EFFECT OF POLYTHENE MULCH AND IRRIGATION FREQUENCY ON GROWTH AND YIELD OF WHITE MAIZE

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CERTIFICATE

This is to certify that the thesis entitled "**EFFECT OF POLYTHENE MULCH AND IRRIGATION FREQUENCY ON GROWTH AND YIELD OF WHITE MAIZE**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of *MASTER OF SCIENCE (MS.) IN AGRONOMY,* embodies the results of a piece of *bona fide* research work carried out by Sumya Binta Belayet, Registration. No. 10-04082 under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated : **(Prof. Dr. Md. Jafar Ullah)**

Dhaka, Bangladesh Supervisor

DEDICATED TO

MY

BELOVED PARENTS

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University farm to study the effect of polythene mulch and irrigation frequencies on the growth and yield of white maize (PSC-121) during rabi 2015-16. Polythene mulching had two levels; without polythene (P_0) and with polythene (P). Four irrigation frequencies constituted the irrigation treatment (I_0 = No irrigation, I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS and I_4 = Four irrigations at 15, 30, 60 and 90 DAS). Polythene was applied between two adjacent rows of maize following each irrigation. The trial was conducted following split-plot design assigning polythene mulch in the main plot and irrigations in the subplot. Results showed that polythene application showed 35% increase yield over without polythene (6.970 t ha^{-1}). Likewise irrigation treatments I_3 and I_4 had statistically similar seed yields (10.540 and 10.610 t ha^{-1}) which were significantly higher than others irrigation treatments. The combination treatments PI_3 and PI_4 showed significantly higher seed yields (12.72 t ha^{-1} and 12.810 t ha^{-1} respectively) than other treatment combinations which may be attributed to the increased dry matter, leaf area index, number of grains per cob (500.3 and 510.1 respectively) and 100-seed weight (35.86 g and 36.33 g respectively).

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LIST OF ABBREVIATIONS

Abbreviations	**Full word**
AEZ	Agro ecological zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Cm	Centimeter
cv.	Cultivar
CV	Coefficient of Variation
DAS	Days After Sowing
et al.	And others (*et alibi*)
FAO	Food and Agriculture organization
G	Gram
Ha	Hectare
HI	Harvest Index
Kg	Kilogram
LAI	Leaf Area Index
LSD	Least Significance Difference
m^2	Square Meter
MP	Muriate of potash
No.	Number
NS	Non Significant
%	Percent
pH	Hydrogen ion concentration
plant^{-1}	per plant
Seed cob^{-1}	Seeds per cob
t /ha	Ton (s) per hectare
TSP	Triple super phosphate

CHAPTER 1

INTRODUCTION

Maize is one of the most important food grains in the world as well as in developing countries. It is the third most important cereal crop in the world after wheat and rice. It is a high yielder in comparison to rice and wheat occupying first position among the cereals in terms of yield (maize: 6.98 t ha^{-1}; wheat: 3.085 t ha^{-1}; and rice: 3.038 t ha^{-1}) BBS (2016). Two types of maize are cultivated around the world, yellow maize and white maize.

White maize is biologically and genetically very similar to yellow maize, although there is a difference in appearance due to the absence of carotene oil pigments in the kernel which otherwise cause the yellow colour of the grain. White maize is grown mainly for human consumption. It is ground to produce maize flour which is softer and more tastier than that of yellow maize. Worldwide white and yellow maize occupy 12 and 88% areas respectively (FAO, 1997) when maize grown in temperate zones is excluded. In the developing world, a larger area is planted to white than to yellow maize in the tropical highland and sub-tropical/mid-altitude environments, and it occupies about 40% of the lowland tropical maize area (Kimeli, 2013).

In Bangladesh present food production is not sufficient as compared to its population growth. Rice is the major staple in Bangladesh whose yield globally has been either stagnated or slowed down (Cassman *et al.*, 2010). With the growing population in the world growing food keeping pace with the demand faces unprecedented challenges (Chen *et al.*, 2014) while raising the yield and production of rice remains questionable (Dass *et al.*, 2012). Under this situation, introduction of white maize in Bangladesh as human food can be a viable alternative for sustaining food security as this crop has much higher yield productivity than rice and wheat (Ray *et al.*, 2013). Modern white maize hybrids with a short growing season produce a softer, smaller kernel that contains about 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100g (Nass *et al.*, 2010) as compared to rice and wheat. Maize grains contain many of the B vitamins and essential minerals (Ranum *et al.*, 2014). In many developed and developing countries people produce and consume maize as staple food (Nuss *et al.*, 2010). White maize constitutes about 12% of the total maize production in the USA and is used for human food.

The traditional crop including rice and wheat seems quite unable to meet up the nutritional requirements to the increasing population. Every year approximately 1.2 million ton maize is utilized mostly for poultry industry of which only 42% is produced by the country and remaining is imported from other countries (BBS, 2005). Maize has been introduced during 1977-1978 in Bangladesh mainly for research purpuse. But at present the Rice- maize cropping system has expanded rapidly especially in the northern Bangladesh (Timsina *et al.*, 2010) mainly due to increasing demand for poultry feed (Ali *et al.*, 2009). Currently maize is grown in 325455 ha producing 2.28 million tons of grains annually (BBS, 2016).

Water shortage is one of the main constraints for crop production for which irrigation is a must for successful crop production (Annon, 2008). Agriculture is the major user of freshwater (with a world's average of 71 % of the water use), which is affected by decreased supply. By the year 2050, it is forecast that there will be an annual global water shortage of 640 billion cubic meters (Spears, 2003). Given that water shortages currently plague almost every country in North Africa and the Middle East, insufficient water supply for irrigation in these regions, even in the short term, will almost certainly become the norm rather than the exception. Therefore, water shortage events have gained increasing importance in both the scientific and political agendas. Because the irrigation sector is the largest consumptive user of water, accounting for 71% of the freshwater use across the world, it is necessary for irrigation management practices to shift from emphasizing production per unit area towards maximizing the production per unit of water consumed (Fereres and Soriano, 2007). Therefore, innovations are needed to increase the use efficiency of the water that is available.

