MAIZE PRODUCTION IN THE COASTAL SAVANNA ZONE OF GHANA

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PETER LEYENAAR

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ABSTRACT

MAIZE PRODUCTION IN THE COASTAL SAVANNA ZONE OF GHANA

Peter Leyenaar, M.Sc.
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Supervisor:
Dr. R.B. Hunter

Three field experiments were conducted on maize (*Zea mays* L.) at the Legon farm in the coastal savanna zone of Ghana during the major and minor seasons in 1975. Several factors affecting maize production were examined. Factors studied included planting date, cultivar, irrigation, side-dressing nitrogen, seed bed preparation and insect damage.

During the major season, substantially greater yields were obtained by growing an improved cultivar of maize and planting as soon as possible after rains started. These two factors require little capital expenditure by the Ghanaian farmer.

In the minor season, greater yields were obtained through irrigation, stem-borer control with Furadan and planting an improved cultivar. In this study, maize production in the minor season was not practical without the use of irrigation. The capital cost of irrigation would be too great for the average farmer and might not be economically feasible. If an irrigation scheme is developed in this region, the use of an insecticide and an improved cultivar would be warranted.

Greater yields were obtained in the minor season with an insecticide, irrigation and an improved cultivar than during the major season. This may reflect the higher level of incoming solar radiation available for photosynthesis during the minor season.

The use of furrow or ridge seed beds did not result in greater yields than growing maize in a flat seed bed. Applying nitrogen as a side-dressing after a liberal fertilizer application of planting did not increase yields.

ACKNOWLEDGEMENTS

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GENERAL INTRODUCTION

Maize (*Zea mays* L.) is the most important cereal crop in Ghana. The production per ha is difficult to assess, as most farmers intercrop maize with other crops. It is estimated however, that yields are approximately 800 - 1,000 kg per ha (FAO, 1974; Ghana Info. Services, 1975), which is relatively low compared to potential yields.

The "Ready Reference Handbook on Crop Production in Ghana" (1971) recommends that maize be grown in the rain-forest region. A number of workers in Nigeria suggest that the highest potential for intensive production of maize in West Africa is in the savanna areas (Kassam *et al*., 1975). They suggest that in the savanna zone there is a reduction in incidence of pests and diseases, higher efficiency of fertilizer use, greater ease of grain drying, more reliable rainfall and a lower cost of production than in the forest zone. It is possible that the coastal savanna zone of Ghana is suitable for intensive maize production. Studies undertaken in this region indicate maize can be grown (Haizel, 1966; Doku, 1969).

Chinwuba (1965) lists several production practices that are important for high yielding maize production in West Africa. These include the following: using a high yielding cultivar adapted to the area of production, fertilizer utilization to meet the plant requirements, having an optimum plant population and good timing of production operations such as planting, fertilizing and controlling diseases and insects.

In order to examine factors which affect maize production in the coastal savanna zone of Ghana, several separate experiments were conducted in both the major and minor seasons in 1975. Factors studied include the following: planting season, planting date, supplemental irrigation, presence or absence of side-dressed nitrogen, cultivar, type of seed bed preparation and insect control. The results of these studies are presented as three separate units.

LITERATURE REVIEW

Maize ranks as the third cereal crop after wheat and rice in the world. One of the advantages of maize is its adaptability to a wide range of climatical conditions (Berger, 1962). As a result, it is grown in temperate, sub-tropical and tropical areas. Yields are highest, however, in countries in the temperate zones (FAO, 1974).

Maize yields are affected to a large extent by the physical environment in which the crop is grown (Evans, 1963). Williams and Joseph (1970) listed light, atmosphere, root environment and temperature as the major environmental factors which influence crop growth. Genotype is another important factor affecting growth and yield. Weeds, diseases and pests are also factors in maize production. Many management factors, such as planting date, use of irrigation, fertilizers, improved cultivars, seed bed preparation and use of weed, insect and pest controls affect maize yields. It is important to develop practices which take these factors for a specific area in which maize is being grown into consideration.

In the coastal savanna zone of Ghana, total rainfall per year averages 750 to 1,000 mm with two seasonal peaks of rainfall each year (Gbeckor-Kove, 1965). Most rainfall occurs during late March to mid-July and a lesser amount falls during September until early November, forming the major and minor seasons, respectively. This area of West Africa is considered to be part of the humid tropics, with relative humidity being on the average over 80 per cent for each month in the year (Ghana Meteorological Services, unpublished data). In general, high humidity reduces maximum temperatures and also reduces incoming solar radiation (Tempany & Grist, 1958; Williams & Joseph, 1970). Haizel (1966) suggested that maize could be grown successfully in this area in the major season only two out of every three years because of limiting rainfall. Maize production in the minor season is severely restricted in most years by lack of moisture.

The effect of planting date on yield of maize grown in the tropics is known to result in large yield differences (Goldson, 1963; Akehurst & Streedhar, 1956; De Geus, 1970; Koli, 1970; Shah & Sharma, 1970; Lal, 1973). A review of research on this factor indicates that the favourable effect of planting early generally was caused by moisture availability to the plants. After the rains commence following the dry season, prompt planting is important. Because rainfall amount and distribution is highly variable among years, it is not possible to suggest specific dates of planting. Rather, one needs to examine long range averages for rainfall in a specific area and to use them as a guide to planting time. In addition to benefiting from available moisture, early planted maize tends to escape heavy insect infestations which result in yield losses (Shah, 1972). Another factor which can cause yield reductions is low incoming solar radiation. (De Wit, 1959; Monteith, 1965; Wrigley, 1969; Duncan, Shaver & Williams, 1973). Planting early in the major season, or during periods of high insolation might result in more plant photosynthesis and greater yields.

Koli (1970) suggested that maize should be planted in the second to third week of April in the coastal savanna zone of Ghana. During the minor season, a planting date effect would be less important as irrigation is necessary for consistent production of maize.

Moisture availability for plants is important for growth and good yields. The seed germinates and emerges much more rapidly with adequate available moisture (Davis & Porter, 1935; Doneen & MacGillivray, 1943;

Delouche, 1953). Lal (1973) has shown that low soil moisture and high soil temperatures were both responsible in reducing per cent emergence of tropical maize. Moisture stress at various stages of maize growth has varying effects on maize yields (Robins & Domingo, 1953; Denmead & Shaw, 1970). Moisture stress at the time of tasseling caused greater yield reductions than at other times during plant development and wilting for six days at tasseling reduced yields up to 50 per cent (Robins & Domingo, 1953). Slatyer (1973) has reviewed the effect of internal water status on the development and yield of plants.

Irrigation is a possible solution to overcoming water deficits (Tempany & Grist, 1958; Masefield, 1962; Ruthenberg, 1971; Manshard, 1974). However, it is often not feasible or practical because of the cost of storing and pumping large volumes of water (Williams & Joseph, 1970). Also, the market value of maize is generally too low to warrant its irrigation rather than that of other more valuable crops (Wrigley, 1969). Careful management is required with irrigation. It has been shown from work in Nyasaland that maize water requirements are not constant (Munro & Wood, 1964). The crop water requirements were the greatest at the time of tassel emergence. Over-irrigation can deprive plant root of oxygen (Gingrich & Russell, 1956; Grist, 1957) and can cause dilution of soil nutrients (Williams & Joseph, 1970). Soil that is repeatedly irrigated tends to accumulate salts which result in a salinity problem (Masefield, 1962).

