EFFECT OF TIME OF BASAL FERTILIZER APPLICATION ON YIELD AND YIELD COMPONENTS OF MAIZE (*Zea* mays L.)

BY

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A thesis submitted to the Postgraduate School, Ahmadu Bello University, in partial fulfilment of the requirement for the degree of Master of Science in Agronomy

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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CERTIFICATION

This thesis entitled EFFECT OF TIME OF BASAL FERTILIZER APPLICATION ON YIELD AND YIELD COMPONENTS OF MAIZE (*Zea mays* L.) by Dalang Mansan Musa meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my biological parents Mr. Thomas Dalang and Mrs Esther Nayal Dalang, who gave birth to me, bred me and educated me out of sheer poverty.

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ABSTRACT

Response of two maize cultivars TZBSR-W (120 days maturity) and TZESR-W C90 days maturity) to time of basal fertilizer application was investigated at the research farm of the Institute for

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, Agricultural Research, Samaru during the 1990 wet season. NPK fertilizer was basally applied at the rates of 60kg N/ha, 26.2 kg P/ha and 50kg K/ha. The two cultivars and four time of basal fertilizer application - 0, 10, 20 and 30 days after planting were laid out in a randomised complete block design with four replications.

The study revealed that delaying basal fertilizer application to TZBSR-W up to 20 days had no significant influence on grain yield. delaying basal fertilizer application beyond 20 days significantly reduced grain yeild (3998 kg/ha). The cultivar TZESR-W did not respond significantly to time of basal fertilizer application (3649 kg/ha, 3655 kg/ha 3667kg/ha and 3574 kg/ha for 0, 10, 20 and 30 days, respectively) The cultivar TZBSR-W outyielded TZESR-W by 9.6%.

Plant dry matter results showed that plants basally fertilized 30 days after planting recorded significantly lower plant dry matter at all times of sampling.

Delaying basal fertilizer application significantly decreased plant height, ear height and leaf area index. Delaying basal

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* fertilizer application significantly increased root lodging. Time of basal fertilizer application did not significantly affect stem lodging, number of ears, ear diameter, kerne] depth, Cob' length and thousand grain weight.

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TZBSR-W had longer cobs ana p

TZESR-W.

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ABBREVIATIONS

g - gram
kg - kilogram
ha - hectare
NS - Not significant
LAI - Lead Area Index
IAR - Institute for Agricultural Research
N - Nitrogen
P - Phosphorous
K - Potassium
Ca - Calcium
C - Carbon
Mg - Magnesium
ppm - Parts per million
% - Percent
cm - centimeter
m - metre
mm - millimetre
CEC - Cation Exchange capacity.
cv - Cultivar

CHAPTER 1

INTRODUCTION

Maize (Zea mays L.) is one of the most popular cereal crops in Nigeria. It is used for human consumption, livestock feed and raw material for agro-allied industries.

In the Nigerian Savanna grain yields of about 5,000 - 6,000kg/ha are readily obtainable with grain yields of about 8,000 - 10,000 kg/ha attainable under optimum soil and crop management practices (Kassam and Kowal, 1973).

Soils of the Nigerian savanna are predominantly ferrogenous tropical soils which are deficient in nutrient elements required for optimum crop growth and low in organic matter content (Bache and Rogers, 1970, Jones, 1973). On these soils, response of maize to fertilizers have been widely reported (Ologunde, 1974 and 1981; Lombin, 1987; Agboola, 1968; Goldsworthy, 1967a and b). As a result of the rapid destruction of the already low soil organic matter content brought about by widespread bush burning and the relatively high nutrient requirement of maize, judicious application of fertilizers are essential for high yields. While the potential benefits from fertilizers are quite enormous, the technical problems in using them efficiently by farmers are widespread.

Correct timing of fertilizer application is a critical factor in fertilizer use efficiency. In the savanna zones of Nigeria, experiences have shown that availability of fertilizers at the right time is a major constraint to maize production. Because of the inefficiency in the distribution system, fertilizers are often available to farmers long after the crops have been established. Since fertilizer prices are increasingly becoming prohibitive because of the gradual removal of government subsidy, farmers tend to apply fertilizers to crops already established. In order to maximise the use of fertilizers, most farmers prefer to apply basal fertilizers to established crops than applying before or at planting. Sometimes conflicting demand in labour arises particularly with the small scale farmers at the onset of the rains. At this period most farmers spend more time cultivating more land, hence they are forced to apply basal fertilizer to their crops at different times.

Recommended time of fertilizer NPK application to maize has been established with P and K applied at planting (Jones, 1976, Jones and Bromfield, 1974, Black 1968, Olugunde 1981, Ignatief and page 1958) and the N split applied with half at planting and half at four to six weeks after planting (Pawson, 1957, Brah and Khehar, 1977, Shukla, 1970, Spaldon and Zuzi, 1972).

While these recommendations exist, the practice of late basal fertilizer application is becoming widespread. Basal application could not exceed 30 DAP since the recommendation is to top dress at 4 - 6 WAP. Since the crop flowers between 50 and 60 DAP, it is not likely to respond to basal fertilizer applied after 30 days.

This study is aimed at determining the effect of time basal fertilizer application on yield and yield components of maize.

CHAPTER 2

LITERATURE REVIEW

About seventeen of the elements that occur in the soil are considered essential for the normal growth of plants (Amon, 1964). These are classified into macro and micronutrients.

Nitrogen, phosphorous and potassium are the macro elements usually sold in fertilizers, the other three calcium, magnesium and sulphur are equally essential and are considered as fertilizers when they have to be added to supplement the supply from the soil (Cook, 1972).

2.1 The Role of Nitrogen, Phosphorous and potassium in Maize Nutrition

Nitrogen is known to be the most limiting factor to maize production on most soils (Goldsworthy, 1972b; Shukla, 1972). Grunenberg, (1959) and Tisdale and Nelson (1975) attributed the role of protein formation to nitrogen. Nitrogen constitutes an integral part of the chlorophyll molecule and is also important in the utilization of carbohydrates. N has been observed to be responsible for vigorous vegetative growth which enhances photosynthetic capacity. The ability of the leaves to remain in a functional state for longer periods hence maximizing production and translocation of photosynthates to the grain has been attributed to nitrogen (Annonymous, 1970). Zuber, et al (1954), Lang, et al (1956) observed nitrogen to be an important constituent of the crude protein content of maize. It is evident from literature that N has a positive effect on the ear size and number per plant (Krantz and Chandler, 1951; Ologunde, 1987, Amoruwa, 1985).

