EFFECT OF SUPPLEMENTARY IRRIGATION AMD WEED CONTROL ON PERFORMANCE OF LATE SOWN MAIZE (*Zen mays* L.)

BY

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A thesis submitted to the Postgraduate School, Ahmadu Bella University, in partial fulfillment of the requirements 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 titled 'EFFECT OF SUPPLEMENTARY IRRIGATION AND WEED CONTROL ON PERFORMANCE OF LATE SOWN MAIZE (*Zea mays* L.)' by Anselm C. OPARA meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and' is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

To my sister, Margaret and inlaw, Paschal Ike, for their tremendous love for me and my family.

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ABSTRACT

To explore the possibility of growing a good crop of late sown maize with supplementary irrigation and suitable weed control measures, on experiment was carried out at Kadawa, Nigeria, in 1984. The irrigation treatments comprised of irrigation at seven, 14 and 21 days intervals and at attainment of severe moisture stress. The weed control treatments comprised of hoe-weeding at three and six weeks after sowing (w.a.s.), atrazine + eradicane (1.5 + 2.0kg a.i./ha) and atrazine + metolachlor (1.25 + 1.25kg a.i./ha) herbicide treatments. The herbicide treatments were followed by supplementary hoe-weeding at six weeks after sowing.

Irrigation at seven, 14 and 21 days intervals significantly increased the grain yield by 96, 58 and 60%, respectively, over the treatment with severe moisture stress.

Parameters such as final plant height, days to maturity, ear length, ear diameter, kernel depth and 1000-grain weight of maize were all significantly superior under irrigated than unirrigated condition.

There were no significant differences between the three weed control treatments on weeds, yield and yield components. They were equally effective.

In areas like Kadawa where water table is high, a good crop of late sown maize can be grown with supplementary Irrigation (325 to 39Qmntwater) at longer irrigation intervals of 14 or 21 days.

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Chapter 1

INTRODUCTION

Maize (Zea mays L.), though not a native crop of Africa, has occupied an important place in the whole continent. It is believed to have been introduced to Africa, from Central America by Portuguese sailors through the West African coast about five centuries ago (Miracle, 1966). It is the third important cereal of the world, after wheat and rice (FAO, 1984) and is grown from about 55°N to 40°S latitudes and from sea level to 3000m altitude, hence it is the most widely adapted cereal (Fischer and Palmer, 1984). It is the most widely grown cereal in the developing world and has the highest genetic yield potential of all cereals (CIMMYT, 1993; Fischer and Palmer, 1984). At present, it is the third most important staple cereal of Nigeria after sorghum and millet.

Traditionally, maize production in Nigeria was restricted to areas south of 8°N latitude which is mainly the rain forest zone, where it has established itself as an important component of the farming system. In recent years, however, zone of production has extended up to 11°N latitude in the northern Guinea savanna where maize yields of 8 to 10 t/ha have been reported (Kassam et al., 1975). The savanna zone offers greater maize yield potential than the forest zone due mainly to its inherent higher solar radiation intensities, lower temperatures and lower levels of diseases and pests (Kassam and Kowal, 1973).

Apart from the climatic factors, another important factor is the development of improved maize varieties and production technology developed by the Institute for Agricultural Research of Ahmadu Bello University, Zaria, and the International Institute for Tropical Agriculture, Ibadan. These varieties have higher yield potentials than sorghum and millet, the traditional Nigerian savanna cereals. Also the drought incidence in the early seventies and early eighties clearly demonstrated the apparent advantage of maize in an area with a short rainy season over sorghum and millet due to the shorter growth cycle of maize (Fajemisin, 1985).

Apart from being an important staple food crop, maize is also used in poultry and livestock feeds and in agro-industry for production of processed food, beverages, starch, alcohol, etc. In fact, it has a wider range of uses than any other cereal (Fischer and Palmer, 1984). To meet the very high demand for maize in Nigeria, a huge amount of foreign exchange is spent on its importation annually. In 1977, about 90,000 tonnes of maize grain was imported into the country at a cost of over N25 million while 293,000 and 345,000 tonnes were imported in 1981 and 1982, respectively, (FAO, 1980; 1984). This is inspite of a production figure of 1.65 million tonnes recorded for 1982. It is imperative, therefore, that efforts should be intensified to increase its production.

To meet the ever increasing demand for maize in the country,

production efforts must be concentrated in two main directions; increase in yield per hectare and increase in total hectarage. The introduction of adaptable hybrid maize varieties and irrigated maize farming to complement the existing package of improved technology appear to be the most viable approaches. This will augment existing efforts in this direction, notably, extension of maize cultivation to the savanna zone and double cropping in the forest zone.

In the southern rain forest zone of Nigeria, maize is normally grown between March and October and in the savanna between May and September depending on the onset and duration of the rainy season. In the tropics, rainfall range from 600 to 900mm during the growing season is adequate for maize production (Purseglove, 1972), depending on the maturity period of the variety and rate of evapotranspiration. In the rain forest zone, where two crops of maize (early and late) are normally grown, much of the produce of the early sown crop is lost due to poor post-harvest handling. The rainfall at this time is still very heavy and the high relative humidity results in higher incidence of pests and diseases, poor drying and grain storage conditions. The late sown crop does not face these difficulties but faces a major problem of dry spells during the growth stage which often causes crop failure. In recent years, periods of dry spells are becoming a common feature. Supplementary irrigation if given under such situations can save the crop from failure.

Besides drought spells, weeds also cause damage to the late rainy season maize crop. It is estimated that 40 to 60% of production cost is spent on manual weeding (Remison, 1979; Legoke et al., 1981). The weeding cost may be minimized to a great extent by use of suitable herbicides because they are cheaper, more convenient to use and more effective for weed control than manual weeding. Among various herbicides, atrazine is probably the most widely used herbicide for weed control in maize (Crafts, 1975). It is effective in controlling annual weeds and at higher concentrations, nutsedges are also controlled (Kasasian, 1971). Besides atrazine, few other herbicides have also been found suitable for controlling weeds in maize. Eradicane and metolachlor when mixed with atrazine have been found to be effective in achieving broader spectrum control of weed species (Pereira et al., 1976; Annon., 1979).

Inspite of the tremendous importance of maize, there is no available literature on supplementary irrigation of late sown maize in Nigeria. Weed control studies under such situations have also not been reported on. To fill these gaps, the present study was, therefore, undertaken with the following objectives:

(i) to find out the optimum frequency and amount of supplementary irrigation required for late sown maize; and

(ii) to evaluate the performance of two herbicide mixtures and hoe weeding in controlling weeds in late sown maize.

Chapter 2

LITERATURE REVIEW

2.1 Plant-Water Relations

Water is essential to the life and growth of plants. The growth and development of plants are influenced by their internal water balance. Water is the main constituent of protoplasm and makes up 85 to 95% of fresh weight of most of their green tissues (Russel, 1959). Absorption and loss of water by plants depend on their internal water balance, which in turn depends on the availability of soil water to plants.

Availability of water can be considered in terms of the total quantity of water available in the root zone of the crop. Water is absorbed by the plant roots and lost by the leaves during transpiration. If transpiration exceeds absorption, water deficit develops in plants. Transpiration is controlled by atmospheric factors such as solar radiation, temperature, humidity, wind, and so forth, while absorption is controlled by rate of transpiration, size and distribution of roots and soil factors such as temperature, acidity, texture and moisture availability.

The problem of plant and soil water relations have been studied extensively for many years. Miller (1938) estimated that maize plants transpire about 90% of all the water they absorb; a very small proportion (0.2%) is used in photosynthesis

and the rest is retained in the plant. Kramer (1949) confirmed earlier views that water stress in plants affects many physiological processes such as water uptake, root pressure, seed germination, stomatal closure, transpiration, photosynthesis and nitrogen metabolism. Later workers (Army and Kozlowski, 1951; Russel, 1959; Kozlowski, 1964) reaffirmed these views. Internal water deficits in plants can be the result of excessive transpiration or slow absorption or more commonly, a combination of both (Kramer, 1962). Chang (1968) estimated that rate of photosynthesis declined noticeably after a reduction of about 30% in water contents of leaves and ceases when 60% of the leaf moisture is lost. Variations outside these limits, however, occur.

2.1.1 Effects of moisture stress on maize

If there is insufficient water for absorption to compensate for transpiration loss, then a water deficit condition develops in plants. Water deficit has a great impact on plant development and this varies with the stage of growth. Inadequate moisture supply limits nutrient uptake and metabolic activities leading to reduced crop growth and yield. In maize, the effect of moisture stress is most evident at the peak water use periods which had been observed during the reproductive and grain filling stages (Salter and Goode, 1967; Freivalds, 1983).

Denmead and Shaw (1960) reported that moisture stress during vegetative growth, silking and grain development in maize

caused yield reductions of 25, 50 and 21%, respectively. Krishnamurthy et al. (1975) obtained yield reductions of 35, 24 and 10% owing to moisture stress at silking, grain filling and dough stages, respectively; the low yields being a consequence of high barrenness at silking and reduction in 1000-grain weight at both grain filling and dough stages. In their experiment, Gardner et al. (1981) observed that plants subjected to moisture stress at grain filling matured faster than those irrigated at that stage and greatest grain yield reductions were obtained when stress was imposed at pollination or grain filling stage. Harder et al. (1982) reported yield reductions of up to 33% due to moisture stress after silking which was also observed to be the most critical period of moisture stress.

Leaf water potential readings are also an important index of moisture status of plants. Crafts (1960) noted that stress may not set in until the leaf water potential approaches -16 bars. Nulsen and Thurtell (1978) stated that the main factor governing stable leaf water potential in plants was in the roots with stems and leaves exerting minor effects. Adeoye (1981) observed that leaf water potential should be above -10 bars to ensure normal plant water status. Annon. (1982a) at Kadawa, Nigeria, obtained safe leaf water potentials of up to -14 bars for wheat grown under a 10-day irrigation frequency.

Apart from the overall effect on yield, moisture stress exerts tremendous impact on most yield components of maize such

as ear size (length and diameter), Kernel numbers and weight, 1000-grain weight, shelling percentage and dry matter yield.

Robins and Domingo (1953) noticed progressive reduction in ear size with increase in degree of moisture stress. Claassen and Shaw (1970) reported reduction in ear size when moisture stress was imposed at 75% silking. Denmead and Shaw (1960) obtained reduced ear length owing to moisture stress at flowering.

Claassen and Shaw (1970) obtained significant reduction in Kernel numbers when stress was imposed before or during silking. Duncan (1975) proposed that ear and Kernel numbers are established shortly after pollination and hence any moisture stress at that period will adversely affect their numbers.