Various types of mulching materials could widely be used which act as an effective cultural practice as well to bring a large area under cultivation. Mulching is a desirable management practice which regulates farm environment by reducing leaching and evapotranspiration and by reducing nutrient loss due to run off (Smart and Bradford, 1999). Mulches can be either organic or inorganic (polythene). The most frequently used organic materials include plant residues such as straw, hay, peanut hull and compost; wood products such as saw dust, wood chips/shavings and animal wastes. The inorganic mulch material includes polythene, plastic sheet etc.

However, organic or natural mulch materials are often not available in adequate quantities for commercial operations or must be hauled to the place of use (McCraws and Motes, 2004). Again natural materials are not easily spread on growing crops and require considerable hand labour. Excessive use of unsorted organic wastes as mulches may lead to changes in soil physical and chemical characteristics. This can distort the inter-relationships among biophysical and chemical soil functions. It may also lead to loading of nitrates and heavy metals in the soil and ground water (Vousta *et* al., 1996).

Now a day, polythene mulch cultivation has gradually become a great break-through in agricultural production (Guo and Gu, 2000). Kulkarni *et al*. (1998) showed that polythene mulch helps to improve soil structure and soil micro–flora, reduces fertilizer leaching, evaporation and weed problem and also increases the levels of available nutrients and moisture in the soil. Moreover, the polythene mulch is less costly, easily available and may also be recycled.

A specific crop needs specific number of irrigation requirement depending on the the crop growth stages, season and soil parameters. The total amount of water need for a crop production can not be applied at a time because to the maximum capacity of the individual soil. The total amount of water needed by the crop has to be splitted and added two or more times maintaining a definite interval between two adjacent irrigation that depends on the duration of the crop and the water holding capacity of the soil. The maximum water holding capacity of the soil depends on the soil texture and structure (Ball, 2001). The number of irrigation that a crop enjoyes is called irrigation frequency that when not well calculated may result in either excessive or inadequate for crop production. The water application applied injudiciously in each irrigation have a negative impact on final grain yield (Djaman, 2013). For instance, very high irrigation frequency, once or more every day, might provide desirable conditions for water uptake by roots, but it will also lessen irrigation efficiency, increase energy and labour cost, and leach water and nutrients below the root zone (Jordan *et al.*, 2003, Wan and Kang, 2006). Very low irrigation frequency, on the other hand, may cause water stress between irrigations, especially in sandy soils because the duration of water application is much shorter than the time over which plants take up water. Low irrigation frequency on sandy soils also may result in substantial percolation below the root zone during irrigation because the amount of water applied at each irrigation may be higher than the soil-water storage capacity. Therefore, a proper irrigation frequency is one which minimizes the amount of water leached from the root zone, provides at lowest requirements of water to a portion of the root zone of each plant and maintains a high soil matric potential in the rhizosphere to reduce plant water stress between irrigations (Shao *et al.*, 2008).

In Bangladesh during winter, rainfall is erratic and evapotranspiration is high, and only 40% of the cultivable land can be brought under irrigation (Islam and Kaul, 1986). This is because of the scarcity of irrigation water. In this situation, using mulch material help to conserve the applied irrigation water (Harris, 1965). With a rapidly growing population, the pressure on limited fresh water resources increases. The agricultural sector faces the challenge to produce more food with less water by increasing Crop Water Productivity (CWP) (Kijne *et al.,* 2003). As irrigation water is expensive due to the high price of petroleum fuel, approaches should be taken to exploit irrigation water efficiently. Maize has been reported in the literature as having high irrigation requirements (Rhoads and Bennett 1990; Stone *et al.,* 2001). A great challenge for the agricultural sector is to produce more food from less water, particularly in arid and semi-arid regions which suffer from water scarcity. On this consideration, there must be an adjustment of polythene mulch and the frequency of irrigation.

Keeping all points in minds mentioned above, the proposed research work was undertaken to achieve the following objectives;

Objectives

i. To assess the impact of polythene mulch on white maize growth and productivity.

ii. To assess the impact of irrigation frequencies on white maize growth and grain yield.

iii. To evaluate interaction effect of polythene mulch and irrigation frequency on the growth and yield of white maize.

CHAPTER 2

REVIEW OF LITERATURE

2.1 Effect of mulches

2.1.1 Effect of mulches on soil moisture

Soil moisture is one of the most important factors affecting crop production. Mulching is very effective to alter the soil moisture level. Generally, the soil moisture under mulched plots were significantly higher than that of the control as reported by most of the workers (Wang *et al*., 1994; Ravinder *et al*., 1997 and Thakur *et al*., 1997).

In a field Study in China, mulching with plastic film improved soil moisture content, decreased heat loss and increased nutrient uptake of maize (Wang *et al*., 1998). Further coloured polythene mulch enhanced soil moisture by 28% compared to control (Gutal *et al*., 1992). Similar result was also reported by many researchers (Rahman, 2004 and Saha, 2001). However mulching saved the soil moisture by 7-25% as reported by Suwan and Judah (1985).

Hasan *et al*. (1994) conducted an experiment with chilli recording the effect of mulches on the soil moisture content and reported that all types of mulches increased soil moisture content compared to control. They further reported that maximum soil moisture content was observed in black polyhene mulches followed by transperent polythene mulch. Similarly, grass and straw mulches also conserved soil moisture content in field crops (Rahman and Khan, 2001; Shinde *et al.*, 1999 and Roy *et al*., 1990).

Singh *et al*. (1987) observed that mulching by paddy straw decreased soil water depletion and increased water use effeciency under both irrigated and rainfed conditions. Baldev *et al*. (1988) mentioned that mulching with 6 ton rice straw per hectare decreased soil temperature at 10 cm depth by 1-6^{0}C.