Nitrogen deficiency in maize is indicated by dwarf growth and spindling with pale yellowish leaves (Annonymous, 1970). Leonard (1983) attributed delayed silk emergence which results in poor ear fill or skipped kernels to nitrogen deficiency. Other factors like drought and overcrowding were observed to produce a similar effect.

Grunenberg (1959) observed phosphorous to be responsible for the formation of organic compounds containing phosphoric acid. This plays an important role in the synthesis of carbohydrates and in the fat metabolism of the plant.

Phosphorous deficiency is usually manifested in stunted growth, premature leaf fall, purple or red anthocyanin pigmentation and the development of dead necrotic areas on leaves (Epstein, 1972, Grunenberg (1959). Grunenberg (1959) attributed the incomplete development of the stigma which results in incomplete kernel develppment and consequently cobs showing irregular rows of kernel to phosphorous deficiency during flowering.

The important functions of carbohydrate and protein metabolism, the transportation of carbohydrates in the plant, the polymerization of simple sugar to starch and the reduction of nitrates hence protein synthesis has been attributed to potassium (Grunenberg, 1959). Humble and Theodore (1969) reported that normal cell division and effective functioning of the stomata are potassium dependent.

Grunenberg (1959) observed potassium deficiency in maize plants as dwarf growth with relatively long leaves on short stems. Anabolism, he reported was considerably inhibited resulting in cobs incompletely developed especially at the tips. The grains are very loosely inserted on the cobs and are chaffy. Potassium deficiency causes protein and iron compounds to accumulate at stem nodes. This hinders carbohydrate translocation and causes poor root development with consequent weak anchorage with root lodging and stalk breakage resulting (Annonymous, 1970).

2.2 Response of Maize to Nitrogen, Phosphorous and Potassium Fertilizers.

Response to N and P have been most pronounced on cereals. All cereals and in particular maize have a high N requirement which is impossible to meet from the mineralization of organic matter because of low content of the latter in savanna soils (Lombin, 1987). Goldsworthy (1967a and b) reported that the application of phosphate to cereals are usually more effective in the presence of applied N and vice versa. A similar situation is obtained in the case of K, as the addition of more N will require more potassium in most cases (Annonymous, 1970). Stockinger (1970), comparing maize and long season sorghum concluded that the greater response of maize might have been due to its shorter growth period and hence greater intensity of demand. The introduction of higher yielding short season varieties over the years have intensified rates of uptake and response (Lombin, 1987).

Potassium has been widely reported as affording little or no benefit on non-intensive savanna agriculture (Goldsworthy, 1967a and b; Pieri, 1971). However, more recent report (Heathcote and Stockinger, 1968; Heathcote, 1972 and 1973; Lombin et al 1985) have shown that under intensive cultivation, potassium becomes an important crop limiting factor in the savanna. Wild (1971), reported the low K buffer capacities of savanna soils. Laboratory measurements and potted croppings have indicated that most of the soils would be rapidly depleted of their available K when intensively cropped (Iwuafor and Mokuenye, 1980). Potash fertilizer appears to be the only viable option for augmenting the fertility of these soils.

Summerising the work carried out over the years in both Sudan and Guinea savanna zones, Balasubramanian et al (1978) showed that the response of maize to N also depends on the nature of the preceding crop as was reported by Lombin (1981b) in respect of sorghum.

They concluded that where maize is preceded by groundnuts, the latter is likely to contribute about 50 - 60 kg N/ha to the maize crop.

Micronutrients have not so far posed any serious problem to cereal production in the savanna (Lombin, 1987). Recently, however, available literature (Heathcote, 1973; Osiname, et al, 1973) show that zinc response of maize has been observed with increasing frequency in the derived and northern Guinea savanna. This calls for the incorporation of zinc in the fertilizer recommendation for this crop in the said zones.

2.3 Time of Nitrogen, Phosphorous and Potassium Fertilizer Application to Maize

The demand by a crop for nutrients must be met if high yields are to be obtained. The type of crop and nature of fertilizer determine the appropriate time of application.

The corn plant if starved of nutrients at any developmental stage will result in reduction of final grain yield (Johnson, 1972). An adequate supply of nutrients at a later stage will often not overcome the early deficiency. It is important that fertilizers are applied to crops at certain stages of development. Leonard (1983) reported that in maize, the best time of N application is at planting to encourage vigorous vegetative growth and at flowering to ensure good grain filling. Various workers have recommended that N fertilizers be applied in two split doses, one half at planting and the other half four to six weeks later (Goldsworthy, 1967b; Fox 1972; Bouldin and Selleck, 1979; Jones, 1976; Lombin, 1985). Stanley and Rhoads (1976) and Daubin, (1978) obtained significantly lower yields when NPK fertilizer application was delayed up to six weeks after planting while treatments which received NPK fertilizer at planting produced the highest grain yield.

Cook (1972) recommended that all P and K needed by cereals on deficient soils be applied with the seed by combine drill since on such soils both superphosphate and muriate of potash are twice as effective when combine drilled as when broadcast. P and K given after cereals are sown, he observed; generally have little effect on the crop to which they are applied.

2.3.1 Time of nitrogen fertilizer application

The time of N fertilizer application is an important factor in determining the yield of maize. While N can be applied at different growth stages of the plant, these times are not of equal effectiveness.

Ologunde (1981) found N to be most effective if applied when the plant is growing more rapidly, indicating that delayed application of N as a side dressing should be most efficient. Ologunde and Ogunlela (1983) recorded higher grain yields with split over the single planting time application. Fayemi (1966) found that applying all the N at planting did not increase yields and delaying applications 60 days after planting significantly reduced yields. He also obtained increased N and Crude protein content of the grain when N was applied 30 days after planting. Pawson (1977) and Brah and Khehra (1977) concluded independently that maximum grain yield of maize was expected with split rather than the planting time single application. Spaldon and Zuzi (1972) found that responses were greatest when half the N and three quater of P were applied to the seed bed, the balance being applied four to six weeks after planting. Shukla (1970) found yields to be highest with split application of half at planting and half at tasseling. At locations where rainfall and leaching losses were high he found the best treatment to be one third at planting one third at the knee high stage and a third at tasseling.