Robins and Domingo (1953) reported that moisture stress at tasselling caused reduction in fertilization due to shedding of non-viable pollen by the tassel and poor reception by the silk. This resulted in poor grain-filling which adversely affected the 1000-grain weight and yield. Moisture stress at silking has also been reported to cause a reduction in net assimilation rate of maize leading to a reduction in 1000-grain weight (Demead and Shaw, 1960; Claassen and Shaw, 1970).

Shelling percentage was reported to have been reduced from 82.7 to 77.6 due to moisture deficit at tasselling (Robins and Domingo, 1953). Wilson and Allison (1970) observed that moisture

stress at grain-filling reduced total dry matter yield.

Apart from the yield and yield components, moisture stress affects the height of the plant. Average height difference of 50cm was reported by Gardner et al. (1981) between fully irrigated and unirrigated plants.

2.1.2 Irrigation requirements of maize

When to irrigate and how much water to apply depend on the water needs of the crop, the water holding capacity of the soil, atmospheric conditions and the availability of irrigation water. Long season varieties generally require more seasonal amounts of water than short season varieties. Maize crop grown in areas with high water table conditions requires smaller individual and seasonal irrigations than those grown in low water table areas.

Chaudhary et al. (1975) reported that soil moisture content in upper 30cm before irrigation, ground water contribution and oxygen diffusion rate in upper 15cm soil depth accounted for 79% grain yield variation for maize grown at different static water table depths ranging from 60 to 150cm. In an experiment with wheat in the Nigerian savanna, Annon. (1984a) reported that variations in amounts of individual irrigations (30, 45 or 60mm) did not affect wheat yield significantly but simply increased the amount of water in the 0 to 30cm layer by about 30mm. Any amount of water applied in excess of 30mm percolated

beyond the 30cm depth and became part of the ground water.

Kaliappa et al. (1974) obtained highest maize grain yield of 2.15 t/ha with 302mm water applied at 50 and 75% depletion of available soil moisture at reproductive and vegetative stages, respectively. Nadanam and Morachan (1974) using 690mm water out of which 260mm was from rainfall, obtained highest maize yield of 4.4 t/ha when irrigation was given at 00% of available soil moisture. Morey et al. (1900) observed no significant yield differences when maize grown on a loamy sand soil was irrigated at 25, 50 and 75% of available soil moisture in the top 45cm of soil.

Irrigating any crop should be aimed at achieving high water use efficiency (WUE) which is expressed as the yield (dry matter or economic product) obtained per unit volume of water used (Evapo-transpiration). Grain yields of up to 7.05 t/ha were obtained when maize was irrigated to a depth of 2.5, 5.0 or 7.5cm; while grain yields and WUE were unaffected by irrigation depths (Deboer et al., 1977). Benz et al. (1970) obtained maximum WUE in unirrigated maize grown on shallow water table probably because the roots were deriving water from the slowly receding water table, a condition which enhanced root proliferation. Annon. (1984b) reported similar findings with wheat at Kadawa, Nigeria.

Excessive amount of water especially under poor drainage conditions has adverse effect on maize growth and yields.

Chan (1977) obtained a yield reduction of 37% when maize was subjected to water-logging for five days at knee-high and silking stages owing to oxygen stress caused by the anaerobic environment created by the water-logging. Walker et al. (1982) in an experiment on yield response of maize and soybeans to irrigation and drainage on a claypan soil obtained average maize grain yield increase of 4.0 t/ha due to synergistic effect of irrigation and drainage; furrow and sprinkler irrigation methods produced similar effects on grain yields.

2.1.3 Irrigation frequency for maize

Irrigation frequency refers to the number of days between water applications to a crop during periods of no rainfall. The irrigation frequency in any design is the time in days between irrigations in the period of highest consumptive use of the crops grown. It depends on the consumptive water use rate of a crop and on the amount of available moisture in the root zone and is a function of soil, crop and climate. For any given soil, sandy shallow soils must be irrigated more often than fine textured deep soils. Consumptive use of water or evapotranspiration (ET), denotes the quantity of water transpired by plants during their growth or retained in the plant tissue plus the moisture evaporated from the soil surface and the vegetation (Michael, 1978).

Effective rooting depth and poliferation tend to increase with decrease in soil moisture which may be due to a very wide

irrigation frequency. Frequent irrigations on the other hand, especially under high water table conditions in shallow soils and with an impermeable layer near the surface, may limit rooting in plants (Michael, 1978); an undesirable condition under inadequate soil moisture. Any frequency chosen must, therefore, guarantee adequate availability of moisture within the crop's effective root zone.

Many workers have used different methods to schedule irrigation or to determine irrigation needs of crops. Richards and Marsh (1961) worked with tensiometers, Marsh (1967) used soil moisture content, while Fischbach and Somerhalder (1974) used electrical resistance blocks. Use of evapotranspiration requires a very good knowledge of the crop ET rates but unfortunately, precise ET values are not available at present in Nigeria. The use of tensiometers is not reliable due to large gravels and stones in most of our sandy soils, which brings about poor contacts. The soil moisture sampling technique appears to be the most accurate method presently in use.

In northern Sudan, Nadi (1975) obtained highest maize yield with 40mm water applied at five days interval. Increasing irrigation increased plant height and extended growth period but reduced leaf area and water use efficiency. Nwa (1979) found that 330mm of water from sprinkler irrigation at seven-day interval or evenly distributed rainfall produced high maize yields. High yields above 3 t/ha were obtained if soil moisture

level was maintained at 70% of field capacity. At Bakura, Nigeria, Annon. (1981a) in an experiment on irrigation requirements of dry season maize in sandy soils obtained best yield with three-day irrigation interval. The five-day interval reduced yields by 25.5% but did not differ significantly from the seven and nine-day intervals.

Annon. (1982b) summarised three paramount factors in determining a correct irrigation schedule:

(i) atmospheric evaporative demand,

(ii) crop's phenological stage and

(iii) optimum soil moisture condition for crop growth.

He obtained no reduction in wheat yield until irrigation was given beyond 50% depletion of available soil moisture. Annon. (1982a) concluded from a two-year trial on wheat that a 21-day irrigation interval in high water table conditions (60 to 90cm) is beneficial because shorter intervals such as seven days will increase anaerobic condition, water-logging and salinity hazard. Annon. (1983a) observed that Kadawa (Nigeria) soils with significant water table fluctuations (80 to 120cm) can give wheat grain yield of 5 t/ha with 30mm water at seven or 10-day interval. Wider intervals between irrigations are likely to depress yields. Annon. (1983b) at Bakura, Nigeria, obtained high maize yields when adequate moisture was guarenteed by a three-day irrigation interval on a sandy soil during the reproductive phase and grain filling stages, the most critical periods of moisture requirement in the crop.

2.2 Weed Control

The traditional and prevalent method of controlling weeds in maize in Nigeria is the hoe-weeding which is very time consuming, laborious and expensive. On the other hand, chemical weed control is more effective and less expensive.

2.2.1 Weed competition in maize

Weed competition does very serious harm to maize growth and yield. In Nigeria, losses of up to 60% have been reported due to unchecked weed competition (Lagoke *et al.*, 1981). Most earlier workers agreed that maize is most sensitive to weed competition during the first month after sowing, while weed growth before 10 days or after 30 to 40 days appears to have less effect (Kneke and Slife, 1965; Okigbo, 1965; Nieto *et al.*, 1968). From experiments in North America, Staniforth (1957) observed that maize yields may not be reduced so long as the first weeding is carried out seven to 10 days before tasseling.

From a recent study, Sandhu and Gill (1973) identified a critical period of competition of two to six weeks after sowing with yield loss of up to 47.2% from weed competition. Chandra-Singh and Narayana Rao (1975) reported yield losses of 29 to 74% and the critical period of competition as the first month after sowing. Carson (1979) and Remison (1979) reported yield

losses of 54 and 50% in the forest zones of Ghana and Nigeria, respectively, the critical periods of weed competition being the first four weeks in the former and three to seven weeks after sowing in the latter. Bakut (1985) reported that critical period of weed competition in maize-pepper mixture was three to six weeks after sowing.

Other factors such as soil nutrient status and weed/crop light interception ability also play an important role in crop/weed competition. Nitrogenous fertilizers if adequately applied, generally appear to benefit maize more than weeds (Nieto and Staniforth, 1961; Staniforth, 1961). Dendixen and Stroube (1977) and Choudhary (1981) stated that nutsedge (Cyperus sp.) vigour is enhanced under high light intensity hence they emphasized the importance of optimum plant populations which will produce a good crop canopy to effectively cover the ground by the time the herbicides breakdown. This will go a long way in suppressing the growth of nutsedges and other problem weeds especially in Nigerian irrigation schemes. Ayeni (1982) stated that weed interference effects on maize grown in a subhumid region on a sandy loam soil was governed by crop season, cropping pattern, crop species and method of land preparation.

2.2.2 Weedicides for maize

Considering the effectiveness, cost and availability of herbicides in Nigeria, atrazine alone or its mixtures with some other herbicides like metolachlor or eradicane has been found to

be most suitable in controlling weeds effectively in maize.

a) Atrazine

Atrazine (2-chloro-4 ethyl-amino - 6 - isopropylamino - 1, 3, 5 - triazine) is a triazine herbicide used for pre-planting, pre-emergence and early post-emergence weed control in maize. More often, however, it is used as a pre-emergence herbicide because of the mixed cropping pattern of maize cultivation in most parts of Nigeria especially for broad-leaf weed control. When used as a post-emergence herbicide, the maize plant should be within 4cm height.

Under very dry conditions, atrazine has given better weed control when applied as an incorporated pre-planting treatment except in soils with high organic matter content (Kasasian, 1971). When applied as pre-planting, it appears to be more effective on grasses than when applied later.

Harmerton (1972) reported very effective control of grasses and sedges except Cyperus rotundus L. when atrazine at 3.3 kg a.i/ha was applied as pre-emergence to maize grown on a clay loam soil. Buchanan and Hiltbold (1973) after a four-year trial reported that atrazine at 2.8 and 5.6kg a.i/ha applied as pre-sowing and incorporated or as pre-emergence to maize,

effectively controlled grasses and broad-leaved weeds; method of application had no effect on herbicidal persistence but soil moisture enhanced degradation. Robison and Wittmus (1973) and Singh et al. (1973) after their respective three-year trials, obtained the most consistent and broadest spectrum weed control with atrazine. The later applied 6.72kg ai/ha of atrazine and obtained highest yields equivalent to those of hand-weeded control. Gill et al. (1973) observed better grass and broad-leaf weed control with 0.5kg ai/ha atrazine applied as pre-emergence plus one inter-row hoeing than two-hoe-weedings. Yield increases of 74 and 44% and weed control efficiencies of 94.7 and 95%, respectively, were recorded by them.