With the use of irrigation, it is important to use fertilizers and improved cultivars of maize to obtain maximum yield response. Fertilizer use is important in maintaining soil nutrients at a high level and allowing good crop productivity (Sayre, 1948; Tempany & Grist, 1958; Berger, 1962; FAO, 1965; Barber & Olson, 1968; Wrigley, 1969). Soil structure and climate strongly influence the nutrient holding capacity of soils. Also, soil management and cultural practices such as fallowing affect the fertility of soils (Clarke, 1962).

Nitrogen is the most commonly needed element for maize production (Sayre, 1948; Tempany & Grist, 1958; Webster & Wilson, 1969; De Geus, 1970). It is chiefly responsible for vegetative growth (Sayre, 1948, De Geus, 1970). Split applications of nitrogen rather than one application reduce leaching losses and consequently increase grain yield (Nair & Singh, 1974). The type of soil and the amount of rainfall are important factors in determining the amount of soil nutrients which are lost by leaching.

Much research work has been conducted to improve maize cultivars. Many new cultivars have been developed at the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, Mexico) and at other plant breeding institutes (CIMMYT, 1974; IITA, 1947; Crops Res. Inst. 1974). Substantial yield increases are possible with improved cultivars. In Ghana, for example, CIMMYT cultivars resistant to certain diseases have been crossed with local maize to produce cultivars adapted to Ghanaian conditions (Doku, 1969). A number of new cultivars, such as La Posta and Composite 4, recently have been developed by the Crops Research Institute in central Ghana (Crops Res. Inst., 1974).

Another factor affecting the development and yield of maize is the type of soil preparation before planting. Takyi (1970), working in central Ghana examined the planting of maize in ridges, in flat seed beds, and in soil not ploughed. His work indicated that maize in ridges have greater yields than maize in flat seed beds. He suggested that there was a higher concentration of fertilizer in the root zone as a result of ridging, which caused the higher yield. Work conducted by Lal (1973) in Nigeria, indicated that maize yields were reduced due to lodging when maize was planted on ridges. In the tropics, availability of moisture is generally unreliable as rainfall comes in the form of thundershowers of short duration but high intensity (White, 1954). In addition, fluctuations in rainfall distribution and amount are great within each season and among years. To conserve moisture and to reduce water run-off and soil erosion, the formation of ridges has been recommended (Buchele, Collins & Lovely, 1955; Lawes, 1966; Maher, 1972). Shaxson (1975) suggested the use of micro-catchments to detain water to allow it to infiltrate into the soil. This provided greater moisture availability for the plants and less erosion of soil (Honisch, 1974).

Insect damage, in particular that of stem borers, can cause considerable reductions in maize yields (Van Eijnatten, 1958; Usua, 1968; Endrody-Younga, 1968; Shah, 1972; IITA, 1974). There is normally an increase of insects during the season of crop growth (Endrody-Younga, 1968). Plants grown in the major season escape heavy infestation and mature before insects cause severe damage. However, when maize is planted late in the major season or in the minor season, a greater amount of plant damage and yield reduction usually occurs.

Van Dinther (1972) listed several methods of controlling insects. The use of insecticides, though often highly effective, has a number of disadvantages. Insects developing resistance to the insecticide, environmental pollution and outbreaks of secondary pests resulting from destruction of their natural enemies have stimulated the search for alternate methods of insect control. Use of cultural and biological control methods has been increasing (Lever, 1972; Chiang, 1973).

The use of insecticides provides a more immediate control of insects than the development of cultivars resistant to insects (IITA, 1972). Furadan (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate), a systemic insecticide, has been very effective in controlling insect damage on maize (CIMMYT, 1974; IITA, 1974). There also may be some growth-stimulating effect in maize when Furadan is applied (Apple, 1971; Daynard et al., 1975). However, it is not known in what manner Furadan causes stimulation of growth.

A number of workers in Nigeria suggest that the highest potential for intensive maize production in West Africa is in the savanna areas (Kassam et al., 1975). They reported that higher maize yields have been obtained in the savanna zone than in the forest zone which has traditionally been regarded as the location for this cereal crop. They indicate that a number of advantages for maize production in the savanna areas are: lower incidence of pests and diseases, higher efficiency of fertilizer use, greater ease of grain drying, more reliable rainfall, and a lower cost of production. The coastal savanna region of Ghana represents a large land area which presently is not being used extensively for the production of maize, or any other crop. The possibility of increasing maize production in this area exists and would be desirable because a large urban center nearby is a ready market for any increased production.

Chinwuba (1965) reported some problems of expanding maize production in Nigeria. He stressed the importance of a combination of practices to obtain high yields. The use of high yielding open-pollinated or synthetic cultivars adapted to the area of production, fertilizers to meet plant requirements, optimum plant population, and good timing of production operations such as planting, fertilizing, weed, disease and insect control are all important factors necessary to increase yields.

Though generalizations can be made as to how maize responds to various factors, it is of value to examine maize production in areas such as the coastal savanna zone of Ghana. Little information on maize production is available for this area. The following papers are results of several experiments conducted in this region which examined various factors affecting maize production.

A STUDY OF FACTORS AFFECTING MAIZE YIELD IN THE COASTAL SAVANNA ZONE OF GHANA

SUMMARY

Maize (_Zea mays_ L.) was planted in the coastal savanna region of Ghana during both the major and minor seasons in 1975. In each season an improved and a local cultivar were sown at both an early and a late planting date. Two irrigation treatments (water and no water) and two fertility treatments (side-dressed nitrogen and no side-dressed nitrogen) were also included in this study. During the major season, the use of an improved cultivar and early planting resulted in large grain yield increases. There was no response to side-dressed nitrogen or irrigation. In the minor season, maize production was very poor without irrigation. The use of an improved cultivar was also an important factor in increasing yields during this season. Higher yields were obtained on irrigated plots during the minor season than in the major season, possibly because of higher levels of incoming solar radiation being available for plant photosynthesis. During the major season, the earlier planted maize received on the average higher levels of insolation than the later planting at all stages of its life cycle. This could be a reason for higher yields with the early planting.

INTRODUCTION

The coastal savanna region of Ghana represents a large land area which presently is not being extensively used for the production of maize, or any other crop. The area contains one of the largest urban centres in Ghana which is a ready market for any increased production. A number of workers in Nigeria suggest that the highest potential for intensive maize production in West Africa is in the savanna areas (Kassam et al., 1975). They reported that higher maize yields have been achieved in the savanna zone than in the forest zone, which has traditionally been regarded as the location for this cereal crop. They indicate that a number of advantages for maize production in the savanna areas are: lower incidence of pests and diseases, higher efficiency of fertilizer use, greater ease of grain drying, more reliable rainfall, and a lower cost of production.

Many factors will affect the success or failure of maize production in this area. Some of these factors include season, rainfall, planting time and cultivar. One of the most important factors is the time of the year when maize production is possible. The coastal savanna zone is considered to have two growing seasons, major and minor, depending on rainfall. The major season which is during late March to mid-July has a higher level of rainfall than the minor season which is from September until early November. A factor which is reported to limit maize production in the coastal savanna zone of Ghana is the unreliable availability of moisture (White, 1954; Haizel, 1966). Generally, this region receives less than 100 cm annually (Brammer, 1967). In addition, fluctuations in rainfall distribution and amount are great within each season and between years.