In order to ensure adequate supply of added N at critical stages of plant growth and to reduce N leaching and losses due to heavy rainfall, Balasubramanian et al (1978) reported that the N fertilizer should be split into two equal doses and applied first at planting and then at four to six weeks after planting.

Reeves and Touchton (1986) obtained greater yields with N applied at five weeks after planting than when applied at sowing. Pawson (1957) had earlier found that applying N six weeks after planting was superior to applying N before planting.

Time of N application is especially important on sandy soils where leaching losses may be high. El-Sharkawy et al (1976), and Brah and Khehra (1977) independently recommended three split dressing of N on sandy loamy soils. Brown (1966) found no relationship between time of N application and maize grain yield Esechie (1982) also obtained no advantage of split over single application.

Cook (1972) observed that the N applied at sowing could be lost to early emerging weeds before it becomes available to the crop. It could also be lost through denitrification, volatilization, leaching or fixation. Knittel (1988), observed that the magnitude of both adsorption and N loss depend on soil type, tillage, fertilizer management, crop rotation and weather condition. Apart from higher grain yields obtained from delayed fertilizer N application, Olson (1978) reported a greater residual fertilizer N for subsequent crops with delayed applications.

2.3.2 Time of phosphorous fertilizer application to Maize.

The recommended time for P application to maize in the savanna zones has been a single application prior to sowing (Jones and Bromfield, 1974; Jones, 1976). The early application of P is recommended because of its immobility in the soil so it is essential it is close to the seed on germination to enhance its being picked up easily. Ologunde (1981) observed response of most field crops to P fertilization to be greatest early in the season and decreases as the crop matures. Black (1968) indicated that P availability decreases with time due mostly to fixation, preferential depletion by crops and extension of roots into soil that does not contain the fertilizer. The early application of P is considered necessary to stimulate root enlargement (Annonymous, 1970; Leonard, 1983).

2.3.3 Time of potassium fertilizer application to maize

Ignatieff and Page (1958) recommended that K fertilizer application be done at or just before planting. However, considering the large quantity of K removed by maize, the ease with which K is lost through leaching and the fact that excess K may be subjected to fixation, Ologunde (1981) recommended that its application be spread three to five times over the growing period. Hanway (1966) recommended that splitting application of K be spread between zero to five weeks when corn plants require this nutrient most. This time corresponds to the time the crop is planted to silking time.

CHAPTER 3

MATERIALS AND METHODS

3.1 Experimental site

The trial was conducted on the Institute of Agricultural Research (IAR) farm Samaru (11^{o} 11'N, 07^{o} 35'E, 680m above sea level) during the 1990 wet season. Samaru is located in the northern Guinea savanna ecological zone of Nigeria. Rainfall and evapotranspiration data are shown in figure 1. Prior to fertilizer application, composite soil sample was taken randomly (0-.3m depth). This was analysed for physiochemical properties (Appendix A).

3.2 Land Preparation

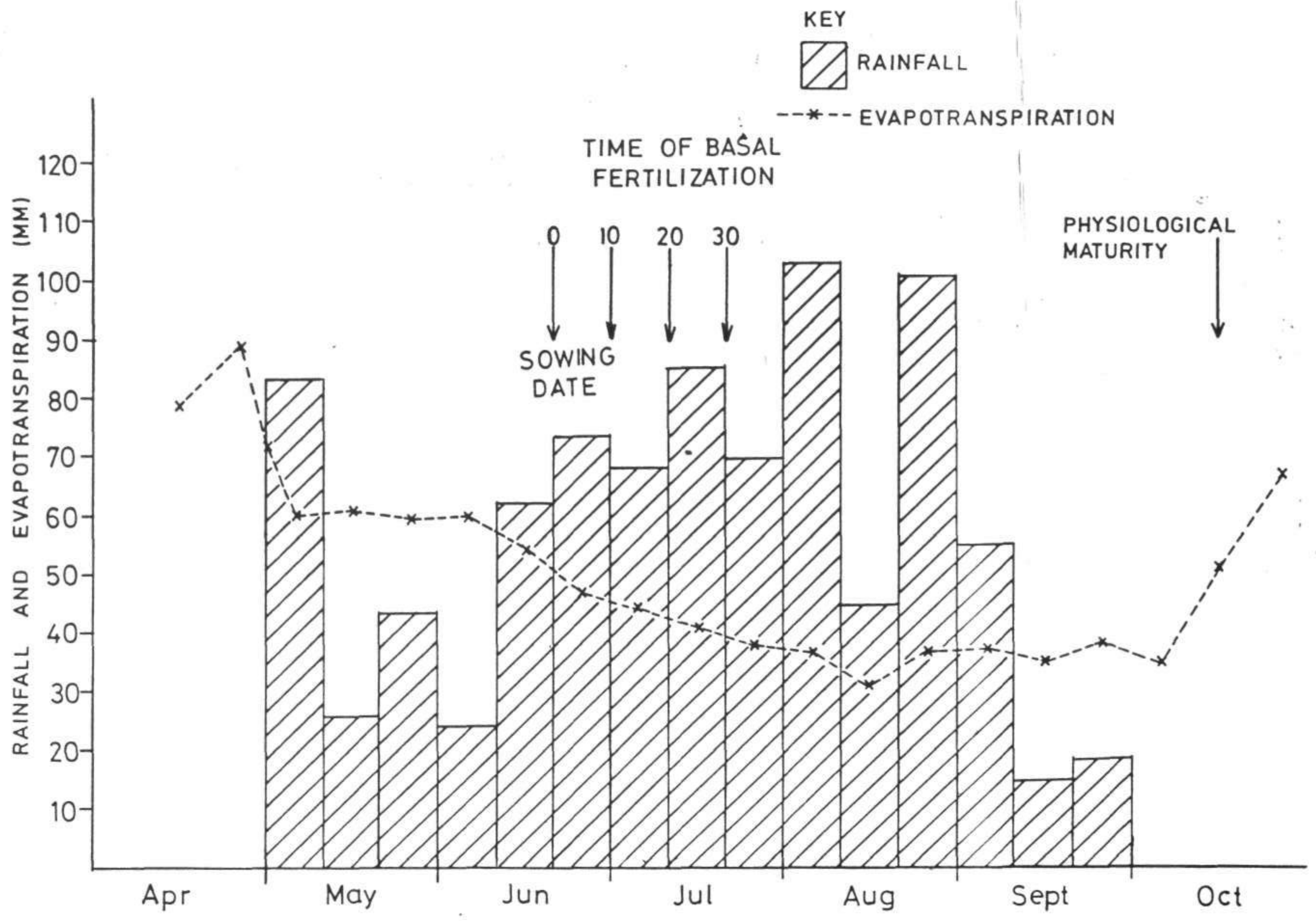
The land was disc ploughed, harrowed to a fine tilth and ridged at .9m spacing.