Using 0.5 to 2.0 kg ai/ha atrazine applied as pre-emergence Gita et al. (1975) obtained high grain yields equivalent to those from handweeded control plots; herbicidal activity lasted for seven to eight weeks with no residual toxicity on subsequent crops like linseed (Linum usitatisimum L.). Rai and Yadav (1976) using 1.75kg ai/ha atrazine obtained effective weed control and grain yield of 2.93 t/ha compared to 3.17 t/ha from thrice hand weeded plots. Meyer and Dryden (1979) noticed better atrazine action in a year with higher average rainfall and more effective control of most broad-leaved weeds.

Very good weed control especially of Cyperus sp. and other sedges have been reported by some workers with atrazine alone or its mixture with butylate. Chandra-Singh and Narayana Rao (1975) reported that atrazine plus butylate at 2.24 and 8.77kg ai/ha, respectively followed by one hoe-weeding gave best weed control. Cyperus rotundus and Echinochloa colonum were effectively controlled. Choudhary (1981) using a tank mixture of atrazine plus butylate at 2 and 6kg ai/ha obtained effective control of Cyperus sp. and other sedges which are increasingly becoming problem weeds in Nigerian irrigation schemes.

b) EPTC and its mixtures with atrazine

EPTC (S-ethyl N N - dipropyl - thiocarbamate) is a thiocarbamate herbicide which has produced very good results where Cyperus sp. is a problem (Kasasian, 1971). It is normally applied as pre-plant and incorporated due to its volatile nature. It is important that the depth of incorporation be less than the depth of sowing to avoid injury to seed, a situation which is more pronounced in coarse sandy soils (Waldrep and Freeman, 1964). To enhance the safety of EPTC, it is now used in mixture with its antidote R25788 (N, N-diallyl - 2, 2-dichloroacetamide), to obtain eradicane which is the new commercial product now in use.

Kasasian (1971) stated that though EPTC applied as soil incorporated controls Cyperus spp effectively, the herbicide loses effect after four to six weeks when the nutsedge starts to resprout under tropical environment; broad-larved weeds also start growth even if triazine herbicide is mixed with it. Gill et al. (1973) observed that EPTC at 2kg ai/ha incorporated before sowing gave short duration control of annual grasses and that a triazine mixture was needed for broader spectrum weed control. Capper (1975) and Burt and Akinsoroton (1976) reported very high herbicide selectivity to maize and weed control efficiency when EPTC was mixed with its antidote R25788 at 12:1 and 10:1 ratios, respectively. Without antidote, toxicity was enhanced by temperature and soil moisture in the later.

In an evaluation of various weed control treatments at Ibadan, Nigeria, Akobundu (1977) reported good weed control without injury to maize with eradicane at 6kg ai/ha applied as pre-sowing and incorporated. Dobrovodsky (1978) and Selley (1978) reported best weed control efficiency including Cyperus sp. with eradicane pre-sowing incorporated at 5 and 3 l/ha, respectively. The former obtained best results at drier sites while the later obtained best results when the herbicide was applied on a fine tilth. In Kenya and Zambia when eradicane was used as pre-sowing and incorporated, it effectively controlled Setaria viridis, Echinochloa crus-galli, Eleusine indica, Amaranthus sp.

and Cyperus sp. (Purnell and Bracey, 1978). Reductions in plant heights have been observed when eradicane was applied to maize grown on a silty loam soil (Zawierucha and Hartwig, 1983); yields were however not affected.

High weed control efficiency and maize yields have also been obtained when eradicane was mixed with atrazine. Among some herbicides tested on a sandy loam soil by Pereira et al. (1976), eradicane plus atrazine at 4 and 1kg ai/ha, respectively, gave highest maize yield and weed control efficiency. Weeds controlled included Cyperus rotundus, Paspalum sp. and Echinochloa crus-galli. In the forest zone of Ghana, best maize yields and weed control efficiency were obtained with EPTC plus atrazine at 3 and 1kg ai/ha, respectively. Moyer and Dryden (1979) and Dobrovodsky (1980) obtained high maize hields with a mixture of eradicane plus atrazine applied as pre-sowing and incorporated under dry conditions.

c) Metolachlor and its mixtures with atrazine

Metolachlor (x - chloro - 6 - ethyl - N - (2 - methoxy - 1 - methylethyl) - O - acetotoluidide) is a pre-emergence herbicide which is selective to maize. Soil moisture is necessary for its absorption hence adequate rainfall or irrigation is needed within two weeks of application especially when not incorporated (Crafts, 1975). When used alone, it is said to be effective in controlling annual

grasses and yellow nutsedge (Annon., 1980).

Dobrovodsky (1970) reported best weed control efficiency and yields with 4kg ai/ha metolachlor used on wet sites. Swain et al. (1978) obtained effective control of grasses such as Echinochloa crus-galli, Digitaria sanguinalis and Setaria sp. with metolachlor which was also noticed to have short residual life in the soil and requires sufficient soil moisture in the root zone for effective action. Highest maize yields of 5.47 t/ha were reported with 0.5kg ai/ha metolachlor applied pre-emergence to maize followed by one hoe-weeding after four weeks (Michieka, 1983).

Metolachlor has also been observed to cause significant reductions in plant heights of some maize hybrids though yields were not affected (Zawierucha and Hartwig, 1983). Moomaw et al. (1983) working on irrigated maize reported that metolachlor among many herbicides tried was very selective to maize and also controlled late germinating weeds.

Broader spectrum weed control have been reported by many workers when metolachlor was mixed with atrazine. Pruss et al. (1976) obtained effective control of annual grasses and broad-leaved weeds with a mixture of metolachlor and atrazine at 1.3 and 1.1kg ai/ha, respectively. Incorporation reduced herbicide activity on coarse textured

soils. Metolachlor plus atrazine at 2.5 and 1.25kg a.i./ha, respectively, effectively controlled most common grass weeds; also greater persistence was obtained with the mixture than with other mixtures even in places with limited soil moisture (Rowe et al., 1976). In Brazil, atrazine plus metolachlor (1:1.5) at 3kg a.i./ha gave best control of both grasses and broad-leaved weeds including Digitaria and Cenchrus spp. (Eschiapati and Dachler, 1976). Akobundu (1977) also reported from Ibadon, Nigeria, that broadest spectrum weed control and high grain yields were obtained with a mixture of metolachlor and atrazine at 2.5kg a.i./ha applied as pre-emergence.

Annon. (1979) obtained better weed control efficiency for up to six weeks when metolachlor was mixed with atrazine than when used alone; metolachlor was also noticed to be more compatible with atrazine than with other herbicides in their mixtures. Wetala (1979) observed a decline in broad-leaf weed control from 80 to 54% and grasses from 91 to 72%, respectively, at three and six weeks after sowing when atrazine plus metolachlor was applied at 3kg a.i./ha as pre-emergence to maize. Cyperus rotundus was not controlled. In Gambia, a mixture of atrazine and metolachlor at 1kg a.i./ha plus one hoe-weeding three and half weeks later, gave highest maize yields on a sandy loam soil (Annon., 1981). A mixture of atrazine plus metolachlor at 6kg a.i./ha applied pre-emergence

effectively controlled most annual grasses and broad-leaved weeds especially on sites with high soil moisture content or irrigation (Dabravodsky, 1980).

Chapter 3

MATERIALS AND METHODS

3.1 Experimental Site

The experiment was conducted at the Irrigation Research Station, Kadawa (11^{0} 39'N, 00^{0} 02'E and 500m above sea level) in the Sudan savanna ecological zone of Nigeria.

The soil at the experimental site is moderately deep, sandy loam with loamy sand tops. Details of the physico-chemical properties of the soil in 1984 are presented in Table 1. During the wet season, the underground water table at Kadawa rises sharply and begins to fluctuate downwards with the inception of the dry season.

The total rainfall recorded during 1984 was 542.6mm with only 110.4mm during the period of experimentation. The total amount of rainfall received in 1984 was less than the average rainfall (759.6mm) for the last ten years (1974 to 1983). The rainfall distribution at Kadawa during 1984 wet season is show in Table 2.

3.2 Treatments

Two sets of treatments consisting of irrigation and weed control were investigated as shown below:

Table 1: Physico-chemical properties of the soil collected up to a depth of 30cm from the experimental location at Kadawa.

Soil Properties	Characteristics
Physical properties	
Sand (%)	52.4
Silt (%)	35.6
Clay (%)	12.0
Textural class	Sandy loam
Chemical properties	
pH in H_2O	6.3
pH in 0.01M $CaCl_2$	5.8
Organic C (%)	0.35
Total N (%)	0.020
Total P (ppm)	102.24
Exchangeable cations (Meq/100g soil)	
Na	0.125
K	0.110
Ca	3.620
Mg	0.061
CEC	5.30

Table 2: Rainfall distribution at Kadawa during the 1984 wet season.

Period		Rainfall (mm)
April	1 - 10	0.0
	11 - 20	0.0
	21 - 30	10.3
May	1 - 10	45.0
	11 - 20	6.0
	21 - 31	51.1
June	1 - 10	31.5
	11 - 20	42.9
	21 - 30	4.6
July	1 - 10	37.4
	11 - 20	54.4
	21 - 31	60.2
August	1 - 10	20.3
	11- 20	14.4
	21 - 31	51.2
September	1 - 10	02.0
	11 - 20	5.5
	21 - 30	24.2
October	1 - 10	0.0
	11 - 20	0.8
	21 - 31	0.0
	Total	542.6mm

Irrigation: (Main-plots)
- I_1 = 7-day irrigation interval
- I_2 = 14-day irrigation interval.
- I_3 = 21-day irrigation interval.
- I_4 = Irrigation at severe moisture stress.

Weed control: (Sub-plots)
- W_1 = Two hoe weedings (at three and six weeks after sowing).
- W_2 = Atrazine + eradicane (EPTC + R25788) at 1.5 + 2.0kg a.i./ha applied pre-sowing incorporated plus supplementary hoe-weeding at six weeks after sowing.
- W_3 = Atrazine + metolachlor at 1.25 + 1.25kg a.i./ha applied pre-emergence plus supplementary hoe-weeding at six weeks after sowing.

Furrow irrigation method was employed with the aid of plastic syphons of 5.5cm diameter. Irrigation treatments started five weeks after sowing when the dry season had commenced. At each irrigation 65mm net water was applied to bring the soil to field capacity. Details of the irrigation scheduling and total amount of water applied are shown in Table 3.

3.3. Experimental Design and Plot Size

The experiment was laid out in a split-plot design and replicated five times. The four irrigation and three weed control treatments were randomly allocated in the main and sub-plots, respectively.

The size of each main and sub-plot was 17.0 x 4.5m and

Table 3: Irrigation scheduling and total amount of water applied to late sown maize at Kadawa in 1984.