Planting date is reported to affect maize yields. In the coastal savanna zone of Ghana, Koli (1970) has suggested that maize be planted in the second or third week of April. Planting earlier or later resulted in lower maize yields due to moisture stress. We have been unable to find reports on the effect of planting date on maize during the minor season.

This study was designed to examine five factors which affect maize production in the coastal savanna zone of Ghana. These factors include season, irrigation, planting date, cultivar and side-dressing with nitrogen.

MATERIALS AND METHODS

Two experiments were conducted at Legon farm, University of Ghana, in 1975. One experiment was grown during the major season and the other during the minor season. Identical experimental techniques were used in both experiments. Two planting dates, two cultivars, two fertility treatments and two irrigation treatments were used in each season. In the major season, the planting dates were April 26 and May 16. The minor season plantings were made on September 3 and September 23. A Local (unimproved) cultivar which was purchased in a nearby market and La Posta (improved), which is a cultivar developed and recommended in Ghana, were chosen for this study. The difference in fertility treatment was the presence or absence of side-dressed sulphate of ammonia. The sulphate of ammonia was applied five weeks after planting at the rate of 84 kg N per ha as a band approximately 10 cm from the row. The irrigation treatments consisted of rainfall plus irrigation and rainfall only. Irrigation was accomplished by hand watering of individual plots. The water was restricted to a plot by ridging soil to a height of about 10 cm around the irrigated plots.

The design of each experiment was a split plot with planting date as the main plot. The sub-plots consisted of all combinations of the two irrigation, cultivar, and fertilizer treatments randomized completely within each main plot. There were five replications. Plots consisted of four rows with the middle two being harvested. Rows were five m long and spaced 75 cm apart. Spacing with the row after thinning was two plants per hill at 50 cm intervals. This gave a plant density of 53,300 plants per ha.

An initial fertilizer application of 90 kg N, 44 kg P and 84 kg K per ha was broadcast prior to final soil preparation. In the major season, weeds were controlled with a combination of hand hoeing and Gesaprim (2-chloro-4-ethyamino-6-isopropylamino-s-triazine) applied post emergence at the rate of 3.6 kg active ingredient per ha. In the minor season, no herbicide was used. Furadan (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate), a systemic insecticide, was applied twice in the minor season to control insect damage. The first application was to the seed at planting time. The second was made into the leaf whorl at six weeks after planting. Each time the application rate was 4.5 kg active ingredient per ha. In the minor season as the maize approached maturity, birds feeding on the ears became a problem. In an attempt to control bird damage, Avitrol (4-aminopyridine), a chemical bird control, was used. Because Avitrol was not a complete control, a person was also employed to scare off the birds.

Just prior to harvest, the number of lodged plants per plot were recorded. A lodged plant was considered to be a plant in which the stem was broken below the main ear or in which the stem was more than 45°

from the vertical. At maturity, the plants were hand harvested. The ears were shelled mechanically and total wet grain weight was recorded. Per cent grain moisture was obtained by oven drying a 100 gm sample of the wet shelled grain for three days at 90 C. Grain yields were calculated on a 15 per cent moisture basis.

RESULTS AND DISCUSSION

Effects of treatments on grain yields are shown in Table 1. During the major season, higher grain yields resulted from early planting and the use of an improved cultivar. Highest yields were obtained in the minor season with the improved cultivar, La Posta, when it was irrigated. There was no response to irrigation during the major season. Without irrigation in the minor season, maize yields were very low. Earlier planting increased yields in both seasons, except when maize was not irrigated in the minor season. Koli (1970) also reported higher yields from maize planting early rather than late in the major season. The improved yields from planting as soon as the rains become regular may result from one or more factors. These include less insect damage, better moisture availability, and greater incoming solar radiation. As has been reported by Endrody-Younga (1968), stem-boring insects including <u>Sesamia botanephaga</u>, <u>Eldana saccharina</u> and <u>Busseola fusca</u>, tend to build up toward the end of the major season. These insects have substantially reduced yields in the coastal savanna zone of Ghana (Leyenaar, 1976). Although moisture stress during the growing season can reduce yields (Koli, 1970), low moisture was not a limiting factor in this study during the major season or when maize was irrigated in the minor season.

During the period from early April until late August, there was an almost linear decrease in incoming solar radiation (Figure 1). This resulted in the earlier planted maize growing during the major season, receiving, on the average, higher levels of insolation than the later planting at all stages of its life cycle. In maize, photosynthetic rates and yields are decreased by low light intensities (De Wit, 1959; Monteith, 1965; Duncan, Shaver & Williams, 1973). Higher insolation throughout the life cycle of the early planted maize is a likely factor contributing to its higher yield during the major season, but less stem borer damage in early planted maize have been equally important. During the minor season, plantings on September 3 and September 20 were exposed to approximately the same total solar radiation during their life cycles. Therefore, insolation and moisture stress likely were not factors responsible for higher yields of earlier planted, irrigated maize grown in the minor season. Good control of stem boring insects was achieved during the minor season with Furadan. Therefore, higher yields in the September 3 planting likely occurred because maize planted on September 23 was more heavily damaged by birds and diseases. Without irrigation, the late planting of maize had higher yields than the early planting, possibly because during 1975, the rainfall was greater in the latter part of the minor season.

With irrigation, higher yields were obtained in the minor season than in the major season. Higher incoming solar radiation levels available for plant photosynthesis during the minor season (Figure 1) may have contributed to the higher yields. Irrigation involves a large capital expenditure and is not considered feasible for the average farmer.

However, if irrigation schemes develop, maize could be grown successfully during the minor season in the coastal savanna area. To obtain high yields, the use of an improved cultivar and control of stem boring insects would be important.

There was no yield response from applying side-dressed nitrogen five weeks after planting, indicating that the initial pre-plant application of 90 kg N per ha was adequate. Under the lower rainfall levels of the savanna zone, leaching of early applied nitrogen may not be as severe as in heavier rainfall areas.

In summary, without irrigation, the most suitable time for maize production in the coastal savanna zone of Ghana is the major season. Planting early after the start of rains and using an improved cultivar are both important factors in increasing grain yields. During the minor season, irrigation is necessary for good maize production.