3.3 Experimental Design and Plot Size

The experiment was laid out in a randomised complete block design (RCBD) with four replications. Each gross plot measured 6 x 5m in length and breath, respectively giving a land area of $30m^2$ per plot. Distance between replicates and within plots was 1m. The net plot harvested measured 5x2.7m in length and breath, respectively. This gives a net plot of $13.5m^2$.

3.4 Experimental Treatment

The treatments comprised of two maize cultivars (TZBSR-W and TZESR-W) and four times of basal fertilizer application (0, 10, 20 and 30 days after sowing) in



MEAN TEN DAY RAINFALL AND EVAPOTRANSPIRATION (mm) (SAMARU 1990 WET SEASON

3.4.1 Decription of test cultivar

The cultivar TZBSR-W is a tall cultivar (2.4-2.5m). It is resistant to streak virus and late maturing (120 days). The kernels are white in colour (Annonymous, 1975).

TZESR-W is short statured (2.0 - 2.20m). It is resistant to streak virus and early maturing. The kernels are white (Anonymous, 1982).

3.5 Stand Establishment

The seeds were dressed with aldrex T at the rate of 10g per 3kg of seeds for protection against soil borne disease causing organisms. Sowing was done on 20 June, 1990 with two seeds of maize planted at .2m within row and later thinned to one plant per stand giving a plant population of 55,556 plants per hectare.

3.6 Fertilizer Application

Nitrogen, phosphorous and Potassium were applied as calcium ammonium nitrate (CAN), Single superphosphate (18.5% P_2O_5) and muriate of potash (Kcl 60% K_2O) at the rate of 120kg N/ha, 262kg P /ha and 50kg K /ha, respectively. Application was by band placement with half the requirement at the various times (0, 10, 20 and 30 days). The remaining half was side dressed 30 days after planting irrespective of the time of basal fertilizer application. i.e at 30 days after planting, a full dose was applied to crops whose basal fertilizer was delayed up to 30 days.

3.7 Weed Control

Three hoeweedings were done - 30 days after planting (20 July, 1990), 47 days (6 August, 1990) and 78 days after planting (5 September, 1990). No herbicide was used in this study.

3.8 Data Collection

3.8.1 Plant height

Five plants were randomly picked. These were measured from the ground level to the tip of the last leaf or tassel and averaged. This was done at 30, 60, 90 and 120 days after planting.

3.8.2 Plant dry matter

The five plants used for height determination above were used for dry matter determination. The samples were oven dried until they attained a constant weight. This was done at 30, 60, 90 and 120 days.

3.8.3 Leaf area index (LAI)

Leaf area determination was done at silking. The product of length and breath of each leaf was multiplied by a factor of 0.75 (Duncan and Hasketh, 1968). To find the LAI, the leaf area for one plant was multiplied by the number of plants in a square metre and divided by the land area ($1m^2$).

3.8.4 Ear height

Ear height was measured from five plants per plot. This was measured from the ground level to the node at which the topmost ear was attached. These plants were tagged and subsequently used for ear diameter, cob diameter, cob length and kernel depth determination.

3.8.5 Lodging percent count

Lodged plants for each plot were counted prior to harvest. A plant was considered as rootly lodged if the angle between the stem and the ground level was less than 45^{o}. If the stem was broken below the ear, it was regarded as having exhibited stem lodging.

3.8.6 Number of ears per plot

Total number of ears from each plot were counted after dehusking.

3.8.7 Ear diameter

Total diameter of five ears from each plot were measured to the nearest 0.5cm. The average of these was recorded.

3.8.8 Kernel depth

This was obtained by subtracting the cob diameter of shelled ear from unshelled ear diameter obtained above.

3.8.9 Cob length

The length of each of the five cobs used above was measured. These were added and the average recorded.

3.8.10 Shelling percentage

Shelling percentage was obtained by dividing the weight of the shelled grains by the weight of ears (unshelled) and multiplying by a hundred.

3.8.11 Thousand grain weight

One thousand grains were taken from each plot and weighed by means of a sensitive balance.

3.8.12 Grain yield

Shelled grains from plots were weighed by means of a sensitive balance and converted to per hectare basis.

3.9 Data Analysis

The data was analysed as described by Snedecor and Cochran (1967). Interactions were determined for the observed parameters. Significance of mean differences were determined using least significant difference (LSD). Simple correlation analysis was done for some variables on varietal basis to test their strength of association.

CHAPTER 4

RESULTS

4.1 Grain Yield

Grain yield was significantly influenced by time of basal fertilizer application. Crops basally fertilized at 0, 10 and 20 days after planting showed no significant difference in grain yield. However, crops which received basal fertilizer at 30 days showed significant reductions in grain yield (Table 1). The cultivar TZBSR-W produced higher grain yield than TZESR-W irrespective of time of basal fertilization.

The interaction between time of basal fertilizer application and variety on grain yield was significant. The cultivar TZBSR- when basally fertilized at 30 days after planting produced significantly lower grain yield than for earlier applications (0, 10 and 20 days) whose yields were at par.

For TZESR-W there was no significant difference in grain yield of crops basally fertilized at the different times 0, 10, 20 and 30 days (Table 2).