Treatments	Initial irrigation	Number of irrigations as per schedule	Total number of irrigations	Total amount of water applied(mm)
7-day irrigation interval	1	10	11	715
14-day irrigation interval	1	5	6	390
21-day irrigation interval	1	4	5	325
Severe moisture stress	1	0	1	65

5.0 x 4.5m, respectively. To prevent seepage, a border of 1.5m between main-plots and 1.0m between sub-plots was left. In a sub-plot, six ridges at 75cm apart were made for sowing maize. Two outermost ridges were discarded, the two innermost ridges were used as net plot for measuring yield and yield components, and the other two ridges were used for sampling.

3.4 Agronomic Practices

The field was ploughed, disc-harrowed and ridged. A basal application of 60kg N and 60kg P_2O_5 as compound fertilizer and 50kg K_2O/ha as muriate of potash was applied just before ridging. Second dose of nitrogen at 60kg N/ha as calcium ammonium nitrate was applied six weeks after sowing. The seeds of variety TZESR which is high yielding, streak virus resistant and adapted to the zone were sown on 4 September, 1984 i.e. towards the end of the rainy season.

Two seeds were sown per hole at 25cm intra-row spacing and later thinned down to one plant per stand to give a population of 44,444 plants per hectare.

The herbicides were applied with a CP3 Knapsack sprayer using a deflector nozzle at a swath of 0.75m, pressure of 2.1kg/cm^2 and volume rate of 267 l/ha.

Following a minor attack of spittlebugs (Locris ruben), Vetox 85 was sprayed in the field on 24 October, 1984, at the rate of 1.12kg a.i./ha. There was no other significant insect or pest attack.

3.5 Data Collection

3.5.1 Weeds

A list of the weed species found in the experimental area before land preparation and at harvest is presented in Appendix A.

Weed cover score

Visual weed cover score based on a scale of 0 to 10 where 0 = no weed and 10 = fully covered with weeds, was taken from each sub-plot at three and six weeks after sowing and at harvest.

Weed weight

A quadrant measuring 0.5m x 0.5m was used to take weed samples from the discarded area at three and six weeks after

sowing and at harvest. The above ground portions of the weed samples were oven-dried to a constant weight and weighed.

3.5.2 Irrigation

Soil moisture

Soil samples were collected one to two days before and after every irrigation with an auger from the 0 to 30cm and 30 to 45cm depth and used to determine soil moisture (%) after oven drying. Three soil samples were collected from each irrigation treatment and their average was used for the calculation of soil moisture value.

Leaf water potential

Using a pressure bomb (Bayer, 1967; DeRon, 1969), leaf water potential readings were taken one to two days before and after every irrigation. In each irrigation treatment, three maize plants were randomly selected for this study. For each plant, two middle leaves were used for measuring leaf water potential. The mean value obtained was recorded for each irrigation treatment.

3.5.3 Crop

The methods of collection of various crop data were as follows:

Emergence count

Plants were counted in the two central ridges (i.e. the net plot) at 10 days after sowing.

Plant height

Plant height was measured at three, six and nine weeks after sowing from the base of the plant to the tip of the last formed leaf or to the base of the tassel as the case may be. In each plot, five plants were measured.

Dry matter

Five plant samples per plot from the sampling ridges were uprooted and air dried to a constant weight and then their weights (excluding the roots) were taken.

Stand count at harvest

Stand count from the net plot was taken at harvest and was expressed as a per cent of the emergence count.

Yield and yield components

The following yield and yield components were investigated:

Grain yield

The grain yield from each net plot area was used to calculate the proportionate yield obtainable from one hectare.

Stalk yield

The grain yield per plot was subtracted from the total dry matter of the plant (excluding roots) to obtain the stalk yield.

Number of ears per plant

This was obtained by dividing the total ear number from the net plot by the stand count at harvest.

In the following parameters, 20 ear samples from each net plot were used.

Ear length

The average ear length from each plot was recorded.

Ear diameter

The average ear diameter from each plot was recorded.

Kernel depth

It was obtained by subtracting the stone diameter from the ear diameter.

Number of grains per ear

The average number of grains per ear from each plot was recorded.

Weight of grains per ear

The average weight of grains per ear from each plot was recorded.

1000-grain weight

A random physical count of 1000-grains from the net plot grain yield was done and weighed to give the 1000-grain weight for that plot.

Shelling percentage

The grain yield from the 20 sample ears in each plot was expressed as a per cent of the weight of the 20 ears to obtain the shelling percentage.

3.6 Data Analysis

The data collected were statistically analysed as described by Snedecor and Cochran (1967). Where F test showed significance, the treatment means were compared by the least significance difference (LSD) technique at probability level of five per cent (5%).

Chapter 4

RESULTS

4.1 Effects of Treatments on Weeds

The effects of irrigation and weed control treatments on weed cover score and weed dry matter are presented in Tables 4 and 5.

4.1.1 Weed cover

As irrigation treatments commenced at five weeks after sowing (w.a.s.), there was no effect of irrigation on weed score at three and six weeks after sowing. At harvest also, there were no significant differences between the irrigation treatments (Table 4).

At three weeks after sowing, twice hoe weeded plots had significantly higher weed cover scores (2.70) than herbicide treated plots whereas at six weeks after sowing, the same treatment had lowest weed score (1.00). The two herbicide treatment effects were similar on both observation dates. For the herbicide treatments, weed cover increased with time up to six weeks. At harvest however, there were no significant differences between the weed control treatments. Interaction effects between irrigation and weed control treatments were not significant.

Table 4: Effect of irrigation and weed control measures on weed cover score at three and six weeks after sowing and at harvest at Kadawa in 1984.

Treatment	Weed cover score		
	3 w.a.s.	6 w.a.s.	Harvest
Irrigation			
7-day irrigation interval	1.30	1.60	1.90
14-day irrigation interval	1.00	1.60	1.60
21-day irrigation interval	1.10	1.30	1.60
Severe moisture stress	1.10	1.40	1.40
S.E. (±)	0.11	0.12	0.20
L.S.D. (0.05)	NS	NS	NS
Weed control			
Hoe-weeded at 3 & 6 w.a.s.	2.70	1.00	1.00
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	0.50	1.70	1.70
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	0.40	1.60	1.60
S.E. (±)	0.07	0.10	0.09
L.S.D. (0.05)	0.21	0.30	NS
Interaction			
Irrigation x Weed control	NS	NS	NS

*Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant

4.1.2 Weed dry matter

The total weed dry matter weight presented in Table 5 includes dry weight of weeds collected at three and six weeks after sowing.and at harvest. Irrigation frequency had no effect on weed dry matter. There was significant difference amongst the weed control treatments. Both herbicide treatments were found to be significantly superior in controlling the weeds than the hoe-weeded treatment as they produced lower weed dry matter weight than the latter. Among the two herbicide treatments, atrazine + metolachlor produced less dry matter (2.41 t/ha) than atrazine + eradicane which produced 2.61 t/ha. However, there was non-significant difference among the two. Interaction effects were non-significant.

4.2 Effect of Irrigation on Soil Moisture Content (%)

Variations in soil moisture readings at eight and 12 weeks after sowing before and after irrigation are presented in Table 6. At eight weeks after sowing, a range of 6.8 to 8.7% was obtained before irrigation while a close range of 12.2 to 13.1% was obtained after irrigation. The lowest soil moisture content of 5% was obtained from the severe moisture stress at 12 weeks after sowing, while a close range of 9.1 to 10.5% was obtained after irrigation at 12 weeks after sowing.

4.3 Effects of Treatments on Crop

The effects of irrigation and weed control treatments on

Table 5: Effect of irrigation and weed control measures on total weed dry matter at Kadawa in 1984.

Treatment	Total weed dry matter (t/ha)
Irrigation	
7-day irrigation interval	2.99
14-day irrigation interval	2.78
21-day irrigation interval	2.84
Severe moisture stress	2.37
S.E. (±)	0.36
L.S.D. (0.05)	NS
Weed control	
Hoe-weeded at 3 & 6 w.a.s.	3.43
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	2.61
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	2.41
S.E. (±)	0.17
L.S.D. (0.05)	0.48
Interaction	
Irrigation x Weed control	NS

*Hoe weeding at six weeks after sowing (w.a.s.)

Table 6: Variations in soil moisture reading (%) at eight and 12 weeks after sowing (w.a.s.) of maize before and after irrigation at Kadawa in 1984.

Irrigation treatments	Before irrigations		After irrigations	
	8 w.a.s.	12 w.a.s.	8 w.a.s.	12 w.a.s.
7-day irrigation interval	8.0	8.2	12.2	10.5
14-day irrigation interval	8.4	6.8	12.8	9.5
21-day irrigation interval	8.7	6.8	13.1	9.1
Severe moisture stress	6.8	5.0	N.I.	N.I.

N.I. = No irrigation

various crop parameters such as emergence, growth, yield and yield components are presented in Tables 7 to 15.

4.3.1 Emergence and stand count at harvest

Pre-sowing or pre-emergence application of herbicides did not affect maize emergence. Emergence percentage ranged from 94.2 to 98.4 (Table 7).

The stand count at harvest was also not affected by either the irrigation or weed control treatments and these ranged from 90.3 to 94.7% for irrigation treatments and 91.5 to 93.5% for the weed control treatments. There were no significant interaction effects between irrigation and weed control treatments on both parameters.

Table 7: Effect of irrigation and weed control measures on emergence and stand count of maize at harvest at Kadawa in 1984.

Treatment	Emergence (%)	Stand count at harvest (%)
Irrigation		
7-day irrigation interval	95.5	91.9
14-day irrigation interval	90.4	94.7
21-day irrigation interval	94.8	93.2
Severe moisture stress	94.2	90.3
S.E. (±)	1.4	1.6
L.S.D. (0.05)	NS	NS
Weed control		
Hoe-weeded at 3 & 6 w.a.s.	97.1	93.5
Atrazine + eradicane (1.5 + 2.0kg a.i./ha) + HW*	94.8	91.5
Atrazine + metolachlor (1.25 + 1.25kg a.i./ha) + HW*	95.4	92.7
S.E. (±)	1.1	1.3
L.S.D. (0.05)	NS	NS
Interaction		
Irrigation x Weed control	NS	NS

* Hoe-weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

4.3.2 Plant height

Plant heights at three, six and nine weeks after sowing are presented in Table 8. Plant height was not affected by irrigation treatments at three and six weeks after sowing but irrigation effect became significant at nine weeks after sowing. Plants irrigated at seven, 14 and 21 days intervals were significantly taller (100.0, 169.0 and 100.1cm, respectively) than those grown under severe moisture stress (154.9cm). Plant height was not significantly affected by any of the weed control treatments. Interaction effects were not significant.