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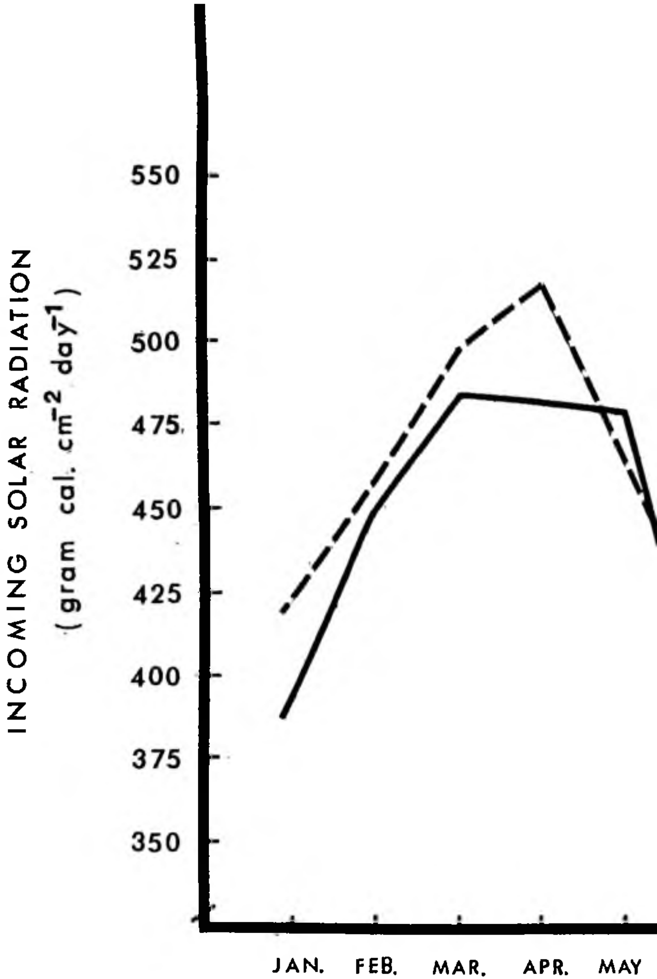
Table 1. Effects of growing seasons, planting dates, cultivars and irrigation on grain yields of maize grown in the coastal savanna zone of Ghana in 1975.

Season	Planting Date	Not Irrigated	Irrigated
		Kg / ha at 15% moisture	
Major	Early	3146	3019
	Late	2010	2134
Minor	Early	776	3553
	Late	954	2790
	Cultivars		
Major	Local	1825	1830
	La Posta	3331	3321
Minor	Local	521	2298
	La Posta	1209	4045
Irrigation treatment means		1722	2874

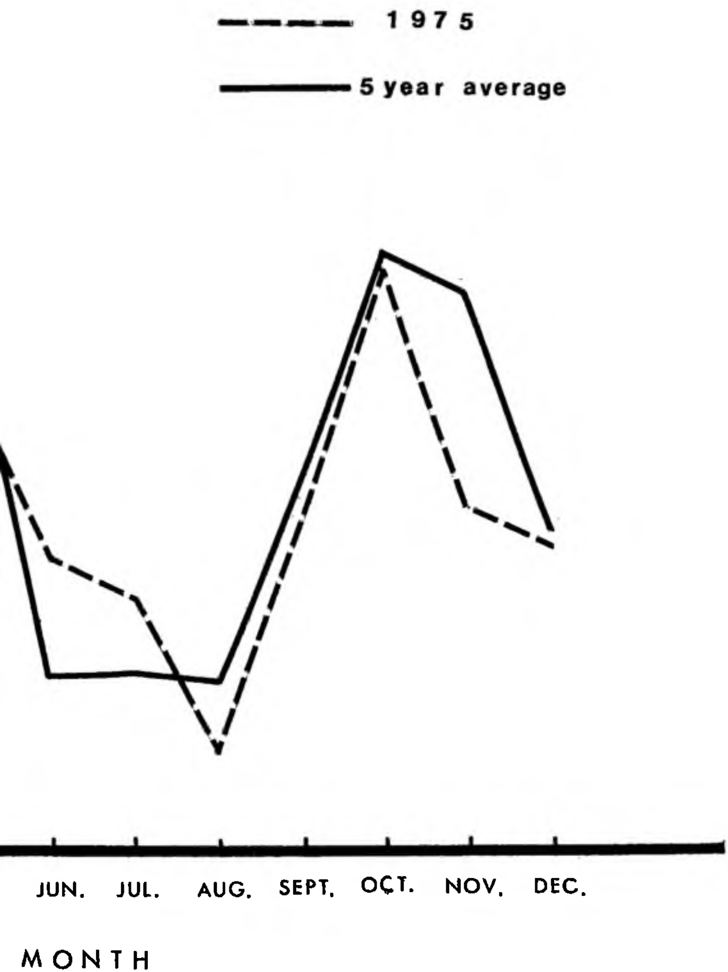
Season Means		Planting Date Means		Cultivar Means	
Major	Minor	Early	Late	Local	La Posta
2577	2018	2624	1972	1619	2977

The following treatments and interactions were significant ($P \leqslant 0.05$) Seasons (S), Planting dates (PD), Irrigation (I), Cultivar (C), S x PD, S x I, PD x I, C x I, S x PD x I, and S x C x I.

Figure 1. Incoming solar radiation (g cal cm^{-2} day^{-1}) during 1975 and for the five year average of the period, 1969-1973. (Ghana Meteorological Services, Legon, Ghana)



INCOMING SOLAR RADIATION
(gram cal. cm^{-2} day^{-1})
550
525
500
475
450
425
400
375
350
JAN.
FEB.
MAR.
APR.
MAY


1 9 7 5
5 year average
JUN.
JUL.
AUG.
SEPT.
OCT.
NOV.
DEC.
MONTH

THE EFFECT OF SEED BED PREPARATION ON MAIZE PRODUCTION IN THE COASTAL SAVANNA ZONE OF GHANA

SUMMARY

Two experiments were conducted in 1975 in the coastal savanna zone in Ghana to study the effect of seed bed preparation on maize production. Three types of seed beds, flat, ridge and furrow, were examined. Planting in flat beds or in furrows produced equal yields but planting in ridges decreased yields. Poor soil in the furrows and high soil temperatures and low soil moisture in the ridges appear to be the major reasons for the poor performance.

INTRODUCTION

In the savanna zone in northern Ghana, furrow seed beds have been used. Both millet (*Pennisetum cinereum*) and sorghum (*Sorghum vulgare*) are grown in furrows on the premise that more moisture is available to the plants (Dadson[1], personal communication). Research results have confirmed that the formation of ridges can control water run-off and soil erosion (Buchele, Collins & Lovely, 1955; Brammer, 1967; Maher, 1972). Also the type of land preparation before planting has considerable influence on the development and yield of a crop such as maize (*Zea mays* L.). A study conducted at the International Institute of Tropical Agriculture (IITA, Nigeria) reports the effects of five types of seed bed preparation on maize performance (Lal, 1973). The types studied included ridge, furrow

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[1]Dr. R.B. Dadson, Crop Sci. Dept., P.O. Box 68, Univ. of Ghana, Legon.

and flat seed beds. Yields were lower when maize was planted in ridges due to increased lodging. At certain times of the year, the soil temperature of ridges showed high diurnal fluctuations attributed mainly to increased soil surface exposure and low soil moisture content. This resulted in poor seed emergence. Buchele et al. (1955) also found that there was less moisture and higher temperatures in the upper portion of ridges relative to furrows. Takyi (1970), working in central Ghana, examined the planting of maize in ridges, in flat seed beds, and in soil not ploughed. His work indicated that maize in ridges outyielded maize in flat seed beds. In this case, fertilizer was applied before ploughing. He suggested that there was a higher concentration of fertilizer in the root zone as a result of ridging. This was suggested as a reason for the higher yield.