4.2 Grain Weight

Effect of time of fertilizer application on thousand grain weight was not significant. The grains of TZBSR-W weighed heavier than those of TZESR-W (Table 1).

4.3 Shelling Percentage

Shelling percentage was not significant for crops basally fertilized at 0, 10 and 20 days after planting. Delaying basal fertilization to 30 days significantly reduced shelling percentage. The cv TZBSR-W showed a higher shelling

Table 1: Effect of time of basal fertilizer application to maize cultivars TZBSR-W and TZESR-W on grain yield, 1,000 grain weight and shelling percentage.

Treatment	Grain yield (kg/ha)	Thousand grain weight (gm)	Shelling percentage (%)
Time of basal fertilizer application (T)			
0	4227a	270.0	88.3a
10	4177a	262.00	87.9a
20	4236a	275.00	89.0a
30	3786b	274.00	75.20b
SE ±	81.6	4.6	3.26
LSD (5%)	239.97	NS	12.20
Variety (V)			
TZBSR-W	4586a	277.0a	87.20a
TZESR-W	3627b	263.0b	76.54b
SE ±	57.7	3.3	1.26
LSD (5%)	169.69	9.7	10.46
Interaction			
TXV	*	NS	NS

NS = Not significant
* = Significant at 5% level of probability
** = Significant at 1% level of probability.

Means followed by the same letter(s) within a column are not statistically significant at 5% level of probability.

Table 2: Interaction of time of basal fertilizer application and variety on grain yield of two maize cv TZBSR-W and TZESR-W .

Variety	Time of fertilizer application (days)			
	0	10	20	30
TZBSR-W	4806a	4787a	4805a	3998b
TZESR-W	3649c	3655c	3667bc	3574c
SE ±	115.4			
LSD	339.4			

Means followed by similar letter(s) in row and column are not significantly different at 5% level of probability

4.4 Ear Diameter

Time of basal fertilizer application did not have any significant influence on ear diameter. Neither the difference between varieties nor the interaction between time of fertilizer application and variety was significant (Table 3).

4.5 Kernel Depth

The result obtained showed that kernel depth was not significantly influenced by time of basal fertilizer application. The varieties, however, differ significantly with TZBSR-W having more deeply inserted kernels than TZESR-W (Table 3).

4.6 Cob Length

Results of analysis showed that time of basal fertilizer application had no effect on cob length. No signficant difference in cob length was noticed between the two cultivars. (Table 3). However, Significant interaction was found between variety and time of basal fertilizer application (Table 4). Applying basal fertilizer to the cultivar TZBSR-W at 20 days resulted in significantly longer cobs than for crops fertilized at 0, 10 and 30 days. Cob length of TZESR-W was not significantly affected by time of basal fertilizer application.

4.7 Number of cobs per plot

The result showed no significant difference in number of ears with different time of basal fertilizer application. The two cultivars showed no significant difference in number of cobs per plot. Time of fertilizer application and variety interaction was not significant (Table 3)

Table 3: Effect of time of basal fertilizer application to two maize cultivars TZBSR-W and TZESR-W on Ear diameter, kernel depth, cob length and Number of cobs

Treatment	Ear diameter (cm)	Kernel depth (cm)	Cob length (cm)	Number of cobs
Time of basal fertilizer application				
0	4.39	1.27	16.20	62.50
10	4.44	1.18	15.68	63.40
20	4.39	1.12	16.10	65.90
30	4.35	1.11	15.40	66.60
SE ±	0.07	0.05	0.32	1.53
LSD (5%)	NS	NS	NS	NS
Variety (V)				
TZBSR-W	4.65a	1.26a	16.0	63.60
TZESR-W	4.21b	1.08b	15.6	64.90
SE ±	0.05	0.04	0.23	1.08
LSD (5%)	0.14	0.01	NS	NS
Interaction				
TXV	NS	NS	*	NS

NS = Not significant
* = Significant at 5% level of probability.
** = Significant at 1% level of probability.

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability.

Table 4: Interaction of time of basal fertilizer application and variety on cob length of maize cultivars TZBSR-W and TZESR-W

Variety	Time of fertilizer application (days)			
	0	10	20	30
TZBSR-W	15.80b	15.40b	17.20a	15.70b
TZESR-W	16.50ab	15.80b	15.0b	15.10b
SE ±	0.45			
LSD	1.33			

Means followed by the same letter(s) in row and column are not significantly different at 5% level of probability.

4.8 Plant Height

Plant height was significantly affected by time of basal fertilizer application (Table 5). At 30 days after planting crops basally fertilized at 10 and 20 days were at par but were significantly shorter than crops basally fertilized at planting. A further significant decrease in height was observed for crops which received basal fertilizer at 30 days. Observation at 60 days after planting showed no significant difference in height for crops basally fertilized at 0 and 10 days. Plants basally fertilized at 20 and 30 days, however, showed a significant reduction in height. Results at 90 days showed that height of plants basally fertilized at 0, 10 and 20 days were at par but were significantly taller than crops which received basal fertilizer at 30 days. At 120 days, heights of crops basally fertilized at 0 and 10 days were at par, so also were those fertilized at 10 and 20 days. Plants to which fertilizer was applied at 0, 10 and 20 days were significantly taller than those fertilized at 30 days.

At 30 and 60 days, time of basal fertilization showed no effect on variety but at 90 and 120 days, the cultivar TZBSR-W was taller than TZESR-W.

Table 5: Effect of time of basal fertilizer application to two maize cultivars TZBSR-W and TZESR-W on plant height(cm) at 30, 60, 90 and 120 days after planting

Treatment	Days after planting			
	30	60	90	120
Time of fertilizer application				
0	51.14a	215.10a	235.38a	252.77a
10	41.68b	214.0a	232.0a	250.3ab
20	37.04b	190.40b	232.1a	243.3b
30	29.66c	169.2c	223.3b	232.78c
SE ±	1.97	6 .46	3.78	3.12
LSD (5%)	5.80	19.01	11.13	9.17
Variety (V)				
TZBSR-W	39.79	196.46	244.1a	258.2a
TZESR-W	39.79	197.89	218.3b	231.4b
SE ±	1.39	4.57	2.67	2. 21
LSD (5%)	NS	NS	7.86	6.49
Interaction				
TXV	NS	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability.