Polythene mulch conserved more moisture in the soil than control (Harris, 1965). Mulching conserved the soil moisture in potato cultivation also (Prihar, 1986; Devaux, 1987 and Ifenkwe *et al.* (1987). Yamaguchi *et al.* (1964) also reported that average minimum temperature fall within the range in bare soil than from clear and black polythene, which delay emergence. Katan (1976) showed that using plastic film mulch to achieve high soil temperature helps to destroy soil pathogenic weeds and nematodes.

Mulching helps in checking evaporation and thus soil can retain sufficient amount of moisture. Polyethylene film mulches reduce evaporation in vegetable cultivation (Lamont, 1993). In a separate experiment, Bieoral (1970) found that polythene sheets caused a 2% increase in the moisture content of the top 30cm of the soil. Black polythene, sawdust and dried grass mulch in tomato production improved soil moisture retention but black polythene mulch had the best result (Patil and Basad, 1972).

Polythene mulch has a positive effect on growth, yield and quality of maize (Kulkarni *et al.*, 1998). Therefore, polythene mulch helps to improve soil structure and soil micro–flora, reduces fertilizer leaching, evaporation and weed problem. However, polythene mulch also increasing the levels of available nutrients and moisture in the soil.

2.1.2 Effect of mulch on plant height

Mulches have a significant effect on plant height as reported by most of the researchers. Plant height increased with polythene mulch in corn (Sencar *et al.*, 1997). Similar result were also observed by Shelley (2002) in maize Saha (2001) in tomato.

Shinde *et al*. (1999) conducted an experiment to know the effect of mulches on microclimatic condition in a chilli field and reported that plant height increased with mulch and the height was observed in polythene mulches compared to other mulches. Similar result was also reported by many workers (Rahman, 2004; Shelley, 2002; Gunadi and Suwanti, 1998 and Buitellar, 1989).

Use of polythene and straw mulches has posetive effect on plant height (Gunadi and Suwanti, 1998). Plant height is significantly higher in mulched plants than unmulched one (Hossain, 1996). Similar result was also reported by Saha (2001) in tomato and Shelley (2002) in maize.

Wien *et al*. (1993) reported that mulching increased plant height and flowering. Both polythene and straw mulches appeared to have considerable increasing effect on plant height (Buitellar, 1989 and olasantan, 1985).

2.1.3 Effect of mulch on stem diameter

Mulches have a profound influence on plant growth as well as stem diameter. Duhr and Dubas (1990) reported that mulched plants have enhanced growth and stem diameter of maize. Similar result was also reported by Shelley (2002) and Chen *et al*. (1996) in maize.

Firake *et al*. (1991) reported that mulch increased plant growth as well as increased stem diameter in tomato. Similar result was reported by Gupta and Gupta (1983) in Legumes. However, Sudha *et al*. (1999) conducted an experiment to know effect of different polythene mulches on growth and development of clilli and reported that polythene mulch in increased plant growth and development and also increased stem based diameter compared to control.

Stem diameter was higher in maize grown with water permeable plastic film than that with conventional plastic film (Yao *et al*., 1998). Similar result was also reported by Shelley (2002) in maize plant. Rahman and Khan (1999) observed that maximum stem diameters were produced in maize plants under water hyacinth followed by rice straw and the minimum in control plants.

2.1.4 Effect of mulch on leaf characters

Mulch has significant effect on leaf charecters *viz*. number of leaves per plant, leaves size. Yao *et al.* (1998) reported that the number of leaves and leaf size of maize increased under plastic mulched condition than in control. Effectiveness of plastic mulches in harnessing greater responsiveness to the variation of leaf number was observed during the period of limited precipitation (Izakovic, 1989). Similar results were reported in maize Shelley (2002) in mungbean (Rahman, 2004) and in tomato (Saha, 2001).

Sidhu *et al*. (2007) reported that the maize crop is grown mostly in tropical/ subtropical environments where drought adversely affects its production. A field experiment was conducted on sandy loam soil for four years (1999 – 2002) to study the effect of wheat straw mulch (0 and 6 t ha^{-1}) and planting methods (flat and channel) on maize sown on different dates. Mulching, on an average, improved leaf area index by 0.42 and plant height by 14 cm, respectively.

Kulkarni *et al.* (1998) reported from a field experiment conducted at College of Agricultural Sciences, Dharwad on maize that plant height at harvest, dry matter production and LAI at 60 days improved considerably and significantly under black polythene mulch as compared to paddy straw mulch and no mulch treatment.

Pinjari (2007) conducted the field experiment during 2005–06 and 2006–07 to find out the effect of polythene mulch on sweet corn and reported that plant height, dry matter accumulation per plant and in the different plant parts *i.e.* leaves, stem, grains, cob axis, cob sheath of sweet corn were significantly superior under 7 polythene mulch over no mulch at all the crop growth stages during both the years and in the mean of two years. Number of leaves $plant^{-1}$ was significantly superior under polythene mulch over no mulch at 30 and 60 DAS. While, at 90 DAS number of functional leaves under the polythene mulch was at par with no mulch and at harvest. The number of leaves was significantly lower under polythene mulch than no mulch during both the years and in the mean of two years.

Gosavi (2006) after conducting the field trial at Aspee foundation, than on sweet corn reported that the significantly greater plant height and numerically increased number of functional leaves plant^{-1} and dry matter at 30 and 60 days after sowing of the sweet corn grown under polythene mulches than no mulch treatment and paddy straw mulch.

Rahman (1999) reported that morpho-physiological characters of maize such as plant height, number of leaves plant^{-1}, leaf length and breadth, base diameter, number of roots plant^{-1}, root length, tassel length, ear height, leaf area index (LAI), crop growth rate (CGR), net assimilate rate (NAR) and cumulative dry matter (DM) accumulation were positively and significantly influenced by all mulches.

