moisture stress on number of ears per plot of dry season maize at Kadawa, 1983/84.

Sowing date	Irrigation		
	I_0	I_1	I_2
Sept. 1983	290.2	259.3	223.4
Oct. 1983	315.4	321.3	300.5
Nov. 1983	242.3	221.5	202.7
Dec. 1983	208.6	214.4	199.2
Jan. 1984	207.5	221.6	211.1
Feb. 1984	207.3	190.6	215.3
S.E. (±) (Irrigation)		9.5	
S.E. (±) (Sowing date)		11.4	
LSD (0.05)(Irrigation)		27.7	
LSD (0.05) (sowing date)		35.9	

I_0 = No moisture stress

I_1 = Stress at flowering

I_2 = Stress at grain filling

conditions except November sowing with stress at grain filling.

Ear length: The data on the length of the ear as influenced by sowing date and moisture stress are presented in Table 4.8.

January sowing being statistically similar with October and November sowing produced significantly shorter ears than the February, December and September sowings. September, sowing was found to be statistically similar with December, February, November and October sowings.

The no moisture stress treatment, which was statistically similar with stress at grain filling and development produced significantly longer ears than the stress at flowering. There was no significant difference between stress at grain filling and stress at flowering.

Ear diameter: The January sowing produced significantly lower ear diameter (3.9 cm) than all the other sowing dates. The September sowing being statistically similar with October sowing produced significantly higher ear diameter than February, December and November sowing (Table 4.9). There was no significant difference between October, February, December and November sowings.

The no moisture stress produced significantly higher ear diameter than the other two stress treatments which were statistically similar.

Table 4.8. Effect of sowing date and moisture stress at different growth stages on ear length of dry season maize at Kadawa, 1983/84.

Treatments	Mean ear length (cm)
Sowing date	
Sept. 1983	15.9
Oct. 1983	14.2
Nov., 1983	14.4
Dec. 1983	15.7
Jan. 1984	13.3
Feb. 1984	15.6
S.E. (±)	0.6
LSD (0.05)	1.8
Irrigation	
No water stress	15.4
Stress at flowering	14.4
Stress at grain filling	14.8
S.E. (±)	0.3
LSD (0.05)	0.8
Interaction	
Irrigation x Date	N.S.

N.S. = Not significant

Table 4.9. Effects of sowing date and moisture stress at different growth stages on ear diameter, cob diameter and kernel depth of dry season maize at Kadawa, 1983/84.

Treatments	Ear diameter (cm)	Cob diameter (cm)	Kernel depth (cm)
Sowing date			
Sept. 1983	4.67	2.73	0.97
Oct. 1983	4.47	2.76	0.06
Nov. 1983	4.31	2.53	0.89
Dec. 1983	4.35	2.56	0.80
Jan. 1984	3.91	2.43	0.74
Feb. 1984	4.35	2.51	0.92
S.E. (±)	0.08	0.04	0.03
LSD (0.05)	0.25	0.12	0.10
Irrigation			
No water stress	4.40	2.62	0.93
Stress at flowering	4.26	2.57	0.85
Stress and grain filling	4.29	2.56	0.85
S.E. (±)	0.06	0.03	0.02
LSD (0.05)	0.16	N.S.	0.07
Interaction			
Irrigation x Date	N.S.	N.S.	N.S.

N.S. = Not significant.

Cob diameter: The data illustrating the effect of sowing date and moisture stress on the cob diameter are shown in Table 4.9.

The October and September sowing being statistically similar had significantly higher cob diameter than the other sowing dates. The December sowing being statistically similar with November and February sowings had significantly higher cob diameter than the January sowing. There was no significant differences between November, February and January sowings.

There was no significant effect of irrigation stress on cob diameter.

Kernel depth: The data illustrating the effect of sowing date and moisture stress on the kernel depth of maize are shown in Table 4.9.

The January sowing produced significantly lower kernel depth than the other sowing dates. The maximum kernel depth (0.97cm) was produced by September sowing which was found to be statistically similar with February, November and December sowings. October sowing was statistically similar with February, November and December sowings.