4.9 Total Dry Mattor

Plant dry matter was significantly influenced by time af basal fertilizer application (Table 6). Results at 30 days showed that dry matter yield of crops basally fertilized at 0 and 10 days were not significantly different, while crops fertilized at 20 and 30 days progressively showed a significant reduction in dry matter yield. At 60, 90 and 120 days, dry matter yield of crops basally fertilized at 0, 10 and 20 days were statistically at par, but were all significantly higher than for crops fertilized at 30 days after planting. The cultivar TZBSR-W produced higher dry matter yield than TZESR-W at 60 and 120 days. No interaction was observed between time of basal fertilizer application and variety.

4.10 Stem and Root Lodging

The results obtained from this investigation showed that neither time of basal fertilizer application nor variety had any significant influence on stem lodging. No significant interaction was observed between time of fertilizer application and variety for stem lodging (Table 7)

Time of basal fertilizer application was observed to significantly influenced root lodging (Table 7). Delaying basal fertilizer to crops up to 30 days significantly increased root lodging compared to earlier applications 0, 10 and 20 days which were at par. Root lodging was observed to be higher for the cultivar TZESR-W than TZBSR-W. Interaction between time of fertilizer application and variety was not significant for root lodging.

Table 6: Effect of time of basal fertilizer application to two maize cultivars TZBSR-W and TZESR-W on total plant dry matter at 30, 60, 90 and 120 days (gm/plant)

Treatment	Days after planting			
	30	60	90	120
Time of fertilizer application (T)				
0	7.48a	109.7a	266.6a	295.81a
10	6.24a	109.3a	274.9a	297.5a
20	3.28b	95.01a	263.7a	285.0a
30	1.86c	90.27b	241.5b	255.9b
SE ±	0.43	6.74	6.66	4.17
LSD (5%)	1.27	19.41	19.59	12.27
Variety (V)				
TZBSR-W	4.64	114.83a	265.65	298.9a
TZESR-W	4.79	87.72b	253.71	268.7b
SE ±	0.31	4.77	41.71	2.95
LSD	NS	14.02	NS	8.67
Interaction				
TXV	NS	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability.

Table 7: Effect of time of basal fertilizer application to **maize cultivars** TZBSR-W and TZESR-W on stem and root lodging, leaf area index and ear height

Treatment	Stem lodging (%)	Root lodging (%)	Leaf area Index (LAI)	Ear height (cm)
Time of fertilizer application				
0	30.35	8.05b	5.05a	103.8a
10	31.32	7.50b	4.72a	96.8ab
20	30.16	9.16b	5.39a	92.9b
30	29.44	19.77a	3.53b	92.7b
SE ±	3.35	3.87	0.41	3.55
LSD (5%)	NS	8.85	1.20	7.98
Variety (V)				
TZBSR-W	32.72	9.19b	5.06	109.52a
TZESR-W	27.92	16.55a	4.29	80.94b
SE ±	2.37	2.74	0.29	2.53
LSD (5%)	NS	5.69	NS	5.86
Interaction				
TXV	NS	NS	NS	NS

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability.

4.11 Leaf Area Index (LAI)

Basal fertilizer time of application was found to significantly influence leaf area index. Leaf area index of crops basally fertilized at 30 days was significantly lower than for crops fertilized at 0, 10 and 20 days whose LAI were statistically at par.

4.12 Ear Height

Time of basal fertilizer application significantly influenced ear height. The ear height of crops basally fertilized at planting was significantly higher than for crops fertilized at 10, 20 and 30 days whose ear height were statistically at par. (Table 7). The cultivar TZBSR-W had significantly higher ear heights. No significant interaction was observed between time of fertilizer application and variety.

4.13 Correlation Among Plant Characters

Grain yield of the cultivar TZESR-W was positively correlated with shelling percentage ($r=.909^{**}$), thousand grain weight($r=.91^{**}$), dry matter at 90 days ($r=.531^{**}$) and at 120 days ($r=.353^{**}$) (Table 8). For the cultivar TZBSR-W, grain yield was positively correlated with shelling percentage ($r=.935^{**}$), thousand grain weight ($r=.45^{*}$), plant height at 120 days ($r=.545^{**}$), Total dry matter at 120 days ($r=.637^{**}$) and leaf area index ($r=.477^{**}$) Table 9).

Table 8: Correlation matrix for TZESR-W plant characters

	GY	SP	GW	ED	KD	CL	PH9	PH12	TDM9	TDM12	LAI
GY	1										
SP	.909**	1									
GW	. 91*	.962**	1								
ED	.207	.241	.073	1							
KD	-.062	.041	-.229	.821**	1						
CL	.073	.015	.286	-.073	-.171	1					
PH9	-.057	-.056	-.456**	.195	.099	.179	1				
PH12	.165	-.017	-.277	.558**	.343	.333	.66**	1			
TDM9	.531	. 41	-.039	.618**	.414*	.107	.264	.675**	1		
TDM12	.353	.177	-.128	.465**	.317	.203	.143	.622**	.854**	1	
LAI	-.073	.082	-.234	.266	.077	-.234	.043	.121	.347	.308	1

GY = Grain yield (kg/ha)
SP = Shelling percentage (%)
GW = Thousand grain weight(gm)
ED = Ear diameter (cm)
KD = Kernel depth (cm)
CL = Cob length (cm)
PH9 = Plant height at 90 days
PH12 = Plant height at 120 days
TDM 9 = Total dry matter at 90 days
TDM 12 = Total dry matter at 9 days
LAI = Leaf Area Index

* Significant at 5%

** Significant at 1%

r = .349 and .449 at 5% and 1%, respectively.