Aguyoh *et al.* (1999) reported that sweet corn grown under clear plastic mulch shortened the time to maturity by 10 days on the silt loam site of Midwestern USA.

Yao *et al*. (1998) reported greater number of leaf, maximum leaf length and maximum leaf width in case of maize plants when grown with water-permeable plastic film than that of conventional plastic film. Increased dry matter in maize was also observed with the application of sugarcane trash mulch (Jadhav *et al*., 1993). The total DM and ear DM of maize were increased by 28–32% and 52–55%, respectively when transparent plastic was used as mulch (Nakui *et al*., 1995).

Wang *et al*. (1994) found the greatest root weight and spread of the root system without plastic cover in a field trial. This variation might be due to different location with different microclimatic environment. Higher NAR and CGR of maize during 15–45 and 46–75 days after emergence with sungrass mulch than soil or no mulch in Chittagong Hill Tract of Bangladesh was observed by Alam *et al*. (1993).

Madsan (1992) observed decreased number of days from sowing to initial flowering by 5–9 days when plastic mulches was applied. On the contrary, despite the promotive effects of optimum fertilization, Taja *et al*. (1991)

observed no significant differences in LAI of maize with rice straw and sugarcane baggage mulches. Similarly, acceleration of flowering date in maize was also observed with black polythene mulch by Izakovic (1990). He also reported that such early maturity was reported in maize when black polythene was used as mulch. Duhr and Dubas (1990) reported that the early flowering and maturity of maize was found with transparent photodegradable polythene film.

2.1.5 Effect of mulch on dry matter content

Bhatt *et al.* (2004) conducted a field experiment at Punjab Agriculture University, Ludhiana on maize and reported that dry matter production with paddy straw mulch was higher by 138% than the dry matter production from bare plots.

2.1.6 Effect of mulch on yield and yield attributes of crops

Pinjari (2007) conducted the field experiment during 2005-06 and 2006-07 to find out the effect of polythene mulch on sweet corn and revealed that the different yield attributes *viz.* cob length, cob girth, number of grains per cob, number of grain rows, weight of grains cob^{-1} and weight cob^{-1} during both the years and in the mean of two years were recorded significantly superior under polythene mulch over no mulch. He also find out the effect of polythene mulch on sweet corn and revealed that number of cobs plant^{-1} were significantly higher under polythene mulch during 2006–07 and in the mean of two years and during 2005–06 the differences was not significant. The cost of cultivation, gross returns, net returns were higher under polythene mulch and lowest with control during both the years. However, the B:C ratio under polythene mulch was at par with control.

J–Econ (2002) conducted a field experiment at Entomolgical Society of America on sweet corn and reported that cob weight, cob length and number of cob per plant were significantly larger in transparent polythene mulch than from no mulch treatment. He also reported that cob yield of sweet corn was 1.5 to 2 times grater in transparent polythene mulch plots than from fallow plots.

Werminghausen *et al*. (1981) conducted 9 trials where unmulched yield of maize was less than 5 t grains/ ha, polythene mulching increased average yield from 3.82 to 8.37 t ha^{-1}.

Synthetic mulches were reported to influence the maize yield favourably. Mulching with plastic film or polyethylene or clear plastic or white and black polythene or semi permanent plastic mulch significantly increased the grain yield (Wang *et al*., 1994, Mohapatra *et al*., 1998). Maize yield with polythene mulch treatment was 127.5% of those of direct sown maize (Chen and Chen, 1996). The highest grain yield with plastic or polythene mulching was 7.52 t ha^{-1} (Duhr and Dubas, 1990) or 5.7 t ha^{-1} (Mohapatra *et al*., 1998) respectively. On the other hand, linear low density polyethylene mulching with irrigation at 50% depletion of available soil moisture, 5.7 t ha^{-1} (Mohapatra *et al*., 1998).

Mulches are reported to have profound effect on field crops. Plastic mulching increased grain yield 2-4 t ha^{-1} in maize as reported by Easson and Fearnehough (2000). Madsan (1992) reported that grain yield increased with plastic mulching from 0.32 to 1.40 t ha^{-1} of maize. However, Black polythene mulch increased grain yield by up to 146% in maize as reported by Izakovic, (1989). Similar result was also reported by Shelly (2002) in maize who observed that among that among the polythene mulches, black polythene showed the highest yield.

In soybean seed yield was significantly increased compared to control when grown with water hyacinth mulch (Sluyters *et al*., 1979). Kumar *et al*. (1995) conducted an experiment with different polythene mulches to know the effect of mulch on yield and yield attributes of mungbean and reported that black polythene mulch showed the highest yield. Similar result was also reported by many researcher (Rahman, 2004; Baten *et al*., 1995).

Decoteau *et al.* (1989) reported that mulches affected the yield of tomato and yield increased with mulching compared to control. Similar result was also reported by Gunadi and Suwanti (1998) and Gutal *et al.* (1992) in tomato who reported that fruit yield increased in plastic mulches compared to control.

A field experiment was conducted by Nagalakshmi *et al.* (2002) to know the effect of different mulching on fruit yield of chilli and reported that all mulches increased fruit yield compared to control but with plastic mulching recording the highest yield. Similar result was observed by Sudha et al. (1999) in chilli who reported that mulches increased fruit yield. Moreover, Panchal *et al.* (2001) conducted an experiment, to under stand the influence of different polythene mulches and observed that yield was increased in all polythene mulches with being the highest in all polythene mulches.

Gosavi (2006) after conducting the field trial at Aspee foundation, Thane on sweet corn reported that the data pertaining to yield attributes indicated that some of them were influenced significantly namely weight of cob, length of cob and kernels per cob by the mulches than no mulch treatments. However, number of rows per cob and number of cobs per plant were not influenced significantly. He also reported that significantly highest green cob and stover yield (246.69 and 303.61 q ha^{-1}, respectively) were recorded under polythene mulch than control (194.38 and 235.11 q ha^{-1}, respectively). The gross return, net profit and B:C ratio were higher under polythene mulch.