4.3.3 Leaf water potential

Diurnal fluctuations of leaf water potentials for the different irrigation treatments are presented in Figs. 1, 2 and 3. Identical leaf water potentials were obtained at eight weeks after sowing (Fig. 1) presumably because irrigation treatments had just commenced at five weeks after sowing. Lowest leaf water potential of -11.7 bars was obtained from the severely stressed crops at 12 weeks after sowing (Fig. 2). Mean leaf water potential values after irrigation were identical for seven, 14 and 21 days irrigation interval treatments and generally ranged from -4.0 to -5.6 bars between 07.00 and 14.00 hours (Fig.3).

4.3.4 Plant dry matter

At three and six weeks after sowing, irrigation treatments

Table 8: Effect of irrigation and weed control measures on plant height of maize at 3, 6 and 9 weeks after sowing at Kadawa in 1984.

Treatment	Plant height (cm) Weeks after sowing		
	3	6	9
Irrigation			
7-day irrigation interval	27.9	137.1	100.0
14-day irrigation interval	29.8	124.1	169.0
21-day irrigation interval	29.8	134.1	100.1
Severe moisture stress	28.0	122.5	154.9
S.E. (±)	1.0	5.8	3.7
L.S.D. (0.05)	NS	NS	11.3
Weed control			
Hoe-weeded at 3 & 6 w.a.s.	29.6	123.5	169.2
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	29.9	132.8	169.2
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	27.1	127.2	174.0
S.E. (±)	0.9	3.9	3.2
L.S.D. (0.05)	NS	NS	NS
Interaction			
Irrigation x Weed control	NS	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant

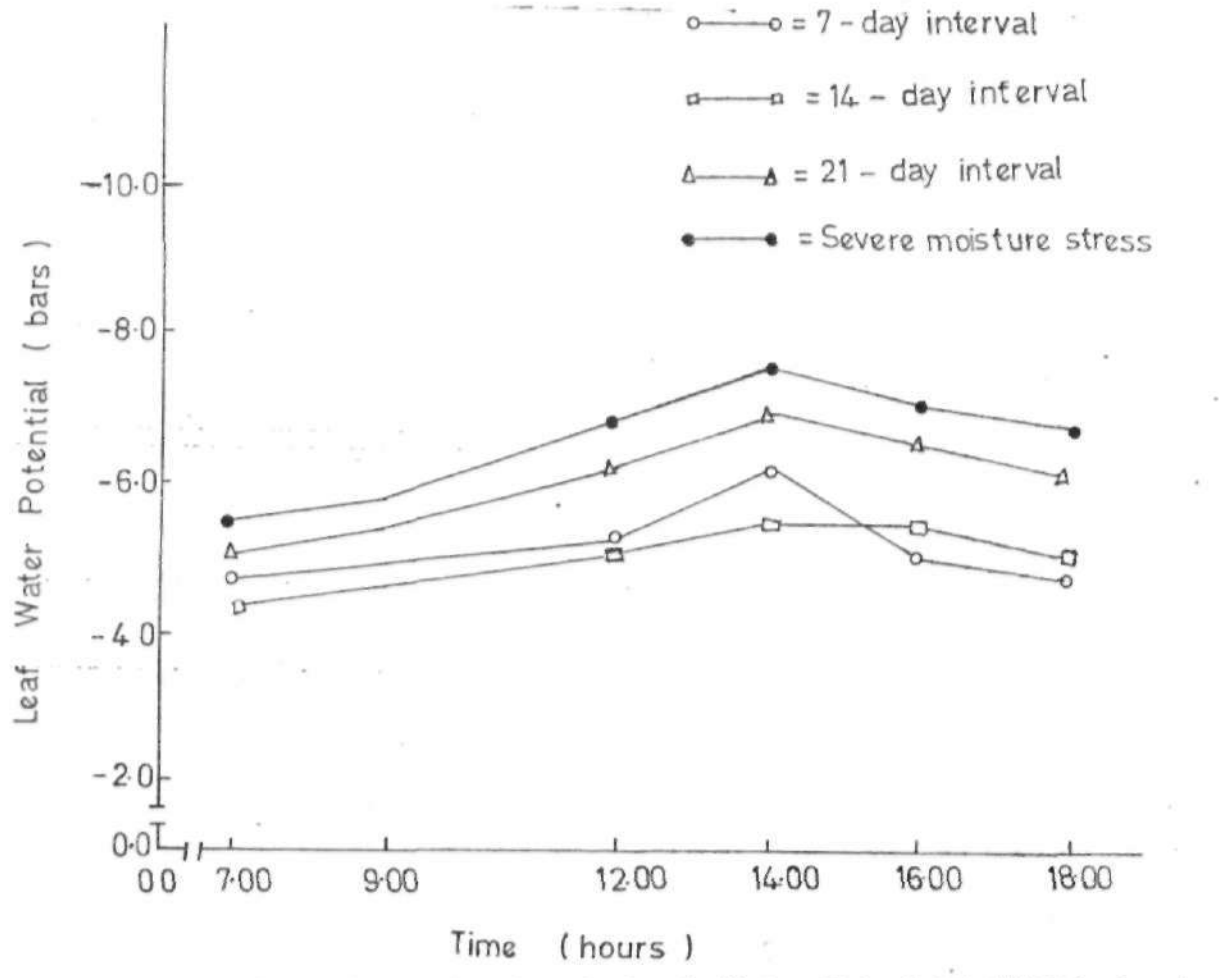


Fig.1 Diurnal fluctuation in Leaf Water Potential (LWP) of maize before irrigation as affected by irrigation schedules at 8 weeks after sowing.

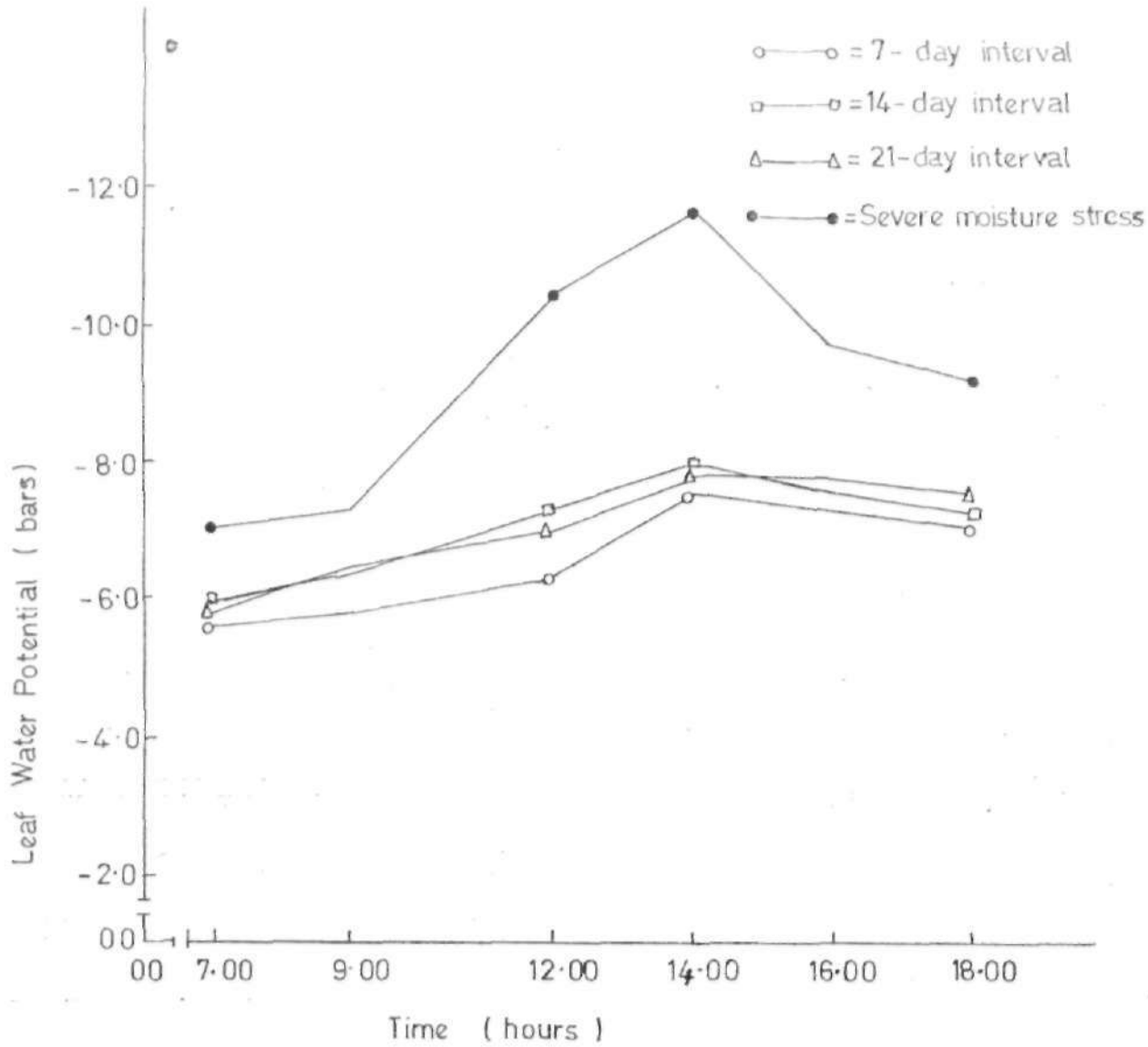


Fig.2 Diurnal fluctuation in Leaf Water Potential (LWP) of maize before irrigation as affected by irrigation schedules at 12 weeks after sowing.

did not significantly affect plant dry matter (Table 9). However, at nine weeks after sowing, irrigation at seven, 14 and 21 days interval produced significantly higher dry matter than those grown under severe moisture stress. Highest dry matter production (207.8g/plant) was obtained from plots irrigated at 21 days interval while the seven and 14 days irrigation interval crops produced similar dry matter weights (193.4 and 194.9g/plant, respectively). Weed control treatments did not significantly affect dry matter production at all the observation dates. Interaction effects were found to be non-significant.

4.3.5 Days to 50% tasselling

Irrigation significantly affected the length of time the plants took to tassel (Table 10). Plants irrigated at seven, 14 and 21 days interval tasseled 54 to 57 days after sowing whereas plants grown under severe moisture stress tasseled 62 days after sowing (i.e. five to eight days later). Weed control treatments did not affect tasselling. Interaction effects were non-significant.

4.3.6 Days to 50% silking

Irrigation treatments caused significant variation in days to 50% silking. Severely stressed plants silked at 72 days after sowing (Table 10), while the seven, 14 and 21 days irrigation interval plants silked at about 63 to 66 days after

Table 9: Effect of irrigation and weed control measures on dry matter per plant of maize at 3, 6 and 9 weeks after sowing at Kadawa in 1984.