Table 9: Correlation matrix for TZBSR-W plant characters

	GY	SP	GW	ED	KD	CL	PH9	PH12	TDM9	TDM12	LAI
GY	1										
SP	.935**	1									
GW	.45*	.212	1								
ED	.104	.006	.234	1							
KD	.027	. 06	.155	.954**	1						
CL	. 18	.273	.484**	.128	. 11	1					
PH9	.165	.175	.105	.287	.356*	-.029	1				
PH12	.545**	.512**	. 87**	. 36	.412*	-.212	.721**	1			
TDM9	. 38	.295	.007	-.043	.047	-.138	.124	.394*	1		
TDM12	.637**	.539**	.266	.173	.209	.042	-.088	.293	.275	1	
LAI	.477**	.469**	.208	.124	.045	-.135	.424*	.621**	-.074	.136	1

GY = Grain yield (kg)
SP = Shelling percentage (%)
GW = Thousand grain weight (gm)
ED = Ear diameter (cm)
KD = Kernel depth (cm)
CL = Cob length (cm)
PH9 = Plant height at 90 days (cm)
PH12 = Plant height at 120 days
TDM9 = Total dry matter at 90 days
TDM12 = Total dry matter at 120 days
LAI = Leaf area Index
* = Significant at 5%
** = Significant at 1%
r = .349 and .449 at 5 and 1%, respectively.

DISCUSSION

5.1 GRAIN YIELD

The results obtained revealed that delaying basal fertilizer application up to 30 days has no significant influence on the grain yield of TZESR-W. For TZBSR-W, however delaying basal fertilizer application up to 30 days significantly reduced grain yield.

The lack of response by TZESR-W could be attributed to its low yielding potential. Because it is low yielding, its nutrient requirement was not as high compared to TZBSR-W, therefore delayed application of basal fertilizer up to 30 days had no significant effect on its yield performance. TZBSR-W which is higher yielding however responded significantly to delayed basal fertilizer application at 30 days. Because of its high yielding potential it requires more nutrients to be able to sustain its growth. The soils nutrient reserve could not sustain this cultivar up to 30 days before the basal fertilizer application because of its high nutrient demand.

The result indicates that crops of TZBSR-W basally fertilized at 30 days could not utilize the nutrients applied at that time to overcome the early deficiency. This result corroborates the findings of stanley and Rhoads (1976) who obtained decreased grain yield when NPK fertilization was delayed up to six weeks after planting. Earlier applications at 0, 10 and 20 days resulted in high grain yields. A similar result was reported by Daubin (1978) who obtained high grain yield with NPK fertilization at Planting.

The 9.6% grain yield difference of TZBSR-W over TZESR-W could be attributed to dirrerence in shelling percentage. TZBSR-W had a 10% difference in shelling percentage over TZESR-W and this was considered significant enough to have contributed to the higher grain yield of the cultivar.

The long vegetative phase of TZBSR-W gives it a comparative advantage over TZESR-W with regards to assimulate production and grain filling. At 90 days, the cultivar TZESR-W had already matured because of its early maturing cycle. Because of the short maturity period, it has a shorter vegetative phase. As a result of the short vegetative phase, dry matter production has been reasonably reduced, therefore the period between 90 and 120 days recorded very little increase in dry matter production. TZBSR-W because of its long vegetative phase was still photosynthetically efficient and was thus producing reasonable amount of photosynthate between 90 and 120 days. Since in the corn plant, about 80% of the assimilate produced after ear formation is directed to the ear to effect grain filling, it is then evident that all the dry matter produced by TZBSR-W between 90 and 120 days was directed towards grain filling. This increased photosynthate production and subsequent grain filling is expected to be responsibe for the higher grain yield of TZBSR-W compared to TZESR-W. Goldsworthy (1969) and sayfikar (1980) found the later maturing variety to produce higher than the early maturing one and attributed this to its longer vegetative phase compared to the early maturing variety.

5.2 OTHER PLANT CHARACTERS

Shelling percentage showed a similar trend of decrease with grain yield. Crops basally fertilized at 30 days had the least shelling percentage. This was expected since shelling percentage is dependent on grain yield. The 10% difference in shelling percent of TZBSR-W over TZESR-W is considered as one of the factors responsible for their yield differences. Difference in grain weight between cultivars could be attributed to differences in dry matter accummulation with grains of TZBSR-W weighing heavier than those of TZESR-W, the early maturing cultivar.

Differences obtained in plant height for the different times of basal fertilizer application was expected since delaying fertilizer application will result in nutrient deficiency for that period of absence which will consequently reduce growth. Gruneberg (1959), Annonymous (1970) and Epstein (1972) identified stunted growth as one of the deficiency symptoms of N and P. Crops basally fertilized at plnating were taller because early application of fertilizer, particularly N stimulates vigorous vegetative growth. Leonard (1983) observed early application of P to be necessary as it stimulates early root enlargement. Early root enlargement will enhance efficiency of nutrient uptake at an early stage.

Plant dry matter determined at 30 days after planting showed crops basally fertilized at 20 days to have produced significantly lower dry matter than crops basally fertilized at 0 and 10 days which were at par and significantly higher dry matter than crops basally fertilized at 30 days. The result for crops basally fertilized at 30 days was expected to be low since plants sampled at that time never received any basal fertilizer and had been sustained only on the soil's reserve which was low. Subsequent sampling at 60 days showed that crops basally fertilized at 20 days recovered from the early nutrient deficiency as they produced a dry matter yield which was at par with earlier applications - 0 and 10 days. This vigour was maintained through 90 days to maturity. The significantly lower dry matter yield produced by crops basally fertilized at 30 days from sampling at 30 days to maturity indicated their inability to recover from the early nutrient deficiency. This deficiency retarded growth and dry matter production with consequent low grain yield. The result corrobartes the report of Johnson (1972) who reported that the corn plant if starved of nutrients at any developmental stage will result in reduction of final grain yield and that an adequate supply of nutrients at a later stage will often not overcome the early deficiency. The study therefore reveals that it is important that fertilizers are applied to crops at certain stages of development.

The longer vegetative phase of TZBSR-W could be implicated for the difference in dry matter yield of the cultivars. Since it had a longer vegetative phase, it accummulated more dry matter than TZESR-W. This result corroborates the findings of Goldsworthy (1969).

The great plant height developed between 30 and 60 days indicates a development for efficient light interception and consequent assimilate production, while the increased dry matter production between 60 and 90 days showed a readiness for effective grain filling.

Since ear height is dependent on plant height, the results obtained for ear height was expected. Crops basally fertilized at 30 days showed significantly lower ear height. Plant height decreased in like manner.