A factor which limits crop production in the coastal savanna zone of Ghana is the unreliable availability of moisture (White, 1954). Generally, this region receives less than 100 cm annually (Brammer, 1967). In addition, fluctuations in rainfall distribution and amount are great within each season and between years. Rainfall usually comes in the form of thundershowers of short duration but high intensity. By decreasing run-off during periods of excessive moisture, soil erosion may be decreased and the crop may benefit from increased water availability. This study was designed to determine if there is any advantage to planting maize in furrows or ridges under this type of rainfall pattern. These two planting methods were compared to planting maize in a flat seed bed.

MATERIALS AND METHODS

Two experiments were conducted in 1975 at the Legon farm, University of Ghana, to examine the effects of type of seed bed preparation on maize. Three treatments, flat, furrow and ridge planting were used. A randomized complete block design with six replications and identical experimental techniques were used for both experiments. One experiment was planted on May 8 during the major season which normally extends from late March to mid-July. The second experiment, planted on September 11, was conducted during the minor season. The minor season is characterized by less rainfall and is much shorter, being from mid-September to early November.

An improved cultivar of maize, Composite 4, which is recommended for use in Ghana, was chosen for this study. A plot consisted of eight rows five m long and spaced 75 cm apart. The soil in this area is classified as being of the Nyigbenya-Hacho complex (Brammer, 1967). It is mostly red loam to clay and is highly variable. Topsoil is often less than 15 cm thick and dries out thoroughly during dry periods. The land was initially prepared by tractor ploughing and discing. The flat treatment was left as the soil was prepared, but the ridges and furrows were developed further by hand hoeing. The ridges were 30 cm high and made by removing soil to a depth of 15 cm. The seeds were over-planted at intervals of 50 cm within the row. With the ridge and furrow plantings, seeds were placed in the crest of the ridge and the lowest portion of the furrow, respectively. The plots were thinned to two plants per hill giving a final plant density of 53,300 plants per ha on June 3 and October 17 for the major and minor seasons, respectively.

Fertilizer was applied at planting time after the ridges and furrows were constructed. At this time, 90 kg N, 44 kg P and 84 kg K per ha was incorporated by hand ten cm from the seeds at an approximate depth of five cm in the soil. An application of 87 kg N per ha was made in a similar manner five weeks after planting. Excellent weed control was obtained by hand hoeing and the use of Gesaprim (2-chloro-4-ethylamine-6-isopropylamine-s-triazine) applied early post emergence at the rate of 3.6 kg active ingredient per ha. In the minor season, no herbicide was used. Furadan (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) was applied in the minor season to control stem borers. The chemical was applied to the seed at planting time and in the leaf whorl six weeks after planting. For both applications, the rate was 4.5 kg active ingredient per ha. During the major season, no water was added. However, in the minor season, water was added using a sprinkler irrigation system, whenever the plants showed symptoms of severe wilting.

During the course of the growing season data were collected on rate and per cent seed emergence, soil temperature, days to mid-anthesis, days to mid-silking, ear height, and leaf dimensions. Rate of seed emergence was calculated by a method outlined by Hunter and Kannenberg (1972). Soil temperatures were taken in the row at a depth of five cm at 0830 and 1430 hours. Temperatures were recorded daily for the first five weeks after planting for the major season experiment only. There was heavy leaf shading after five weeks and temperature differences among treatments were small. Days to mid-anthesis and mid-silking were taken to be the number of days from planting until one half of all plants in a plot were shedding pollen or silking, respectively. Ear height was recorded two weeks after mid-silking and was the average height from the ground to the main ear-bearing node as determined from ten random plants per plot. Leaf length and maximum width were measured on all green leaves of ten random plants per plot three weeks after mid-silking. Leaf area index was calculated by the following formula: leaf width x leaf length x 0.75.

Whole plant dry matter was determined at thinning. Grain and stover yields were determined seven days after mid-silking and at maturity. In the first harvest, 20 plants per plot were selected from the thinned plants and oven-dried at 80 C. For the remaining two harvests, all plants from each of two rows were harvested. Stover and ear-weights were recorded separately. With the harvest one week after mid-silking, rows two and three within a plot were used and for the final harvest rows six and seven were used. The remaining rows constituted border plants. In the second and third harvests, a sub-sample of ten ears and stover from ten plants per plot were used to determine per cent moisture. The sub-samples were oven-dried at 80 C for three days. At seven days after mid-silking, the grain was not removed from the ear. However, at maturity, the dried ears were shelled. Per cent ear moisture, grain weight and shelling per cent were recorded.

Data were collected on plant lodging, ears per plant, and plants per plot at seven days after mid-silking and at maturity. A plant was considered to be lodged if the stem was broken below the ear or the angle of the stem was greater than 45° from vertical.

RESULTS AND DISCUSSION

Results from the two experiments were averaged to determine the effect of the three seed bed treatments. There did not appear to be any benefit by planting in furrow or ridge seed beds. For the ridge-planted maize, there were significantly lower grain yields at maturity and lower stover yields in all three harvests (Table 1). The furrow and flat plantings yielded the same at all stages of maturity for both stover and grain.

Yield differences among the various treatments may be the result of several developmental factors. There was a significant difference among each of the three treatments in rate of emergence. Emergence was delayed when the maize was planted on ridges (Table 2). The delay probably resulted from lower soil moisture levels because once the planted seed received a substantial rain, the maize in ridges emerged rapidly. This delayed emergence affected subsequent developmental stages in the life cycle of the plants as exemplified by days to mid-anthesis, days to mid-silk and per cent ear moisture at harvest (Table 2). This might account for the lower total dry matter yields in the first harvest.

Soil temperature readings differed in the afternoon, but were not different among treatments in the morning. In the afternoon, the ridge treatment averaged 35.5 C compared to the flat and furrow which averaged 34.0 C and 32.7 C respectively. The highest ridge temperature for any day was 43.2 C.

The maize grown in the ridge had a significantly lower per cent emergence (Table 2). This was also shown by Lal (1973) and could be accounted for by high soil temperatures. In the afternoon, the furrows had lower soil temperature than the other two treatments. The reason for the poor emergence in this case might be due to the poor soil into which the seeds were planted. At planting time it was noted that the soil in the furrows was relatively hard.

The stover dry matter yields at seven days after mid-silking were lower for the ridge treatment than either of the other treatments. Since each plot had reached the same stage of physiological development, delayed emergence in ridges probably would not be implicated here. Higher soil temperatures and increased incidence of lodging (Table 3) were more likely to have been responsible for reduced ridge yields.

At maturity, there were significantly fewer plants and ears per plot harvested in the ridge planting (Table 2). This, at least in part, would explain the reduced grain yield in ridges. The fact that there were less plants per plot harvested indicates higher mortality in the ridges. The increased mortality may have resulted from the increased lodging apparent shortly after silking. Lodged plants were more susceptible to rodent, bird and mould damage.

At maturity, there was no significant difference in per cent lodging. There were also no differences in plant and ear heights, or in leaf area index, suggesting that differences in plant size were not responsible for the performance differences.

In summary, it appears that the ridge-planted maize was stressed more than the flat or furrow-planted maize. This stress initially caused slower development, weaker plants and eventually higher mortality and barrenness. Poor soil might have prevented the furrow-planted maize from producing higher yields. This study suggests that a farmer in the coastal savanna zone of Ghana can expect the best yields with the least labour or capital input by planting in flat seed beds. The maize planted in furrows in this study did not appear to benefit from increased moisture which might have accummulated in the furrow.