Treatment	Dry matter (g)		
	Weeks after sowing		
	3	6	9
Irrigation			
7-day irrigation interval	3.17	86.6	193.4
14-day irrigation interval	3.09	86.2	194.9
21-day irrigation interval	3.09	76.8	207.8
Severe moisture stress	2.92	78.5	143.4
S.E. (±)	0.19	3.2	8.9
L.S.D. (0.05)	NS	NS	27.5
Weed control			
Hoe-weeded at 3 & 6 w.a.s.	3.06	80.0	170.4
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	2.82	78.4	196.0
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	3.33	80.7	180.2
S.E. (±)	0.16	0.72	13.2
L.S.D. (0.05)	NS	NS	NS
Interaction			
Irrigation x Weed control	NS	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

Table 10: Effect of irrigation and weed control measures on days to 50 per cent tasselling and silking of maize at Kadawa in 1984.

Treatment	Days to 50% tasselling	Days to 50% silking
Irrigation		
7-day irrigation interval	57.0	66.0
14-day irrigation interval	56.0	63.0
21-day irrigation interval	54.0	63.0
Severe moisture stress	62.0	72.0
S.E. (±)	1.3	1.7
L.S.D. (0.05)	4.2	5.5
Weed control		
Hoe-weeded at 3 & 6 w.a.s.	56.0	63.0
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	58.0	63.0
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	55.0	61.0
S.E. (±)	0.9	1.0
L.S.D. (0.05)	NS	NS
Interaction		
Irrigation x Weed control	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

sowing. Weed control treatments had no effect on days to 50% silking. There were no significant interaction effects.

4.3.7 Grain yield

Grain yield/ha was very much affected by irrigation treatments. Highest grain yield of 5544kg/ha was obtained in plots irrigated at seven days interval while lowest grain yield of 2027kg/ha was obtained from severely stressed plots (Table 11). Plants grown under irrigation significantly out-yielded those grown under severe moisture stress. Irrigation at seven days interval produced significantly higher yields than irrigation at 14 and 21 days interval. Though the three weed control treatments did not significantly affect the grain yield, atrazine + erradicane produced more grain yield (4502kg/ha) than atrazine + metolachlor (4331kg/ha) and twice hoe-weeding (4191kg/ha). Interaction effects were not significant.

4.3.8 Stalk yield

Like grain yield, stalk yield was also affected by irrigation treatments. Irrigation at seven and 21 days interval being statistically similar, yielded more stalk than the 14 days interval and severe moisture stress plants (Table 11). Highest stalk yield of 7929kg/ha was obtained from plots irrigated at seven days interval while lowest stalk yield of 4129kg/ha was obtained from plots subjected to severe moisture stress. Maize stalk yield was not significantly affected by weed

Table 11: Effect of irrigation and weed control measures on grain and stalk yields of maize at Kadawa in 1984.

Treatment	Yields in kg/ha	
	Grain	Stalk
Irrigation		
7-day irrigation interval	5544	7929
14-day irrigation interval	4471	6209
21-day irrigation interval	4523	7690
Severe moisture stress	2827	4129
S.E. (±)	167	332
L.S.D. (0.05)	523	1022
Weed control		
Hoe-weeded at 3 & 6 w.a.s.	4191	5995
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	4502	6864
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	4331	6615
S.E. (±)	167	266
L.S.D. (0.05)	NS	NS
Interaction		
Irrigation x Weed control	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

control treatments, but like grain yield, highest stalk yield was obtained from atrazine + eradicane treated plots. Interaction effects were non-significant.

4.3.9 Number of ears per plant

Highest and lowest number of ears (1.40 and 1.14) per plant were produced when irrigation was given at seven and 14 days intervals, respectively (Table 12). Plants irrigated at seven and 21 days interval produced similar number of ears per plant (1.40 and 1.36) while the severely stressed plants and plants irrigated at 14 days interval also had similar number of ears per plant (1.20 and 1.14). However, plants irrigated at seven and 21 days interval produced significantly more ears per plant than those grown under severe moisture stress. Weed control treatments did not affect number of ears per plant. No significant interactions between irrigation and weed control treatments were observed.

4.3.10 Ear length

There was a significant reduction in ear length in severely stressed plants as compared to plants irrigated at seven, 14 and 21 days interval (Table 13). Plants irrigated at seven and 21 days interval being at par produced ears of 16.6 and 15.8cm, respectively. There was no significant difference between the ear lengths of 14 and 21 days irrigation intervals. Weed control treatments did not affect ear length significantly.

Table 12: Effect of irrigation and weed control measures on number of ears per plant of maize at Kadawa in 1984.

Treatment	Number of ears per plant
Irrigation	
7-day irrigation interval	1.40
14-day irrigation interval	1.14
21-day irrigation interval	1.36
Severe moisture stress	1.20
S.E. (±)	0.04
L.S.D. (0.05)	0.14
Weed control	
Hoe-weeded at 3 & 6 w.a.s.	1.31
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	1.32
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	1.31
S.E. (±)	0.04
L.S.D. (0.05)	NS
Interaction	
Irrigation x Weed control	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

Table 13: Effect of irrigation and weed control measures on ear length, ear diameter and kernel depth of maize at Kadawa in 1984.

Treatment	Ear length (cm)	Ear diameter (cm)	Kernel depth (cm)
Irrigation			
7-day irrigation interval	16.60	4.11	1.07
14-day irrigation interval	15.10	3.96	0.99
21-day irrigation interval	15.00	4.04	1.05
Severe moisture stress	13.90	3.75	0.93
S.E. (±)	0.29	0.03	0.02
L.S.D. (0.05)	0.09	0.09	0.07
Weed control			
Hoe-weeded at 3 & 6 w.a.s.	15.40	3.96	1.02
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	15.40	3.93	1.05
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	15.20	3.97	1.01
S.E. (±)	0.20	0.03	0.02
L.S.D. (0.05)	NS	NS	NS
Interaction			
Irrigation x Weed control	NS	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

Interaction effects were not significant.

4.3.11 Ear diameter

Like ear length, ear diameter was also significantly effected by irrigation. Wider ears (4.11cm) were produced when irrigation was given at seven days interval and these were at par with ears from the 21 days irrigation interval (Table 13). Plants under severe moisture stress produced significantly narrower ears (3.75cm) compared to irrigated plants. Irrigation at 14 and 21 days interval produced ears with identical diameter. Weed control treatments did not affect ear diameter significantly. There were no significant interaction effects.

4.3.12 Kernel depth

Kernel depth was also affected by irrigation treatments. Highest and lowest kernel depths of 1.07 and 0.93cm were obtained from the seven day irrigation interval and severely stressed crops, respectively, and these differed significantly from each other (Table 13). Among the three irrigation intervals, the seven and 21 days intervals which were statistically similar, produced significantly deeper kernel depths than that of the 14 days interval plants (0.99cm). Weed control treatments had no significant effect on kernel depth. Interaction effects were non-significant.

4.3.13 Number of grains per ear

Number of grains per ear was significantly affected by

irrigation treatments. The irrigation treatments of seven, 14 and 21 days interval produced grain numbers that were similar but these were significantly higher than that obtained with severe moisture stress (Table 14). Highest grain number per ear (443) was obtained from the seven days irrigation interval while severely stressed plants had the lowest grain numbers (386) per ear. The weed control treatments did not differ significantly in this aspect. Similarly, no significant irrigation x weed control treatment interactions were obtained.

4.3.14 Weight of grains per ear

Significantly lowest grain weight (73g) was obtained from plants grown under severe moisture stress (Table 14). There was no significant difference between the other three irrigation treatments. There was no significant effect of weed control treatments on grain weight per ear though the highest value of 97g was obtained from plants treated with atrazine + eradicane. Interaction effects between irrigation and weed control treatments were non-significant.

4.3.15 1000-grain weight

The 1000-grain weight was markedly affected by the irrigation treatments. Plots irrigated at seven, 14 and 21 days intervals did not differ significantly from each other but they produced significantly higher 1000-grain weights than severely stressed plots (Table 15). The seven-day irrigation interval

Table 14: Effect of irrigation and weed control measures on number of grains and weight of grains per ear of maize at Kadawa in 1984.

Treatment	Number of grains per ear	Weight of grains per ear (g)
Irrigation		
7-day irrigation interval	443.0	107.0
14-day irrigation interval	439.0	90.0
21-day irrigation interval	430.0	101.0
Severe moisture stress	386.0	73.0
S.E. (±)	10.9	7.0
L.S.D. (0.05)	33.8	22.4
Weed control		
Hoe-weeded at 3 & 6 w.a.s.	419.0	94.3
Atrazine + eradicane (1.5 + 2.0kg ai/ha) + HW*	437.0	97.0
Atrazine + metolachlor (1.25 + 1.25kg ai/ha) + HW*	418.0	93.0
S.E. (±)	8.5	1.3
L.S.D. (0.05)	NS	NS
Interaction		
Irrigation x Weed control	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

Table 15: Effect of irrigation and weed control measures on 1000-grain weight and shelling percentage of maize at Kadawa in 1984.

Treatment	1000-grain weight (g)	Shelling percentage
Irrigation		
7-day irrigation interval	242.0	83.0
14-day irrigation interval	223.0	81.0
21-day irrigation interval	234.0	81.6
Severe moisture stress	190.0	79.6
S.E. (±)	5.5	1.5
L.S.D. (0.05)	17.1	NS
Weed control		
Hoe-weeded at 3 & 6 w.a.s.	225.0	81.3
Atrazine + eradicane (1.5 + 2.0kg a.i/ha) + HW*	222.0	82.6
Atrazine + metolachlor (1.25 + 1.25kg a.i/ha) + HW*	220.0	80.0
S.E. (±)	4.9	1.3
L.S.D. (0.05)	NS	NS
Interaction		
Irrigation x Weed control	NS	NS

* Hoe weeding at six weeks after sowing (w.a.s.)

NS = Not significant.

gave the highest 1000-grain weight of 242g while the lowest weight of 190g was obtained from the severe moisture stress treatment. Weed control treatments did not significantly affect the 1000-grain weight. Interaction effects between irrigation and weed control treatments were not significant.

4.3.16 Shelling percentage

Though there were no significant differences among the four irrigation treatments (Table 15), highest and lowest shelling percentages were obtained with irrigation at seven days interval and under severe moisture stress, respectively. Shelling percentage was not significantly affected by weed control treatments. Interaction effects were non-significant.

Chapter 5

DISCUSSION

5.1 Effects of Irrigation and Weed Control Treatments on Weeds

5.1.1 Weed cover

Irrigation treatments had no significant effect on weed cover score at three and six weeks after sowing (w.a.s.) since the treatments commenced after five weeks of sowing. At harvest also, irrigation treatments did not affect weed cover score (Table 4). This may be because weeds emerging after the general hoe-weeding at six weeks after sowing could no longer compete with the maize crop which had developed sufficient canopy cover by that time to effectively suppress the late emerging weeds due to shading, irrespective of moisture regimes. With good crop canopy, variation in moisture regime may no longer be a major factor for weed growth.