Easson and Fearnehough (2000) studied the effect of growing forage maize with or without plastic mulching treatments on the dry matter (DM) yield, cob yield and dry matter content was investigated in Northern Ireland in 1996–97 and reported that plastic mulch, when compared with the unmulched control, increased maize yield from 12.0–14.7 t DM ha^{-1}, cob yield from 3.7–6.6 t DM ha^{-1} and dry matter content from 230–270 g kg^{-1}.

The increase in grain yield of corn under mulching conditions may be due to increased soil moisture storage and suppressing weed growth (Bhardwaj and

Sindwal, 1998). Kwabiah (2004) after conducting a field experiment at Atlantic Cool Climate Crop Research Centre, Agriculture and Agri–food Canada on sweet corn reported that the plastic mulch increased the total biomass yield and cob yield by 8–17% and 3–6% over no mulch, respectively.

The yield contributing attributes of maize that is which contribute to the seed yield like number of ears plant^{-1}, ear length, ear diameter, grain number ear^{-1}, number of rows ear^{-1}, 1000 grain weight were markedly influenced by mulches. The highest grain number cob^{-1} and highest weight of 1000 grains in maize with straw mulches was reported by Quayyum and Ahmed (1993) at RARS of Jamalpur. They also reported significantly increased grain yield of maize by using rice straw mulch in conventionally tilled plots at Regional Agricultural Research Station (RARS), Jamalpur.

Bhatt *et al*. (2004) reported from a field trial conducted at Punjab Agriculture University, Ludhiana on corn that straw mulch increased the cob yield by 60.5% as compared to unmulched treatment.The study was conducted by Bhatt *et al*. (2004) to evaluate the effect of tillage and different modes of straw mulch application on corn yield was carried out in a submontaneous rainfed tract of Punjab, India. Dry matter yield in Mw plots was 138% higher as compared to in the Mo plots whereas minimum tilled plots had 22% higher values of dry matter yield as compared to the conventionally tilled plots. Grain and straw yield was observed to be 4 and 3% higher in minimum tilled plots as compared to the conventionally tilled plots. Minimum tillage was more effective in conserving soil moisture than the conventional tillage. Mulch spread on the whole plot increased the grain yield by 60.5% as compared to unmulched control.

Summers and Stapleton (2002) reported that sweet corn yields of marketable ears was 1.5–2.0 times greater in plastic reflective mulch plots than from fallow plots. This was due to the larger ears (individual ear weight and length) rather than an increase in the number of ears.

Liu *et al*. (2002) reported that the transplanting spring maize with plastic film mulching improved the ecological environment of the soil, increased soil temperature and soil water contents, promoted the growth and maturation of maize and increased crop yield.

Sannigrahi and Borah (2002) conducted a field experiment in Assam to evaluate effectiveness of different organic mulches along with black polythene on tomato and okra production under rainfed conditions. The maximum okra yield was recorded with black polythene mulch (121.2 q ha^{-1}) followed by water hyacinth (107.1 q ha^{-1}) and poultry waste (101.3 q ha^{-1}). Black polythene increased okra yield by 88 per cent over control. Also black polythene mulch was the most effective treatment for weed control (83.5%).

Kulkarni *et al*. (1998) reported from a field experiment on maize conducted at University of Agriculture Science, Dharwad that grain number per cob, grain weight per cop and 1000 grain weight were improved considerably and significantly under black polythene mulch as compared to paddy straw mulch and no mulch treatments. They also reported that cob yield and stover yield were significantly higher under mulch over than paddy straw mulch and no mulch treatment. They also reported that the polythene mulch has a positive effect on growth, yield and quality of maize.

2.2 Effect of irrigation and irrigation frequency

When water resources (particularly in arid regions) or operational costs are limiting factors in yield production, efficient irrigation scheduling needs to be applied to enable maximum production for each unit of irrigation water (Doorenbos and Kassam, 1979).

Panda *et al.* (2004) evaluated the effect of different irrigation scheduling methods on root zone soil moisture, growth, yield parameters and water use efficiency of corn and concluded that under water scarcity conditions, irrigation should be scheduled at 45% of the maximum allowable depletion of available soil water of corn to obtain high yield parameters and high IWUE.

Caldwell *et al.* (1994) stated that irrigation frequencies of 1, 3, 5, or 7 days produced similar high corn yields of (11.9–12.5 Mg ha^{-1}). Higher irrigation water-use efficiencies were obtained with the longer 7 day frequency because of better storage of in-season precipitation and because of reduction in deep percolation below the root zone. The results indicated little need to perform frequent subsurface drip irrigation events for fully irrigated corn on the deep silt loam soils of western Kansas. These deep soils and a deep-rooted crop such as corn have the ability to buffer out a large amount of temporal water stress that would normally occur on shallow-rooted crops on shallow soils. Although, high frequency is generally touted as a major advantage of micro irrigation, this is not the general case for corn in that region. Howell *et al.* (1997) also found that daily or weekly frequencies did not affect corn yields for either surface or subsurface drip irrigation on a clay loam soil in Texas. Camp *et al.* (1989) reported that irrigation frequency (continuous or pulsed irrigation) did not affect micro irrigated corn yields on loamy sands in the Atlantic Coastal Plain. Camp (1998) also reviewed several SDI studies concerning irrigation frequency and concluded that some crops respond to high frequency on some soils and some do not.