The no stress treatment produced significantly higher kernel depths than the stressed treatments which were statistically similar with each other.

Weight of grains per ear: The September and January sowings produced significantly highest (160.0g) and lowest (70.0g) weight of grains per ear. The effect of the other sowing dates on weight of grains per ear was statistically same and they being statistically similar with each other were in between these two extremes (Table 4.10).

The no stress treatment produced significantly higher grains per ear than the two stresses which were statistically similar with each other.

Shelling percentage: September sowing produced significantly higher shelling percentage than the other sowing dates (Table 4.10). The lowest shelling percentage was from January sowing which was statistically similar with November and December sowings. February sowing being statistically similar with October produced more than that of December and November sowings. Sowing in October, Novmber and December did not differ significantly.

The no stress produced significantly higher shelling percentage than the two stress treatments. The stress at flowering and grain filling were found to be statistically similar with each other.

Weight of thousand grains: September, December, January and October sowings being statistically similar produced significantly more thousand grain weight than November sowing which was superior to February sowing (Table 4.11).

Table 4.10: Effects of sowing date and moisture stress at different growth stages on weight of grains per ear and shelling percentage of dry season maize at Kadawa, 1983/84.

Treatments	Grain weight per ear (gm)	Shelling percentage
Sowing date		
Sept. 1983	160.0	00.1
Oct. 1983	111.0	69.4
Nov. 1983	108.9	64.9
Dec. 1983	126.7	65.5
Jan. 1984	70.8	59.7
Feb. 1984	119.6	71.9
S.E. (±)	8.0	1.9
LSD (0.05)	27.0	6.2
Irrigation		
No water stress	129.0	070.9
Stress at flowering	107.6	67.8
Stress at grain filling	112.2	67.0
S.E. (±)	4.4	0.9
LSD (0.05)	12.0	2.5
Interaction		
Irrigation x Date	N.S.	N.S.

N.S. = Not significant.

Table 4.11. Effect of sowing date and moisture stress at different growth stages on 1000-grain weight of dry season maize at Kadawa, 1983/84.

Treatments	1000-grain weight (gm)
Sowing date	
Sept. 1983	291.0
Oct. 1983	275.6
Nov. 1983	251.5
Dec. 1983	284.3
Jan. 1984	276.0
Feb. 1984	226.0
S.E. (±)	6.0
LSD (0.05)	21.4
Irrigation	
No water stress	271.6
Stress at flowering	263.7
Stress at grain filling	4.8
S.E. (±)	N.S.
LSD (0.05)	N.S.
Interaction	
Irrigation x Date	N.S.

N.S. = Not significant.

There was no significant effect of moisture stress on 1000-grain weight.

4.1.3 Grain yield

The October sowing being statistically similar with September sowing produced significantly more grain yield than other sowing dates. The total grain yield were 7167 and 5567 kg/ha with October and September sowings, respectively. The January sown crop produced least grain yield (2000 kg/ha). There was no significant difference between September, November, December and February sowings (Table 4.12).

The crop grown without any water stress produced significantly higher grain yield (5528 kg/ha) than the stress at flowering and grain filling treatments which were statistically similar with each other.

4.1.4 Harvest index

Higher harvest index was achieved with September sowing which was statistically similar with October sowing. October sowing being statistically similar with November sowing produced more harvest index than February, January and December sowings. November being statistically similar with February sowings produced more harvest index than January and December. There was no significant difference between February, January and December.

There was no significant effect of moisture stress on harvest index.

Table 4.12. Effect of sowing date and moisture stress at different growth stages on grain yield of dry season maize at Kadawa, 1983/84.

Treatments	Grain yield (kg/ha)
Sowing date	
Sept. 1983	5567
Oct. 1983	7167
Nov. 1983	5189
Dec. 1983	4022
Jan. 1984	2000
Feb. 1984	4167
S.E. (±)	542
LSD (0.05)	1700
Irrigation	
No water stress	5520
Stress at flowering	4294
Stress at grain filling	4633
S.E. (±)	235
LSD (0.05)	685
Interaction	
Irrigation x Date	N.S.