Pre-emergence application of herbicides and optimum plant population providing a good canopy suppress early and late emerged weeds, respectively (Sendixen and Stroube, 1977; Choudhary, 1981).

At three weeks after sowing, twice hoe-weeded plots had significantly higher weed cover scores than herbicide treated plots because weed cover score observation was taken just before hoe-weeding at three weeks after sowing (Table 4). There was no

significant difference between the two herbicide treatments, although atrazine + metolachlor mixture at 1.25 + 1.25kg ai/ha was found to be slightly better than the atrazine + eradicane mixture at 1.5 + 2.0kg ai/ha. The herbicides performed better than two hoe weedings as a result of more effective control of broad-leaf weeds and sedges. Among the broad-leaf weeds, Vernonia pauciflora (L.), Amaranthus spinosus (L.), Acanthospermum hispidium DC., Ageratum conyzoides (L.) and Commelina benghalensis (L.) were the most controlled ones (Appendix A).

At six weeks after sowing, the weed cover score followed the same trend as at three weeks after sowing for the herbicide treatments. The twice hoe-weeded plots had significantly lower weed cover score (Table 4) because one hoe-weeding was done at three weeks after sowing. The higher weed cover scores from the herbicide treated plots might be due to declining effectiveness of the herbicides. Kasasian (1971) made a similar observation with atrazine + EPTC mixture and Swain et al. (1978) and Wetala (1979) with metolachlor and its mixtures with atrazine.

The weed control treatments produced identical weed cover scores at harvest. This was because all the plots received a general hoe weeding at six weeks after sowing.

5.1.2 Weed dry matter

Consistent with the trend observed for weed cover

score, irrigation treatments did not affect weed dry matter (Table 5). The slightly lower dry matter of 2.37 t/ha obtained from severe moisture stress plots was as a result of moisture deficiency in uppermost soil layers which adversely affected most of the shallow rooting weeds.

Plots hoe-weeded twice produced significantly more weed dry matter (3.43 t/ha) than herbicide treated plots (Table 5). This is due to relatively heavier weed infestation at three weeks after sowing in the twice hoe-weeded plots than the herbicide treated plots (Table 4).

5.2 Effects of Irrigation and Weed Control Treatments on Crop

5.2.1 Emergence and stand count at harvest

Weed control treatments had no significant effect on maize emergence (Table 7). The slightly lower emergence percentage obtained with the herbicide treated plots might be as a result of minor seed injury which is sometimes observed with herbicides. Similar findings were reported by Waldrep and Freeman (1964) with eradicane.

Stand count at harvest was not effected by irrigation treatments (Table 7) since the plants were fully established before commencement of irrigation treatments. Maize plants even in the severe moisture stress treatments did not attain the permanent wilting point at any stage hence there was not

appreciable reduction in stand count at harvest. The soil moisture readings (Table 6) before and after irrigations also indicate that permanent wilting condition was not attained. After irrigations, the soil moisture content was brought back to near field capacity by the uniform 65mm water applied. The lowest leaf xylem water potential at 12 weeks after sowing was -11.7 bars which was obtained from the severe moisture stress plants (Fig. 1) and always, good overnight recovery was achieved. Adeoye (1981) stated that leaf water potential should be above -10 bars to ensure sufficient plant water status while Crafts (1960) noted that stress may not set in until leaf water potential approaches -16 bars. Annon. (1982a) at Kadawa, Nigeria, obtained safe leaf water potentials of up to -14 bars for wheat grown under 10 days irrigation frequency. Moreover, at no time were the plants subjected to water-logging even under the seven-day irrigation frequency as this could induce oxygen stress due to anaerobic conditions which could lower stand count and yield. Ohen (1977) emphasized the harmful effects of water-logging to maize stand establishment and yield.

The weed control treatments had no effect on the stand count at harvest presumably because at no stage in the growth of the plant were the weeds allowed to compete critically with the crop.

5.2.2 Plant height

Plant height at three and six weeks after sowing was

not effected by irrigation treatments obviously as a result of the late commencement (five weeks after sowing) of the irrigation treatments (Table 8). At nine weeks after sowing, however, plant height was significantly reduced due to severe moisture stress. This may be attributed to chlorophyll deficiency in late formed leaves and temporary closure of stomata in the older leaves of the severely stressed plants which lowers photosynthesis, net assimilation rate and consequently growth. Denmead and Shaw (1960) and Wilson and Allison (1978) obtained considerable reduction in plant height when they imposed drought at vegetative stage of maize growth. Heiae and Acevedo (1974) made similar observations but attributed the decline in growth to increase in leaf respiration and altered ability of the chloroplasts to photosynthesize owing to decline in nitrate reductase activity during drought.

The weed control treatments had no significant effect on plant height at three, six and nine weeks after sowing because of the selectiveness of the herbicides and the high tolerance of maize to these herbicides.

5.2.3 Maize dry matter

Irrigation treatments did not affect maize dry matter production at three and six weeks after sowing (Table 9). The reasons are same as explained under plant height. However, lowest dry matter was produced by the severe moisture stress

at nine weeks after sowing. Plants irrigated at seven, 14 and 21 days interval had 35, 36 and 45% more dry matter, respectively than plants grown under the severe moisture stress treatment. The severe moisture stress must have caused a decline in photosynthesis which resulted in fewer new leaves emerging and smaller leaf area at flowering which ultimately caused a reduction in dry matter production. Baker and Musgrave (1964) reported similar findings and attributed the decline in photosynthesis in moisture stressed plants to decreased permeability of the leaves to carbon dioxide. This adversely affects dry matter production and ultimately grain yield.

Maize dry matter was not significantly affected by any weed control treatment (Table 9) for the same reasons for which they did not affect plant height.

5.2.4 Days to 50% tasselling and silking

Irrigated plants attained reproductive stage earlier than unirrigated ones. Plants irrigated at seven, 14 and 21 days interval tasselled between 54 to 57 days after sowing while severe moisture stress plants tasseled later at 62 days after sowing (Table 10). This behaviour conforms with the general pattern in plants under moderate to severe moisture stress in which the overall life cycle is extended. A similar trend was observed for days to 50% silking (Table 10). In irrigated plots, plants attained 50% silking between 63 and 66 days after sowing while the severely stressed plants silked later at

72 days after sowing. This was also as a result of extended life cycle in the severe moisture stress plants. Robins and Domingo (1953) observed that tasselling and silking were delayed by four to five days owing to moisture stress at vegetative stage while Tsolo (1985) at Kadawa, Nigeria, obtained two to three days delay in silking as a result of moisture stress at flowering in dry season maize.

5.3 Effects of Irrigation and Weed Control on Grain Yield and Yield Components

5.3.1 Grain yield

The final grain yield obtained on a unit of land is the sum total of all the yield components. All the yield components showed higher values with irrigation than under moisture stress. Table 11 confirms this conclusion as irrigation at every seven, 14 and 21 days increased the grain yield by 96, 50 and 60%, respectively over severe moisture stress.

The seven-day irrigation interval produced highest grain yields (5544kg/ha) obviously as a result of favourable moisture conditions for growth and development which resulted in better leaf development and overall plant growth, higher values for yield components and higher leaf water potentials. Besides, the shallow rooting which the shorter irrigation interval might have induced could have enabled the plants to have access to adequate irrigation water provided throughout

the growth period. The low yields from the severe moisture stress is not surprising at all in view of the damaging effects of moisture stress on plant metabolism. Under moderate to severe stress, assimilate translocation in plants is reduced and this is due to a change in source and sink strengths and not necessarily to any damage to the phloem transport mechanism (Hsiao and Acevedo, 1974). In severely stressed plants, source strength might, therefore, have been reduced through a decrease in photosynthesis while sink strength might have been reduced through growth inhibition. The effects of stress on leaves culminates in stomatal closure which leads to reduction in carbon dioxide assimilation and transpiration rates (Denmead and Shaw, 1960; Baker and Musgrave, 1964; Hsiao and Acevedo, 1974; Wilson and Allison, 1978). Moisture stress at grain filling has been reported to reduce translocation of photosynthates from the leaves to the grain causing reduced grain yields (Claassen and Shaw, 1970; Gardner et al., 1981 and Harder et al., 1982).

Weed control treatments had no significant effect on grain yield and yield components. However, particular note should be taken of the consistent marginal enhancement of yield and yield components by the atrazine + eradicane mixture at 1.5 + 2.0kg ad/ha. The yield advantage of 7.4 and 4.0% above the twice hoe-weeded and atrazine + metolachlor (1.25 + 1.25kg ad/ha) treatments, respectively, might not be unconnected with the apparent enhancement of assimilate translocation by the

atrazine + cradicane mixture (1.5 + 2.0kg a.i./ha) as compared to the other weed control treatments. In addition, since the herbicides gave more effective control of the broad-leaved weeds and the sedges which are major problems at Kadawa, the maize crop might have been spared of the harmful effects of these sedges especially in respect of underground competition for nutrients and moisture.

5.3.2 Ear numbers

Number of ears per plant was affected by irrigation frequencies. Plants irrigated at seven and 21 days intervals produced more ears per plant than those irrigated at 14 days interval or grown under severe moisture stress (Table 12). Number of ears per plant which can develop in maize is established at or shortly after pollination beyond which no more can develop (Duncan, 1975). In this study, it might be possible that there were more favourable growth conditions for the seven and 21-day irrigation frequency during pollination in terms of water availability within the effective root zone of the crop. The shorter irrigation frequency might have induced shallow rooting thereby enabling the plants to obtain adequate moisture in the upper soil layers while the longer irrigation frequency might have induced deep ronting of the crop for easier access to underground water. Michael (1970) and Annon. (1982a) reached similar conclusions on rooting behaviour with respect to irrigation frequency and underground water.

5.3.3 Ear length, ear diameter and kernel depth

Irrigation treatments were found to influence the three important yield components viz; ear length, ear diameter and kernel depth in the same manner (Table 13). Irrigation at seven days interval and severe moisture stress produced the highest and lowest values of these parameters, respectively. There is a lot of literature emphasizing that these yield components are severely affected when moisture stress is imposed either at the vegetative or reproductive growth stages. Robins and Domingo (1953), Denmead and Shaw (1960) and Claassen and Shaw (1970) all reported significant reductions in ear size (length and diameter) due to moisture stress imposed at reproductive or grain filling periods.

Weed control treatments did not affect the ear length, ear diameter and kernel depth.