Lopes *et al.* (1988) reported that moisture deficiency resulted in lower number of leaves, pods per plant, reduced plant height-root length ration in *Phaseolus vulgaris*. Pannu and Singh (1988) demonstrated that the total dry matter as well as grain yields were affected by moisture deficit in lentil. Talukder (1987) reported that wheat seed yield and harvest index were the most susceptible parameters to water deficit. Pandy *et al*. (2000) stated that applying drought stress at various growth stages of corn generally reduced seed yield, number of seeds/cob, 1000-seed weight, stem diameter, and plant height.

Saran and Giri (1988) reported that plant height of rapeseed was found to be increased when one irrigation at 30 DAS was applied. But two irrigations applied at 30 and 60 DAS produced higher plant height than under rainfed condition. There was a significant relationship between irrigation levels and plant height.

Tomar *et al*. (1992) found increasing dry matter production in mustard plant with increasing number of irrigation. They conducted an experiment with no irrigation, one irrigation at pre-flowering and two irrigation (one at pre-flowering and one at fruiting). Significant increase in dry matter was found with irrigation. The maximum dry matter production was found to be highest with two irrigations while one irrigation and control produced lower dry matter per plant, respectively.

Thousand seed weight was significantly increased by irrigation. Clarke and Simpson (1978) reported that under field scarcely affected 1000-seed weight of mustard. The seed yield was positively correlated with 1000-seed weight.

Sarker and Hassan (1988) made an experiment with Brassica juncea at two lication in Bangladesh. They irrigated the crop at one to six levels commencing 20-25 day after sowing and obtained maximum seed yield at BINA farm with three levels of irrigation and that at RARS Ishwardi farm with five levels of irrigation.

2.3 Interaction effect of mulch and irrigation on crop

Mohapatra *et al.* (1998) concluded that polythene mulching increased the intensity of cobbing. Mulching with 50 micron LLDPE with irrigation of 50 per cent available soil moisture increased the cobs/plant, cob length, cob diameter, weight/cob, rows of grains/cob, grains/cob and grain yield/ha.

The effect of mulch on the increase of yield contributing attributes of maize was also reported by Alam *et al*. (1993) while they using sungrass mulch. They also observed 18% and 77% higher grain yields with sungrass mulch than soil mulch and no mulch treatment, respectively in the hilly areas of Chittagong. The intensity of cob setting was increased by linear low density polyethylene mulch with irrigation (Mohapatra *et al.*, 1998).

Siddique and Rashid (1990) conducted experiments for 3 seasons (1987/88) to study the effect of irrigation and mulching on the yield of 3 varieties of potato (Challisha, Lalpakri and Pakri Lalita). Water hyacinth was used for mulching. From the results they found that the varieties responded very well to both irrigation and mulching. Mangaser *et al.* (1986) stated that mulch in potato improved yield and proportion of marketable size tubers compared to no mulch plants. They also reported that potato planting with mulch should be done from the last week of November up to second week of December to obtain the best yield.

Collins (1977) reported that transparent black polythene and polythene coated black paper mulches increased soil temperature and advanced emergence of potato. He also reported that transparent black polythene and polythene coated black paper mulches non significantly reduced the yield of potato from bare soil of 46.9 and 48.3 t ha^{-1} and clear polythene mulch. Chowdhury *et al.* (2000) conducted a field experiment in the rabi season of 1997-1998 on a clay terrace soil in Salna, Gazipur, Bangladesh, to study the effect of rice straw mulching and irrigation on the yield total water use and water use efficiency of an indigenous low yielding cultivar of potato, Lalpakri. Irrigation is indispensable in the rabi season of Bangladesh and the yield was significantly lowest in the treatment of no irrigation after seedlings establishment. Rice straw mulch conserved soil moisture and maintained a higher moisture regime in each irrigation level through the cropping period. The treatments of rice straw mulching and the single irrigation at 30 days after sowing were the best combination with a satisfactory high yield.

Bhuyan (2003) conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from

November 2002 to March 2003 to investigate the effect of mulching, variety and crop management practices on growth and yield of potato. The experiment was conducted with four mulching treatments, (no mulch no irrigation, irrigation, saw dust and straw mulch); two varieties (‘Diamant’ and ‘Cardinal’) and use of organic manure without pesticides application). Mulching treatments showed significant effect on most of the yield and yield components. The highest yield (21.31 t ha^{-1}) was obtained from straw mulch followed by sawdust (19.47 t ha^{-1}), irrigation treatment (19.06 t ha^{-1}) and no mulch no irrigation treatment (15.29 t ha^{-1}). The variety also caused significant variations on most of the parameters. The variety Diamant gave the higher yields (19.07 t/ha) and compare to Cardinal (18.51 t ha^{-1}) yield.

The yield of maize was influenced by different organic mulches and the maximum or highest grain yield was observed 6.78 t ha^{-1} with rice straw. Kalaghatagi *et al.* (1990) reported that irrigation at 0.8 IW/CPE ratio with black polythene mulch spread between the rows significantly increased the number of grains cob^{-1}, grain weight cob^{-1}, 1000 grain weight of maize. Kalaghatagi *et al.* (1990) also reported that irrigation at 0.8 IW/CPE ratio with black polythene mulch spread between the rows significantly increased the dry matter at harvest, leaf area at 60 days after sowing and grain yield and fodder yield.

CHAPTER 3
MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, fertilizer application, intercultural operations, data collection and statistical analysis.

3.1 Location

The field experiment was conducted at the Agronomy field, Sher-e-Bangla Agricultural University, Dhaka during the period from November 2015 to March 2016. Geographically the experimental field is located at 23°46' N latitude and 90° 22' E longitude (Google maps, 2014) at an elevation of 8.2 m above the sea level belonging to the Agro-ecological Zone “AEZ-28” of Madhupur Tract (BBS, 2011). The location of the experimental site has been shown in Appendix I.

3.2 Soil

The soil of research field was general soil type. Shallow red brown terrace soils under Tejgaon series. The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period. The experimental plot was also high land.