N.S. = Not significant.

Table 4.13. Effect of sowing date and moisture stress at different growth stages on harvest index of dry season maize at Kadawa 1983/84.

Treatments	Harvest index
Sowing date	
Sept. 1983	0.326
Oct. 1983	0.308
Nov. 1983	0.272
Dec. 1983	0.181
Jan. 1984	0.195
Feb. 1984	0.214
S.E. (+)	0.018
LSD(0.05)	0.050
Irrigation	
No water stress	0.256
Stress at flowering	0.256
Stress at grain filling	0.236
S.E. (±)	0.012
LSD (0.05)	N.S.
Interaction	
Irrigation x Date	N.S.

N.S. = Not significant.

Chapter 5

DISCUSSION

5.1 Effect of Sowing Date on Grain Yield and Yield Components

The early sowing dates (September and October produced grain yields of 5567 kg/ha and 7167 kg/ha, respectively (Table 4.12). These yields are more than the yields obtained in the wet season trials at Kadawa which ranges from about 3 to 4 t/ha. This could be because the Sudan zone receives higher global solar radiation (500 - 520 Cal/m^2/day) in the dry season than the wet season (407 - 450 Cal/m^2/day) (Kowal and Knabe, 1972). During the rainy season, there is a steady decline in radiation the lowest coinciding with the peak of the rains. Also there is a less infestation of diseases, insects and weeds in the dry season maize crop.

It was found that delaying sowing beyond October reduced grain yields by 27.6, 33.0, 72.1 and 42.0% when sown in November, December, January and February, respectively. George (1943), Benoit et al. (1965), El-Sharkamy et al. (1975), Balan (1977), Briggs and Attinaw (1979) and Kamel et al. (1979) also reported reduction in yield due to late sowing. Very similar to the finding reported herein, Farrel (1975) obtained maximum grain yield with early sowing on October 25. The early sowing dates produced more grain yield because of the optimum temperature (19 - 24^{0}C) and high relative humidity (29.6 - 33.0%) during the periods of

flowering and fertilization (Table 3.1). The low yields obtained by late sowing could be explained in the light of the high temperatures (35 - 38^{0}C) and low relative humidity (21 - 26%) in March and April, the period of flowering and grain development. A comparison of yields with mean maximum temperature and relative humidity for ten days immediately after tasselling is shown in Table 5.1).

Table 5.1. Maize yields as influenced by Mean Maximum Temperature and Relative Humidity (RH) during Flowering and Grain Development at Kadawa, 1983/84.

Sowing date	Tasselling		Mean Maximum temp. (^{0}C) at tassel-ling + 10 days after	RH (%) at tasselling	Mean Maximum temp.(^{0}C) at grain develop-ment	RH (%) - at grain develop-ment	Grain yield kg/ha
	Days	Date					
Sept.1983	73	5 Dec.	32	36	27	33	5567
Oct. 1983	77	7 Jan.	29	26	29	28	7167
Nov. 1983	83	14 Feb.	31	27	36	31	5109
Dec. 1983	89	22 Mar.	36	26	30	23	4022
Jan. 1984	69	3 Apr.	37	21	38	29	2000
Feb. 1984	52	16 Apr.	37	25	35	51	4167

NB: Mean maximum temperature at grain development was recorded at 10 days after silking for 30 days.

It is clear from Table 5.1 why the January sown crop produced significantly lowest grain yield than the other sowing dates. This is because of the low relative humidity (21%) at the time of flowering. Arnon (1975b) has reported that, high temperatures (35 - 38^{0}C) and low relative humidity during the period of flowering have adverse effect on fertilization by causing excessive dehydration of pollen or Stigma. Similar effect have been reported by Benoit et al. (1965). Kumar et al. (1982) have reported that low humidity and high temperature during tasselling and silking of maize may result in floret sterility. They explained further that, the environment with cool night (14 - 18^{0}C) and moderate day temperatures (25 - 30^{0}C) is more favourable for maize grain production. They reported that every 1^{0}C increase in minimum temperature (night temperature) beyond 14^{0}C decreased grain yields by 153 kg/ha. While each 1^{0}C increase in mean temperature beyond 30^{0}C decreased grain yield by more than 211 kg/ha.