The fertilizer element K could be implicated for the results obtained for root lodging. The soil's K status of 0.09 Meg/100 g of soil was low. Considering the ease with which K is lost through leaching, this reserve would have been inadequate to meet the crops requirement before the basal application at 30 days. Gruneberg (1959) showed K deficiency to be responsible for poor brace root development and Ologunde (1974) found that K deficiency hastens the breakdown of parenchyma both in roots and stems resulting in lodging. The ratio of N and P to K (NP:K) could have influenced lodging. The result of the soil test showed N and P particularly P to be higher compared to K, N and P applied at the rates of 120 kg N/ha and 26.2 kg P/ha compared to K applied at 50 kg k /ha. The excess of N and P over K might have enhanced lodging and thus could be partly responsible for the results obtained for root lodging in this study. Krantz and chandler (1951) and liebhardt and Murdock (1965) obtained similar results and reported that N and P influenced lodging especially when their ratios were increased at low levels of K.

Considering the root-stalk ratio of the two cultivars, TZBSR-W was expected to lodge more since it was taller and bigger sizewise compared to TZESR-W and thus expected to be more susceptible to any windstorm. The results obtained from this study, however, showed TZESR-W to have lodged more. Chobe (1987) obtained a similar result. Krantz and chandler (1951) and Liebhardt and Nurdock (1965) reported varietal differences as important in causing lodging. Lodging has a negative effect on crop performance. When crops are lodged, they are shaded by standing crops. Their ability to intercept and utilize incident radient energy is reduced. This results in reduced photosynthetic efficiency hence reduced assimilate production with consequent yield reduction.

Photosynthesis and dry matter production are dependent on and are usually limited by the efficiency with which the foliage of a crop intercepts and utilizes solar radiation. The varying degree of efficiency with which plant canopies intercept light is associated with the leaf area index aspect of their leaves. The least leaf area index obtained in this study was 3.53 from crops basally fertilized at 30 days. This was considered adequate for effective light intercepttion. The result conforms with the findings of Loomis et at (1968) who obtained matured maize canopies from leaf area index of 3.5-8.5 with planting densities from 17,000-125,000 plants per hectare. Evans (1975) reported similar observations Donald (1968) cited maize as close to ideal as a plant for building efficient canopies.

5.3 Correlation among plant characters.

Grain yield of the cultivar TZBSR-W was positively and significantly correlated with shelling percentage, thousand grain weight, plant height at physiologic maturity and leaf area index. For the cultivar TZESR-W, grain yield was positively and significantly correlated with shelling percentage, thousand grain weight, cob length and plant dry matter at 90 days. This reveal these characters as important grain yield determinants, indicating that an increase in each of these variables will lead to increase in grain yield. Amoruwa (1985) obtained positive and significant correlation between grain yield and shelling percentage and thousand grain weight. Chobe (1987) obtained significant correlation between grain yield and hundred grain weight. They concluded that an increase in any of these variables will result in increased grain yield.

CHAPTER 6

SUMMARY AND CONCLUSION

A field experiment was conducted on the farm of the Institute for Agricultural Research Samaru during the 1990 wet season to investigate the effect of time of basal fertilizer application on the yield and yield components of two maize cultivars - TZBSR-W and TZESR-W. The experiment was laid out in a randomised complete block design (RCBD) with eight treatments - two maize cultivars and four times of basal fertilizer application (0, 10, 20 and 30 days after planting) and replicated four times. Fertilizers used were calcuim ammonium nitrate, single superphosphate and muriate of potash as sources of N,P and K, respectively and applied at the rates of 120kg N/ha, 26.2kg P /ha and 50kg K /ha.

Time of basal fertilization significantly influenced grain yield with crops basally fertilized at 30 days recording significantly lower grain yields, compared to earlier applications. Plant dry matter was significantly influenced by basal fertilizer timing with crops basally fertilized at 30 days recording significantly lower dry matter yield. Plant height, root lodging and LAI were significantly influenced by time of basal fertilizer application. Thousand grain weight, ear diameter, kernel depth, cob length, number of ears per plot, stem lodging were not significantly influenced by time of basal fertilizer application. Interaction between time of fertilizer application and variety was significant for cob length and grain yield. TZBSR-W had longer cobs and produced higher grain yield than TZESR-W.

From the results obtained and discussed above, it could be said that:

1. for the cultivar TZBSR-W, Basal fertilizer application should not be delayed beyond 20 days after planting, since after 20 days significant yield reductions results. But for TZESR-W, however basal fertilization can still be delayed to 30 days after planting with no resultant significant yield reductions.

2. To obtain high grain yields, the cultivar TZBSR-W could be a better choice where rainfall duration is not a limiting factor to crop production.

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APPENDIX A: PHYSICOCHEMICAL PROPERTIES OF SOIL FROM EXPERIMENT SITE (0-30 CM)

PHYSICAL PROPERTIES

SOIL PARAMETERS	SOIL TEXTURAL VALUES
Particle size(%)	
Sand	56
Silt	36
Clay	8
Soil textural class	Sandy Loam

CHEMICAL PROPERTIES

Soil P^H (H_2O)	5.3
Soil P^H (0.01MCaCl$_2$)	4.7
Organic Carbon (%)	0.58
Total nitrogen (%)	0.03
Available Phosphorous (PPM)	14. 1

EXCHANGEABLE BASES Meq/100 g OF SOIL

SODIUM (Na)	0.30
Potassium (K)	0.09
Calcium (Ca)	1.34
Magnesium (Mg)	0.31
Cation exchange capacity (CEC) (Meq/100 g of soil)	12.28

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1. L.E.A. Primary School Kerang	1971	1977	First School Leaving Cert.
2. Boys& Secondary School Gindiri, Plateau State	1978	1983	G.C.E. O'level.
3. School of Basic Studies (A.B.U., Zaria)	1984	1985	I.J.M.E.
4. Ahmadu Bello University, Zaria.	1985	1988	B.Sc. (Botany)

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Organization	From	To	Position
Directorate for food, Roads and Rural Infrastructures (DFRRI) Gusau Local Government, Sokoto State	1988	1989	Chairman, Project monitoring and Evaluation Committee (NYSC).

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