3.3 Climate

The experimental area is situated in the sub-tropical climatic zone and characterized by heavy rainfall during the months of April to September (Kharif Season) and scanty rainfall during the rest period of the year (Biswas, 1987). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991).

3.4 Plant materials and features

Maize cv. PSC-121 were used as plant materials for the present study.

The description of the variety is given below:

PSC-121 (White maize variety)

Identifying character: Double cross hybrid, bold grain quality, stays green at maturity, good crop standibility and drought tolerant. Developed by: Proline seed company, India. Crop duration: Medium, Maturity period 90-100 Days. Yield : 10-12 t ha^{-1}. Sowing time: Ideal for kharif season. Harvesting time: After attaining physiological maturity.

3.5 Treatments

The experiment consisted of two treatment factors as mentioned below.

Factor 1 : Polythene mulch

1. P_0 = No polythene mulch (control)
2. P_1 = Polythene mulch

Factor 2: Irrigation frequency

1. I_0 = No irrigation (control)
2. I_1 = 1 irrigation at 15 DAS
3. I_2 = 2 irrigations at 15 and 30 DAS
4. I_3 = 3 irrigations at 15, 30 and 60 DAS
5. I_4 = 4 irrigations at 15, 30, 60 and 90 DAS

3.6 Design and layout

The experiment was laid out in a split plot design with three replications (Appendix II) . The size of the individual plot was 5m × 2m and total numbers of plots were 30. There were 10 treatments combinations. Polythene mulch treatments were placed along the main plot and irrigation frequency treatments were placed in the sub plot. Layout of the experiment was done on November 18, 2015 with inter-plot spacing of 0.50 m and inter block spacing of 1 m.

3.7 Land preparation

The land of the experimental field was first opened on November 20, 2015 with a power tiller. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Thereafter, the land was ploughed and cross-ploughed to obtain good tilth. Deep ploughing was done to produce a good tilth, which was necessary to get better yield of the crop. Laddering was done in order to break the soil clods into small pieces followed by each ploughing. All the weeds and stubbles were removed from the experimental field.

3.8 Fertilizer application

The following doses of manure and fertilizers were used (BARI, 2011):

Cowdung	:	4-6 t ha^{-1}
Urea	:	525 kg ha^{-1}
TSP	:	250 kg ha^{-1}
MoP	:	200 kg ha^{-1}
Zypsum	:	250 kg ha^{-1}
Zinc sulphate	:	12 kg ha^{-1}
Boric acid	:	6 kg ha^{-1}

The total amount of cowdung, TSP, M0P, gypsum, zinc sulphate and boric acid were applied during final land preparation. Urea was applied in three equal splits, during final land preparation, 30 DAS and 60 DAS. The fertilizers were incorporated to soil by spading one day before sowing.

3.9 Seed treatment

Seeds were treated with Provex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease.

3.10 Seed sowing

Seeds were sown on November 27, 2015 continuously in 60 cm apart rows opened by specially made iron hand tine. Two to three seeds were sown per hill maintaining 25 cm plant to plant spacing. After sowing, the seeds were covered with soil and slightly pressed by hands.

3.10.1 Intercultural operations

The following intercultural operations were done for ensuring the normal growth of the crop.

3.10.2 Gap filling and Thinning

Gap filling was done at 6^{th} and 7^{th} days after sowing. Emergence of seedling was completed within 15 days after sowing. Overcrowded seedlings were thinned out for two times. First thinning was done after 15 days of sowing which was done to remove unhealthy and lineless seedlings. The second thinning was done 10 days after first thinning keeping one healthy seedling in each hill according to the treatment.

3.10.3 Mulching

Mulching is done only on treatment plots between the rows of the plants with black polythene mulch after emergence of seedlings.

3.10.4 Weeding

Weeding was done twice in the during the whole growing period, the first weeding after 20 days of sowing and the second other after 40 days of sowing.

3.10.5 Irrigation

Irrigation was given by pipe as per treatment. During the irrigation care was taken so that water could not flow from one plot to another or overflow the boundary of the plot.

3.10.6 Insect and pest control

Ripcord 10 EC @ 2 ml litre^{-1} water were sprayed to control worm/caterpillar on 22 and 29 February, 2016 to protect the crop. Insecticide was applied to the plots at afternoon. Two guards were appointed to protect the maize cob from birds especially parrots from mid February to harvest.

3.10.7 Earthing up

Earthing up was done on 29 December, 2015 which was 32 days after sowing. It was done to protect the plant from lodging and for better nutrition uptake.

3.11 General observations of the experimental field

Regular observations were made to see the growth stages of the crop. In general, the field looked nice with normal green plants which were vigorous and luxuriant in the treatment plots than that of control plots.

3.12 Sampling

Five plants were collected randomly from each plot. These 5 plants were used for taking yield component data.

3.13 Harvest and post-harvest operation

The crops were harvested when the husk cover was completely dried and black coloration was found in the grain base. The cobs of five randomly selected plants of each plot were separately harvested for recording yield attributes and other data. The inner two lines were harvested for recording grain yield and stover yield. Harvesting was done on 4 May, 2016. The harvested products were taken on the threshing floor and it was dried for about 3-4 days.

3.14 Collection of data

Data were collected on the following parameters-

3.14.1 Crop growth characters

1. Plant height (cm) at 30, 60, 90 Days after sowing (DAS) and at harvest

2. Collar Leaf no. plant^{-1} at 30, 60, 90 DAS and at harvest

3. Leaf Area (cm^2) at 30, 60, 90 DAS and at harvest

4. Base diameter (cm) at 60, 90 DAS and at harvest

5. Dry matter weight plant^{-1} (g) at 30, 60, 90 DAS and at harvest

3.14.2 Yield Contributing Characters

- Cob length (cm)
- Cob diameter (cm)
- Number of rows cob^{-1} (no.)
- Number of grains row^{-1} (no.)
- Number of seeds cob^{-1}

- Grain weight cob^{-1}
- Weight of 100 grains (g)

3.14.3 Yield and harvest index

- Grain yield (t ha^{-1})
- Straw yield (t ha^{-1})
- Biological yield (t ha^{-1})
- Harvest index (%)

3.15 Procedure of sampling for growth study during the crop growth period

Plant height (cm)

At different stages of crop growth (30, 60, 90 DAS and at harvest), the height of five randomly selected plants from the inner rows of every plot was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm.