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Table 1. Yields of maize grown in flat, furrow and ridge seed beds, averaged over the major and minor seasons, 1975.

Plant part	Stage of development								
	Thinning			Seven days after mid-silking			Maturity		
	Flat	Furrow	Ridge	Flat	Furrow	Ridge	Flat	Furrow	Ridge
	kg/ha								
Stover (dry matter)	400 a*	320 a	155 b	7722 a	7622 a	6262 b	7460 a	7293 ab	6380 b
Ear[1] (15% moisture)	-	-	-	739 a	862 a	679 a	-	-	-
Grain (15% moisture)	-	-	-	-	-	-	3590 a	3470 a	2664 b

[1]Ear yield includes grain plus cob as it was not possible to shell ears at this stage.

*For any given harvest, means with different letters are significantly different at the 0.05 level of probability.

Table 2. Developmental characteristics of maize grown in three types of seed beds averaged over the major and minor seasons, 1975.

Seed bed	Rate of emergence[1]	Per cent emergence	Days for planting to mid-anthesis	Days from planting to mid-silk	% Ear moisture at maturity	Surviving plants/ plot at maturity	Ears/plant at maturity
Flat	21 a*	91 a	59 b	65 b	36 b	35.0 a	0.91 a
Furrow	16 b	83 b	62 a b	68 b	37 b	33.4 a	0.87 a b
Ridge	13 c	80 b	66 a	72 a	41 a	31.8 b	0.80 b

[1] Calculated by the method of Hunter and Kannenberg (1972).

* There was no significant difference between means with the same letter within each characteristic at the 0.05 level of probability.

Table 3. Per cent lodging of maize grown in three types of seed beds averaged over the major and minor seasons, 1975.

Seed bed	Stage of development	
	Seven days after mid-silking	Maturity
	% lodging	
Flat	3 a*	36 a
Furrow	6 a	32 a
Ridge	15 b	37 a
MEAN	8	35

*Means within columns with different letters are significantly different at the 0.05 level of probability.

THE EFFECT OF STEM BORER DAMAGE ON MAIZE YIELD IN THE COASTAL SAVANNA ZONE OF GHANA

SUMMARY

A study was conducted in the coastal savanna zone in Ghana to obtain an estimate of maize grain yield losses due to stem borer damage. The experiment was undertaken in 1975 during the latter part of the major season and the minor season. Furadan, a systemic insecticide, was used as a means of stem borer control. Grain yield reduction when the insecticide was not used averaged 63.6 per cent. Increased lodging, premature cessation of grain filling and early plant senescence appear to be the major reasons for the reduction in yield.

INTRODUCTION

Insects are a pest which can seriously reduce maize (*Zea mays* L.) yields. One group of insects, the maize stem borers, is very widely distributed throughout the tropics and is known to cause considerable losses in production (Frohlich & Rodewald, 1970). Endrody-Younga (1968) reports that the three most common borer species of maize in Ghana were *Sesamia botanephaga*, *Eldana saccharina* and *Busseola fusca*. *S. botanephaga* and *E. saccharina* causing the most damage to maize in the forest zone of Ghana. *B. fusca* was reported to be found more in the savanna area of Ghana. For all three species, the female moth lays eggs on the inner surface of the leaf sheath. The larvae developing from the eggs enter the stem and cause damage by feeding in the stem. The damage to maize by these insects appears to be most serious in the second season crop. This results from a build-up of insects during the first season maize crop. Plants grown early in the first season escape heavy infestations and mature before insects cause much damage. However, when maize is planted late in the first season or in the second season, one can expect a higher infestation of insects (Endrody-Younga, 1968).

At the International Institute of Tropical Agriculture (IITA, Nigeria) work is in progress on the development of maize cultivars which are resistant to the borer insects (IITA Report, 1974). In addition, the use of insecticides in controlling insects is being studied as a more immediate solution. Furadan (2,3-dihydro-2, 2-dimethyl-7-benzofuranyl methylcarbamate), systemic insecticide, has been shown to be very effective in controlling insect damage on maize (Soto, 1975). At the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT, Mexico) trials with Furadan showed considerable increases in maize yield (CIMMYT, 1974).

This study examines yield losses resulting from insect damage on maize in the coastal savanna zone of Ghana. In this area, there are two growing seasons per year. They are defined as major and minor according to the amount of rainfall. Late March until mid-July is considered the major season and mid-September until early November, the minor season. Rainfall in the minor season is usually insufficient for good maize production (Leyenaar, 1976). However it is possible to produce maize with irrigation. It is during the latter part of the major season and throughout the minor season that the borer insects cause the most damage (Endrody-Younga, 1968). This study deals with damage during this period.

MATERIALS AND METHODS

The experiment was conducted during 1975 at the University of Ghana's Legon farm. Two cultivars of maize which are recommended in Ghana, Mexican 17 and Composite 4, were chosen for this study. Chemical control of insects was obtained by the use of Furadan. A granular formulation of Furadan was applied with the seed at planting at the rate of 4.5 kg per ha active ingredient (0.170 g active ingredient per hill). Six weeks after planting, it was applied at the same rate per ha to the whorl of each plant (0.085 g active ingredient per plant). The check plots received no chemical control.

The experiment consisted of five plantings with the first planting on June 26 and thereafter at three week intervals. The experimental techniques were identical for each planting. The maize was hand-planted in 5 m rows spaced 75 cm apart. Plots were two rows wide with hills being spaced 50 cm apart within rows. The maize was over-planted and thinned to two plants per hill giving a final plant density of 53,300 plants per ha. The two plants at each end of the row constituted border plants. The experimental design was a split plot with five replications. The main plots were planting dates.

The plots were fertilized at the rate of 90 kg N, 44 kg P and 84 kg K per ha at planting. Sulphate of ammonia was sidedressed at the rate of 87 kg N per ha five weeks after planting. Water was added using a sprinkler irrigation system whenever the plants showed signs of water stress. Weeding was done by hand hoeing. As the maize approached maturity, birds became a problem. In an attempt to reduce bird damage to the ear, Avitrol (4-aminopyridine), a chemical bird control, was used.

In addition, a bird watcher was employed to scare off birds as Avitrol did not offer complete control.

The number of lodged plants per plot was recorded just prior to harvesting. A lodged plant was one in which the stem was broken below the ear or the stem was more than 45° from being vertical. Harvesting was done 109 days after planting. Ears were removed by hand and the number of ears per plot recorded. Ten ears were selected to determine average number of kernel rows per ear and kernels per row. After mechanical shelling, wet grain yield per plot was recorded. Per cent grain moisture at harvest was obtained by taking a 100 g sample of wet shelled grain and oven-drying it at 80 C for three days. Grain yields at 15 per cent moisture were calculated. Kernel size was determined by obtaining the dry weight of 1,000 random kernels at harvest.

Per cent damaged internodes has been used as a means of estimating the amount of borer damage to the plant (Coker[1], personal communication). A count of internodes and damaged internodes below the main ear was made on ten random plants per plot. To do an accurate count, it was necessary to remove the leaves and sheaths from the stem of the plant.

RESULTS AND DISCUSSION

Insect damage seriously reduced maize yield (Table 1). The treatments with no insect control had a mean yield about one-third of the chemically treated maize. The low yield for the untreated maize indicated both the seriousness of insect damage and the relatively high effectiveness of Furadan in controlling insects. The chemical treatment was highly effective on both cultivars and throughout all the planting periods.