The February sown crop produced more grain yield than the January sown crop, because the temperature was lower and relative humidity was higher at the time of grain filling and development (Table 5.1).in February sown crop.

The low yield obtained by late sowing, December to February could also be explained in the light of reduced dry matter production, number of ears per plot, ear length,

weight of grains per ear and shelling percentage which were all affected by changes in temperatures and relative humidity at the time of crop growth, development and grain formation.

The number of ears per plot, ear length, ear and cob diameter, kernel depth, weight of grains per ear, shelling percentage and harvest index (Table 4.6, 4.8, 4.9, 4.10 and 4.13) were found to be affected by sowing date in this study in a similar trend to the grain yield. The earlier sowing dates, September and October produced more of these parameters, whereas the later sowing dates from December to February produced the least. The January sowing was observed to produce the least of these parameters when compared to other sowing dates. Weight of grains per ear was reduced by 55.7% when sowing was delayed from September to January. The reduction in these parameters could be attributed to the high temperatures and low relative humidity at the time of flowering when most of these parameters were formed. Similar result were reported by Balan (1977), Kamel et al. (1979).

Thousand grain weight (Table 4.11) was found to be affected by sowing date in a similar trend to grain yield. The highest (291.0g) and the lowest (226.0g) 1000-grain weight were produced by September and February sowing, respectively. This could be attributed to acceleration of growth and translocation of assimilation into the grain because of the higher temperatures in March and April during the time of grain formation in the later sown crop. Similar

result has been reported by Balan (1977) who got 1000-grain weight of 300g from early sowing.

5.2 Effect of Moisture Stress on Grain Yield and Yield Components

The grain yield (Table 4.12) was influenced significantly by withholding irrigation at both flowering and grain-filling and development periods. No water stress treatment (control) produced the highest grain yield (5527.8 kg/ha). The least grain yield was obtained when irrigation was not given at flowering, resulting in 22.3% yield reduction. Withholding irrigation at grain filling and development reduced grain yield by 16.2%. This marked reduction in yield when water stress was imposed at flowering was attributed by Slatyer (1973) to the reduced fertilization and grain set, caused by the dehydration of pollen grain or probably poor germination of the pollen or failure of growth of the tube from the stigma to the ovules. Robins and Domingo (1953), Denmead and Shaw (1960), Kemper et al. (1961) and Claassen and Shaw (1967), asserted that water stress at flowering reduced grain yield due to production of dried sterile tassels, which may fail to shed viable pollen causing partial fertilization. Moisture stress during grain filling has been shown to reduce translocation of photosynthate from the leaves to grain, thus leading to reduced grain yield Henkel (1964), Claassen and Shaw (1967), Arnon (1975b), Gardner, (1901), and Harder et al. (1982) have also reported

similar findings.

Ear length, ear diameter, kernel depth, weight of grains per ear and shelling percentage were adversely affected by moisture stress. The effect of moisture stress on these parameters following a similar trend to grain yield. Moisture stress at flowering produced the least of these parameters. The reduction in these parameters with moisture stress could be attributed to reduction in translocation of photosynthate from the leaves to the ear, reduction in cell enlargement and destruction of the productive tissues for want of moisture. Similar results were reported by Kiesselbach (1950), Robins and Domingo (1953) and Claassen and Shaw (1967). Salter and Goode (1967) reported that moisture stress during the formation of reproductive organs and later at flowering were most sensitive, resulting in aborted or sterile florets. This, of course, may be expected since the number of grains per ear is established during inflorescence development (Slatyer, 1973 and Fischer, 1973). Loomis (1934) and Robins and Domingo (1953) had reported earlier that moisture stress at tasselling, earing and pollination resulted to sterile tassels and reduction in fertilization.