5.3.4 Number and weight of grains per ear

Irrigation treatment effects were also pronounced on the number of grains per ear (Table 14). Irrigated plants produced more number of grains per ear than the unirrigated. However, irrigation frequency did not affect this yield component significantly. This trend may also be explained on the basis of the plants rooting behaviour with respect to underground water and irrigation frequency. Claassen and Shaw (1970) offered similar explanations when they obtained a similar pattern.

Weight of grains per ear followed the same significance trend as number of grains per ear with respect to irrigation treatments. All irrigation treatments were statistically superior to moisture stress condition (Table 14). Grain weight behaviour of a variety is genetically controlled but the growth and development of assimilate source and sink have a great effect on ultimate grain weight. It is evident from Table 14 that the reduction in weight of grains per ear from severe moisture stress was a consequence of the prolonged period of stress. This result is obviously a follow-up of the consistent low values obtained from the severe moisture stress for most other yield attributes notably, ear length, ear diameter, kernel depth and grain numbers. Claasson and Shaw (1970) reported marked reduction in grain weight per ear owing to moisture stress at ear development and silking.

Weed control treatments had no significant effect on number and weight of grains per ear (Table 14). The slightly higher grain numbers and grain weight per ear obtained from the atrazine + eradicane mixture at 1.5 + 2.0kg ai/ha may be attributed to the effect of the EPTC component of the herbicide mixture on assimilate translocation within the plant. Since its translocation is mainly via the apoplast system involving the xylem vessels and non-living cell-walls, the assimilate translocation route (phloem vessels) might have suffered minimal injury; a situation which could enhance assimilate mobility from source to sink (Klingman and Ashton, 1975), as

compared to the atrazine + metalochlor (1.25 + 1.25kg a.i./ha) herbicide mixture. In addition, the detoxifying effect of the antidote component of the eradicane mixture increases the tolerance of the maize crop to the herbicide thereby further promoting assimilate synthesis and mobility within the plant.

5.3.5 1000-grain weight and shelling percentage

The 1000-grain weight followed an identical pattern with the weight of grains per ear. Highest and lowest 1000-grain weights were obtained from the seven-day irrigation interval and severe moisture stress treatments, respectively (Table 15). The 1000-grain weights under the three irrigation intervals were similar but significantly higher than that of the severe moisture stress treatment. This might apparently be due to the effect of the prolonged mosture stress which extended to the grain filling period thereby reducing translocation of photosynthates from the leaves to the grain. Moisture stress at silking reduces the net assimilation rate of maize leading to reduction in 1000-grain weight (Denmead and Shaw, 1960). Many other workers have also reported similar findings as a result of moisture stress imposed at silking or grain filling period (Claassen and Shaw, 1970; Gardner *et al*., 1901; Harder *et al*., 1902).

Shelling percentage was not significantly effected by irrigation treatments. However, the lowest shelling percentage

(79.6%) was obtained from the severe moisture stress (Table 15). Robins and Domingo (1953) obtained similar results and reported that the reduction in shelling percentage from 82.7 to 77.6 was due to moisture deficit at tasselling.

Weed control treatments did not affect the 1000-grain weight and shelling percentage.

Chapter 6

SUMMARY AND CONCLUSIONS

To explore the possibility of growing a good crop of late sown maize with supplementary irrigation and suitable weed control measures, an experiment was carried out at Kadawa in 1984 in a split-plot design involving four irrigation and three weed control treatments. The irrigation treatments comprised irrigation at seven, 14 and 21 days interval and at attainment of severe moistures stress. The weed control treatments comprised hoe-weeding at three and six weeks after sowing (w.a.s.), and herbicide treatments, i.e. atrazine + eradicane (1.5 + 2.0kg a.i./ha) and atrazine + metolachlor (1.25 + 1.25kg a.i./ha). The herbicide treatments were followed by supplementary hoe-weeding at six weeks after sowing.

Maize variety TZESR was sown on 4 September, 1984, i.e. towards the end of the rainy season. Irrigation treatments were applied from five weeks after sowing.

The two herbicide treatments were more effective in controlling weeds than twice hoe-weeded in the early stage of the crop growth. By six weeks after sowing, herbicides became less effective.

Emergence of maize seedlings and stand count at harvest were not affected by the treatments investigated. Moisture stress affected the plant height only at nine weeks after sowing.

Irrigated plants tasselled and silked five to nine days earlier than unirrigated plants. With regard to yield components such as ear length, ear diameter, kernel depth, weight of grains and 1000-grain weight, irrigations at seven, 14 and 21 days interval, were significantly superior to the unirrigated ones. Neither yield nor yield components were affected by weed control treatments.

In this study, it was observed that the two sets of treatments influenced the weeds and yield components in different ways. The first set of treatments i.e. irrigation treatments were very effective in influencing the yield and yield components but failed in suppressing the weeds. Irrigation at seven, 14 and 21 days intervals significantly increased the grain yield by 96, 58 and 60%, respectively over the severe moisture stress treatment. The second set of treatments were very effective in controlling the weeds but did not differ among themselves in influencing yield and yield components. Thus the combination of the two different sets helped in increasing the final grain yield per hectare.

In areas like Kadawa where water table is high, a good crop of late sown maize can be grown with supplementary irrigation (325 to 390mm water) at longer irrigation intervals of 14 or 21 days.

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Appendix A: Common weed flora at the experimental site at Kadawa in 1984 wet season.

Weed species		OCCURENCE	
		Before land preparation	At harvest@
(A)	Broad-leaved weeds		
	Acanthospermum hispidium DC.	* * *	*
	Ageratum conyzoides (L.).	* * *	*
	Amaranthus spinosus (L.).	* * *	*
	Hyptis odoratum (L.).	*	-
	Solanum nodiflora (L.).	*	-
	Solanum nigrum (L.).	*	-
	Vernonia ambigna (L.).	* * *	* *
	Vernonia penciflora (L.)	* *	-
	Commelina benghalensis	* * *	*
(B)	Sedges		
	Cyperus rotundus (L.).	* * *	*
	Cyperus esculentus (L.).	* * *	*
(C)	Annual grasses		
	Chloris pilosa Schum	*	-
	Cynodon dactylon (L.).	* *	*
	Dactyloctenium aegyptium (L.) Richt	*	*
	Digitaria ciliaris (Tetz) Kocht	* *	*
	Elausine indica (L.).	* * *	* *

@ Weed flora taken from herbicide treated plots only

* * * High occurence

* * Moderate occurence

* Minor occurence

- Nil occurence

Appendix 8: Mean squares from analysis of variance for weed cover score of maize at three and six weeks after sowing, harvest and total weed dry matter at Kadawa in 1984.

Source of variation	Degree of freedom	Mean Squares			
		Weed cover score			Total weed dry matter
		3	6	Harvest	
Replication	4	0.33	0.02	0.50	2.70
Main treatment	3	0.50	0.64	0.73	5.23
Error (a)	12	0.10	0.22	1.18	1.90
Sub treatment	2	32.05**	2.64**	0.10	5.00**
Interaction	6	0.33	0.34	0.30	0.45
Error (b)	32	0.11	0.21	0.18	0.56

** F value significant at 1% level of probability.

Appendix C: Mean squares from analysis of variance for emergence and stand count at harvest of maize as affected by irrigation and weed control at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares	
		Emergence	Stand count at harvest
Replication	4	0.05	0.35
Main treatment	3	0.53	0.50
Error (a)	12	0.31	0.39
Sub treatment	2	0.30	0.20
Interaction	6	0.10	0.22
Error (b)	32	0.23	0.35

Appendix D: Mean squares from analysis of variance for plant height of maize at three, six and nine weeks after sowing at Kadawa in 1904.

Source of variation	Degrees of freedom	Mean Squares		
		3	6	9
Replication	4	26.57	0.14	0.04
Main treatment	3	16.90	0.14	0.23**
Error (a)	12	15.62	0.05	0.02
Sub treatment	2	45.96	0.04	0.02
Interaction	6	13.40	0.03	0.01
Error (b)	32	17.24	0.03	0.02

** F value significant at 1% level of probability.

Appendix E: Mean squares from analysis of variance for dry matter per plant of maize at three, six and nine weeks after sowing at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares		
		3	6	9
Replication	4	101.02	0.00	20.15
Main treatment	3	4.21	2.62	30.21**
Error (a)	12	14.20	2.93	2.90
Sub treatment	2	32.03	0.07	0.50
Interaction	6	17.70	0.33	9.15
Error (b)	32	12.42	0.00	0.66

** F value significant at 1% level of probability.

Appendix F: Mean squares from analysis of variance for days to 50 per cent tasselling and silking of maize at Kadawa in 1984.

Source of variation	Degreas of freedom	Mean Squares	
		Days to 50% tasselling	Days to 50% silking
Replication	4	0.12	0.14
Main treatment	3	0.30*	0.27*
Error (a)	12	0.06	0.05
Sub treatment	2	0.00	0.07
Interaction	6	0.02	0.02
Error (b)	32	0.03	0.03

* F value significant at 5% level of probability.

Appendix G: Mean squares from analysis of variance for grain and stalk yield of maize at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares	
		Grain yield	Stalk yield
Replication	4	2.46	0.00
Main treatment	3	18.95	45.91**
Error (a)	12	0.42	1.65
Sub treatment	2	0.49	4.00
Interaction	6	0.21	1.60
Error (b)	32	0.56	1.41

** F value significant at 1% level of probability.

Appendix H: Mean squares from analysis of variance for number of ears per plant, ear length, ear diameter and kernel depth of maize at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares			
		Number of ears per plant	Ear length	Ear diameter	Kernel depth
Replication	4	0.06	3.26	0.05	0.01
Main treatment	3	0.32**	18.42**	0.37**	0.06**
Error (a)	12	0.03	1.25	0.01	0.01
Sub treatment	2	0.01	0.16	0.01	0.01
Interaction	6	0.04	1.45	0.02	0.01
Error (b)	32	0.04	0.81	0.02	0.01

** F value significant at 1% level of probability.

Appendix I: Mean squares from analysis of variance for number and weight of grains per ear of maize at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares	
		Number of grains per ear	Weight of grains per ear
Replication	4	0.47	0.23
Main treatment	3	1.10**	0.51**
Error (a)	12	0.10	0.00
Sub treatment	2	0.31	0.15
Interaction	6	0.09	0.03
Error (b)	32	0.15	0.09

** F value significant at 1% level of probability.

Appendix J: Mean squares from analysis of variance for 1000-grain weight and shelling percentage of maize at Kadawa in 1984.

Source of variation	Degrees of freedom	Mean Squares	
		1000-grain weight	Shelling percentage
Replication	4	0.20	0.15
Main treatment	3	0.70**	0.29
Error (a)	12	0.05	0.32
Sub treatment	2	0.01	0.35
Interaction	6	0.04	0.26
Error (b)	32	0.05	0.47

** F value significant at 1% level of probability.

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