[1]Dr. R.A. Coker, Entomologist, IITA, PMB 5320, Ibadan, Nigeria.

The yield reduction is closely related to insect damage as measured by per cent damaged internodes. Furadan very significantly reduced per cent damaged internodes (Figure 1). This was true for both cultivars at all planting dates. The untreated maize had extensive damage in all five plantings with some reduction in damage in the final planting. It would have been desirable to have had earlier plantings. However, in adjacent experiments planted in mid-April, it was determined that the per cent damaged internodes for Mexican 17 and Composite 4 was 9 and 13 per cent, respectively. This suggests that there is a build-up of boring insects from the major season to a peak in the minor season as has been reported by Endrody-Younga (1968).

There are a number of possible reasons for the reduced yields where no insect control was used. Lodging per cent was much higher in the untreated maize (Table 2). With increased lodging, there is increased ear and plant loss due to rodents and other pests. This is illustrated by a 11 per cent reduction in the final number of plants per plot and a 25 per cent reduction in ears per plant. Lodging occurs mainly because stems are weakened by the insects. Another possible factor causing lower yields in the untreated maize is hastened leaf senescence, which would shorten the grain-filling period. Earlier maturity in the untreated maize is indicated by the lower per cent grain moisture at harvest (Table 3). Reduced yields also could have been caused by the reduction in both kernel size and kernel number. On the average, in untreated maize, kernel size was reduced by 14 per cent and kernel number by 15 per cent. Most of the reduction in kernel number was due to a decrease in number of kernels per row rather than number of kernel rows per ear.

Throughout the growing season, the insects that were noted to be most prevalent were S. botanephaga and E. saccharina. Plants which were dying prematurely as a result of insect damage usually had S. botanephaga present. However, a larvae count at harvesting indicated that E. saccharina was most plentiful. B. fusca were also present at harvest but in smaller numbers. The almost complete absence of S. botanephaga at harvest may have resulted from the fact that many of these larvae had already left the stalk. Hence it is difficult at harvest time to give an accurate estimate of the number and type of insects. S. botanephaga and E. saccharina have also been reported to be the two major species causing the maize damage in the forest zone in Ghana (Endrody-Younga, 1968).

In summary, maize yield was severely reduced by insects when the maize was planted in the coastal savanna zone of Ghana during both the latter part of the major season and the minor season. The use of Furadan was a highly effective control. Furadan use resulted in maize yields of more than 170 per cent greater than the untreated maize for both cultivars. The high yield losses in the untreated maize appear to result from increased lodging, early plant senescence and premature cessation of grain filling.

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Table 1. Grain yield of two maize cultivars grown with and without insect control.

Planting date	Mexican 17		Composite 4		Planting date mean
	No control	Furadan	No control	Furadan	
	kg/ha at 15% moisture				
June 26	1152	3303	1475	3525	2364 ab*
July 17	1170	4477	1200	4914	2949 a
Aug. 7	1028	3573	1474	3781	2464 ab
Aug. 28	1124	2258	935	3045	1841 b
Sept 18	1462	2550	1712	3520	2311 ab
Mean	1187	3232	1359	3757	

The following treatments and interactions were significant ($P \leqslant 0.05$): Planting date (PD), Insecticide treatment (T), Cultivars (C) and PD x T.

*There was no significant difference between means with the same letter at the 0.05 level of probability.

Table 2. Lodging per cent at harvesting of two maize cultivars growth with and without insect control.

Planting date		Mexican 17		Composite 4		Planting date mean
		No control	Furadan	No control	Furadan	
		% lodging				
June	26	35.0	3.9	30.0	2.0	17.7 b*
July	17	30.6	8.0	35.9	4.1	19.6 b
Aug.	7	47.1	9.2	44.5	11.1	28.0 ab
Aug.	28	46.8	19.6	59.7	19.7	36.4 a
Sept.	18	38.3	15.4	40.5	17.5	27.9 ab
	Mean	39.6	11.2	42.1	10.9	

Planting date and insecticide effects were significant ($P \leqslant 0.05$).

*There was no significant difference between means with the same letter at the 0.05 level of probability.

Table 3. Grain moisture per cent at harvesting of two maize cultivars grown with and without insect control.

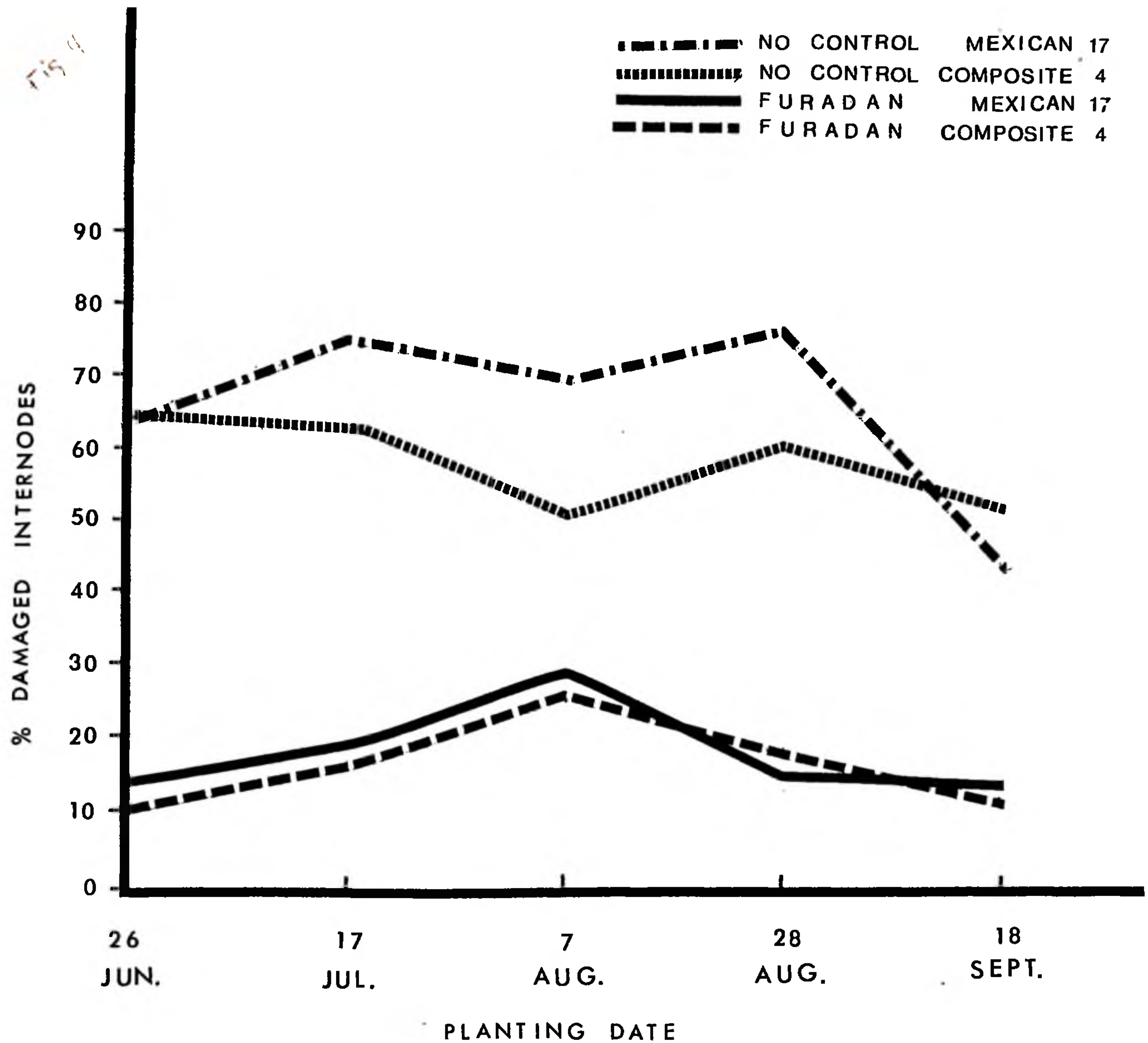
Planting date		Mexican 17		Composite 4		Planting date mean
		No control	Furadan	No control	Furadan	
		% grain moisture				
June 26		26.0	30.0	29.7	33.9	29.9 a*
July 17		27.2	30.8	29.3	32.6	30.0 a
Aug. 7		28.3	29.5	31.1	33.1	30.5 a
Aug. 28		23.7	26.9	24.1	29.0	25.9 b
Sept. 18		23.8	24.0	23.9	25.4	24.3 b
	Mean	25.8	27.6	28.3	30.8	