The number of ears per plot, cob diameter, 1000-grain weight and harvest index (Table 4.6, 4.9, 4.11 and 4.13) were not significantly affected by moisture stress. The highest of these parameters, however, occured under no moisture stress condition and the lowest with stress at

flowering.

5.3 Effect of Sowing Date on Plant Growth

The growth and development of maize crop plant was influenced by date of sowing in relation to variation in the environmental conditions at Kadawa. The plant height measured at different periods during vegetative phase was influenced by sowing date. The effect was clear and pronounced during all the sampling periods. It was observed that at three and six weeks after sowing the February sowing produced the tallest plant. The November, December and January sowings produced shorter plants. This might be because of changes in the atmospheric temperatures during the growth period. Rise and fall of temperatures accelerate and retard the growth of plants, respectively. Rise in temperatures in the months of March and April favoured the February sown plants to grow taller. The November, December and January sowing dates produced shorter plants because of the lower temperatures during the months of December to February (Table 3.1 and 4.1).

At tasselling, the October sowing produced the tallest plant. This could be attributed to the optimum temperatures and other environmental conditions during the crop's growth period. Low temperatures during December and January and high temperatures during March and April might have checked the growth of plants when sown during November

to February. November and December sown plants suffered due to very low temperatures and January and February sown plants suffered from high temperatures during tasselling. This is further evidenced from the data presented in Table 4.3 showing the number of days to 50% tasselling. El-Gharkawy et al. (1973) had also reported that plant height declined by late sowing.

Like the height of a plant, size of leaves is another parameter of measuring the growth of a plant. As the variations in temperatures affected the height of plants when sown on different dates, so also the leaf area was affected. The October and September sowing which produced taller plants at tasselling consequently produced higher leaf area index (Table 4.3).

The ear height was affected by sowing dates. The trend was similar to the plants height at tasselling and leaf area index. The October and September sowing produced the tallest ear height. In the other sowing dates i.e. from November to February, ears were formed at the same height on the plants which were at par with September sowings. This variation in ear height is as a result of variation in plant height because of changes in environmental temperatures.

There was a wide variation i.e. 56 days in February sown to 89 days in December sown on the number of days to 50% tasselling. The six date of sowings can easily be grouped into

three i.e. February and January, September and October and November and December. Tasselling was earlier (52 - 69 days) in the former and later (03 - 89 days) in the later group. The variation must have been due to the changes in the temperatures during tasselling.

So far number of days to 50% silking was concerned the trend and the reasons are the same as for 50% tasselling. Low temperatures during December to February and high temperatures during March to April retarded and accelerated the formation of the reproductive organs, respectively. This observation is in agreement with the findings of Coligado and Brown (1975) and Hunter et al. (1975).

The last parameter measured during the vegetative phase was the dry matter production. Plant height and number of leaves per plant determine the total dry matter production. Early sowing during favourable environmental conditions produced the highest dry matter. The September and October sowings produced taller plants and higher leaf area index consequently produced higher dry matter. These findings are also in harmony with those of Nagase and Takemura (1965), Dechev (1974) and Balan (1977). Arnon (1975b) explained that the amounts of dry matter produced dependent on the differences of photosynthesis of the crop, which will further depend on a large and efficient assimilating area and favourable environmental conditions.

5.4 Effect of Moisture Stress on Plant Growth

Water as a constituent of protoplasm, solvent for nutrients and reagent, is the most important factor affecting the growth and survival of plants. The effect of moisture stress caused by withholding irrigation at different stages of maize growth was investigated in this study.

Imposing moisture stress at flowering produced lower leaf area index (4.7), but not significantly different from the no moisture stress treatment (4.9). This is expected since the irrigation treatment commenced during the reproductive phase before which the vegetative growth has presumably ceased and it is expected that leaf area may not be effected by moisture stress at any of the reproductive stages. Moisture stress at flowering reduced ear height significantly (Table 4.3). This is because, during the moisture stress periods, protoplasmic dehydration reduced the physiological activity of the cells, particularly in tissues which require water supply for their development (Salter and Goode, 1967). Stress at grain filling had no effect on ear height because this occured after the ear formation.