The following treatments and interactions were significant ($P \leqslant 0.05$): Planting date (PD), Insecticide treatment (T), Cultivar (C), PD x T, PD x C.

*There was no significant difference between means with the same letter at the 0.05 level of probability.

Figure 1. Per cent damaged internodes for two maize cultivars grown with and without insect control.

Fig 4


NO CONTROL MEXICAN 17
NO CONTROL COMPOSITE 4
FURADAN MEXICAN 17
FURADAN COMPOSITE 4
% DAMAGED INTERNODES
0
10
20
30
40
50
60
70
80
90
26 JUN.
17 JUL.
7 AUG.
28 AUG.
18 SEPT.
PLANTING DATE

SUMMARY AND CONCLUSIONS

Results of three experiments conducted at the Legon farm in the coastal savanna zone of Ghana in 1975 indicated that there was good potential for maize production. Grain yields of up to 4500 kg/ha were obtained with good cultural practices.

During the major season, substantially higher yields were obtained by growing an improved cultivar of maize and planting as soon as possible after rains started following the dry season. These two factors would require little capital expenditure by the farmer, but more than doubled grain yields. Long-term averages of rainfall distribution indicated that planting early would minimize moisture stress during the flowering and grain-filling period. However, in this particular study, there was adequate rainfall because no response to irrigation occurred. Another possible reason for the decreased yields with the later planting was low light intensity. From early April until late August, there is an almost linear decrease in insolation. This results in the early planted maize receiving, on the average, higher levels of light than the later planting at all stages of its life cycle. Another possible reason for the reduced yields with the later planting is insect damage. Insect populations are at low levels at the beginning of the major season and build up towards the end of the major season and during the minor season.

In the minor season, the best yields were obtained through irrigation, stem borer control and planting an improved cultivar. During this period, maize production was not practical without the addition of water. The capital cost of irrigation would be great for the average farmer and might not be economically practical. If an irrigation scheme is developed in this region, the use of an insecticide and an improved cultivar would be warranted with maize production.

Greater yields were obtained using an insecticide, an improved cultivar and irrigation in the minor season than during the major season. This may reflect the higher level of incoming solar radiation available for plant photosynthesis during the minor season.

Yields of untreated maize were on the average 63 per cent lower than the yields of maize treated with Furadan during the latter part of the major season and in the minor season. Furadan was highly effective in controlling stem borers (*Sesamia botanephaga*, *Eldana saccharina* and *Busseola fusca*) throughout the entire period of the study and with both cultivars of maize, Mexican 17 and Composite 4.

The use of furrow or ridge seed beds did not give greater yields than planting maize in a flat seed bed. Applying nitrogen as a side-dressing after a liberal fertilizer application at planting did not increase yields.

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APPENDIX

Table 1. Rainfall during 1975, at the Legon farm.

Month	(mm)	Days with more than 2mm
Jan.	0.3	0
Feb.	54.0	4
Mar.	162.8	7
Apr.	78.9	4
May	83.7	9
June	154.9	10
July	73.0	3
Aug.	12.5	2
Sept.	11.8	2
Oct.	74.0	5
Nov.	106.5	7
Dec.	98.3	2
TOTAL	910.6 mm	55 days

Table 2. Analysis of variance for grain yield during the major and minor seasons, 1975, showing only significant treatment effects.

Source	df	Mean Square
Season(s)	1	12489571*
Error a	8	1823991
Planting date (PD)	1	16976982**
S x PD	1	5168064**
Error b	8	226490
Irrigation (I)	1	53115153**
S x I	1	53299687
Cultivar (C)	1	73762078**
PD x I	1	1189818*
S x I x C	1	2886026**
S x PD x I	1	3557138**
I x C	1	2734845**
Error c	112	266636
TOTAL	159	1767923

C.V. (a) = 58.8% C.V. (b) = 20.7% C.V. (c) = 22.5%

*, ** Significant at 0.05 and 0.01 levels, respectively.

Table 6. Analysis of variance for per cent of internodes damaged by stem borers.

Source	df	Mean Square
Planting Date (PD)	4	652*
Error a (Reps/PD)	20	152
Cultivars (C)	1	444*
Treatment (T)	1	48668**
PD x C	4	116
PD x T	4	528**
C x T	1	254
PD x C x T	4	175
Error b	60	86
	C.V. (a) = 30.9%	C.V. (b) = 23.3%

*, ** Significant at 0.05 and 0.01 levels, respectively.

Table 3. Analysis of variance for grain yield at maturity in the major and minor seasons, 1975, with flat, furrow and ridge seed beds.

Source	df	Mean Square
Season (S)	1	548145
Error a (Reps/S)	10	530583
Treatment (T)	2	2201675**
T x S	2	61756
Error b	20	306651

C.V. (a) = 26.4% C.V. (b) = 20.1%

** Significant at 0.01 level

Table 4. Analysis of variance for stover dry matter yield at maturity in the major and minor seasons, 1975, with flat, furrow and ridge seed beds.

Source	df	Mean Square
Season (S)	1	6020609**
Error a (Reps/S)	10	1345502
Treatment (T)	2	4100352*
T x S	2	382208
Error b	20	1103799
C.V. (a) = 16.5%		C.V. (b) = 14.9%

*, ** Significant at 0.05 and 0.01 levels, respectively.

Table 5. Analysis of variance for grain yield of maize planted at five planting dates and with and without insect control.

Source	df	Mean Square
Planting date (PD)	4	3082246**
Error a (Reps/PD)	20	429714
Cultivars (C)	1	3031434**
Treatments (T)	1	123380608**
PD x C	4	112874
PD x T	4	3344574**
C x T	1	778166*
PD x C x T	4	338210
Error b	60	244740
	C.V. (a) = 27.5%	C.V. (b) = 20.6%

*, ** Significant at 0.05 and 0.01 levels, respectively.