Moisture stress at flowering significantly reduced the dry matter production in comparison to no moisture stress. This and the stress at grain filling and development reduced dry matter production by 14.05% and 0.07% over the no stress treatment, respectively. The amount of dry matter produced

depend on the effectiveness of photosynthesis of the crop. In maize, apparent photosynthesis was reduced by soil moisture stress (Baker and Musgrave, 1964). The findings in this study are also in harmony with those of Claassen and Shaw (1964); Vivekanandan et al. (1974) and Wilson and Allison (1970).

The moisture stress at flowering (Table 4.3) was found to delay silking by 2 - 3 days in this study. This is because moisture stress reduces the rate of appearance of floral primordia (Larson, 1975). Similar findings have been reported by Kemper et al. (1961); Robinson and Domingo (1953) and Claassen and Shaw (1964).

5.5 Sowing Date and Moisture Stress Interaction

From the study of the interaction of moisture stress and sowing date, it has been found that October sowing produced taller plants, higher leaf area index at tasselling and more number of ears per plot in all the irrigation treatments. The later sowings from December to February on the other hand produced the least of these parameters. This observation can be attributed to the sensitivity of the plants to increasing soil moisture stress under condition of high temperature experienced by the later sowing dates.

Chapter 6

SUMMARY AND CONCLUSIONS

A field trial was conducted at the Regional Irrigation Research Station, Ahmadu Bello University, Kadawa, during 1983/84 dry season to study the response of growth, development and yield in maize to dates of sowing and moisture stress imposed at various growth stages.

THE treatments consisted of combination of six sowing dates (main plots) and three moisture stress conditions (sub-plots). The sowing of maize was done on 23 of each month from September, 1983 to February, 1984. The irrigation treatments were: normal irrigation of 65mm depth of water at 7 days interval, moisture stress at flowering and moisture stress at grain filling.

It was observed, that, late sowing beyond the month of October reduced the growth parameters viz: plant height, leaf area index and dry matter production at tasselling. Delaying sowing till the month of January reduced ear length, ear diameter, cob diameter, grain weight per ear, shelling percentage and kernel depth.

The final grain yield was very much affected by sowing dates. The highest grain yield (7167 kg/ha) was obtained when maize was sown in October. Delaying the sowing beyond October reduced grain yield by 27.6, 33.0, 72.1 and 42.0% when

sown in November, December, January and February, respectively.

It was observed that moisture stress either at flowering or at grain filling and development reduced most of the yield parameters viz: ear diameter, kernel depth, grain weight per ear, shelling percentage and grain yield when compared with no moisture stress. Grain yield was reduced by 22.3 and 16.2%, when maize suffered from moisture stress at flowering and grain filling and development, respectively.

Based on the present findings, it may be concluded that the optimum time to sow maize in the dry season under irrigation in the Sudan savanna is from September to late October. Late sowings beyond October reduced grain yield and most of the other parameters because of either low relative humidity or high temperatures during fertilization and grain-filling. With the high yields (7167 kg/ha) obtained, there will be no exaggeration in saying that there is a good scope of maize cultivation in the dry season in the Sudan savanna with irrigation.

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Appendix A: Growth stages of the Maize Plant*

State	Days after sowing
Stage 0	5 - 7 days
Stage 1	About 2 weeks after plant emergence
Stage 2	About 4 weeks after plant emergence
Stage 3	About 6 weeks after plant emergence
Stage 4	Tassel has emerged from the whole at the tip
Stage 5	Emergence of silks and the shedding of pollen
Stage 6	Reached about 12 days after silking
Stage 7	Dough stage reached 24 days after 50% silking
Stage 8	Grain development and growth of embryois rapid
Stage 9	Kernels fully dented. Reached about 40 days after 50% silking
Stage 10	Plant physiological meture

*Source: P. N. Egharevba (1974).

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