Collar Leaf no. plant^{-1}

At different stages of crop growth (30, 60, 90 DAS and at harvest), the total number of collar leaf of five randomly selected plants from the inner rows of each plot was counted and the mean value of the number of collar leaf was recorded in number.

Leaf area index

Leaf area was estimated manually by counting the total number of leaves per plant and measuring the length and average width of leaf and multiplying by a factor of 0.70 (Keulen and Wolf, 1986). It was done at 30, 60, 90 days after sowing (DAS) and at harvest.

Leaf area = Surface area of leaf sample ($m^{2)}$ ×correction factor ÷ ground area from where the leaves were collected.

Base diameter

From each plot, 3 plants were uprooted randomly. Then the diameter was taken from the base portion of each plant. Then average result was recorded in cm.

Dry matter weight plant^{-1}

From each plot 3 plants were uprooted randomly. Then the stem, leaves and roots were separated. The shoot sample (stem and leaves) was sliced into very thin pieces and put into envelop and placed in oven maintaining 70^0 C for 72 hours. Then the shoot sample was transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. It was performed at 30, 60, 90 DAS and at harvest.

3.16 Procedure of data collection for yield and yield components

Number of grains cob^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted and then the average result was recorded.

Number of rows cob^{-1}

Five cobs from each plot were selected randomly and the number of rows was counted and then the average result was recorded.

Number of grains rows^{-1}

Five cobs from each plot were selected randomly and the number of grains was counted in each row and then the average result was recorded.

Weight of 100 grains

From the seed stock of each plot 100 seeds were counted and the weight was measured by an electrical balance. It was recorded in gram.

Grain and straw yield (t ha^{-1})

An area of 2.0 m^2 harvested for yield measurement. The crop of each plot was bundled separately, tagged properly and brought to threshing floor. The bundles were dried in open sunshine,cobs were threshed and grains were cleaned. The grain and straw weights for each plot were recorded after proper drying in sun.

Biological yield (t ha^{-1})

Biological yield was calculated by using the following formula:

Biological yield = Grain yield + straw yield

Harvest index (%)

Harvest index is the relationship between grain yield and biological yield (Gardner *et al.*, 1985). It was calculated by using the following formula:

$$\text{Harvest index } = \frac{\text{Grain yield (t/ha)}}{\text{Biological yield (t/ha)}} \times 100$$

3.17 Statistical analysis

The recorded data were subjected to statistical analysis. Analysis of variance was done following two factor split plot design with the help of Statistix10 software. The mean differences among the treatments were adjusted by least significance difference (LSD) at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The present experiment was conducted to know the effect of polythene mulch and irrigation frequency on the growth and yield of white maize. Data on different growth and yield of maize were recorded. The analysis of variance data on different growth and yield contributing characters as well as yield of maize as was influenced by polythene mulch and irrigation frequency have been presented in Appendix III-IX. The results have been presented and discussed with the help of either table or graphs and possible interpretations have been given under the following headings.

4.1 Growth parameters

4.1.1 Plant height:

4.1.1.1 Effect of polythene mulch

Plant height of maize was significantly affected by the application of polythene mulch. The external application of polythene mulch significantly increased the plant height of white maize (Table.1). Plant height of maize progressively increased with the application of polythene mulch. The longest plant (37.92, 65.71, 170.3 and 173.3 cm) was recorded with the polythene mulching (P) at all the growth stages of 30, 60, 90 and at harvest stage. Whereas, the lowest plant heights (28.13, 47.40, 137.7 and 142.0 cm) were observed in P_0 (control). Sencar *et al*. (1997) also reported that plant height increased with polythene mulch in corn.

Table 1: Effect of polythene mulch on plant height of white maize at different growth stages

Treatments	Plant height (cm) at			
	30 DAS	**60DAS**	**90DAS**	**Harvest**
P_0	28.13 b	47.40 b	137.7 b	142.00 b
P	37.92 a	65.71 a	170.3 a	173.3 a
$LSD_{(0.05)}$	4.308	7.8	7.49	9.38
CV%	8.3	8.78	3.09	3.79

P_0 = No polythene mulch. **P** = Polythene mulch.

4.1.1.2. Irrigation frequency:

Statistically significant variations were observed on plant height except 30 DAS by different irrigation frequency (Table. 2). The highest Plant height of maize (41.41, 71.62, 183.6 and 186.1cm) were recorded with I_4 and lowest plant height of maize were (25.63, 44.77, 122.7 and 127.4 cm) with I_0 treatment. I_3 treatment showed second highest plant height (39.73, 68.23, 173.9 and 181.1 cm) which was very close to I_4 treatment.

Table 2: Effect of irrigation frequency on plant height of white maize at different growth stages

Treatments	Plant height (cm) at			
	30 DAS	60DAS	90DAS	Harvest
I_0	25.63 c	44.77 d	122.7 e	127.4 e
I_1	28.83 bc	45.33 d	134.8 d	137.0 d
I_2	30.38 b	52.84 c	154.9 c	156.8 c
I_3	38.88 a	68.23 b	173.9 b	181.0 b
I_4	41.41 a	71.62 a	183.6 a	186.1 a
$LSD_{(0.05)}$	3.93	2.59	5.49	4.71
CV%	9.72	3.75	2.91	2.44

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.1.3 Interaction effect of polythene mulch and irrigation frequency

From the value of plant height it was found that interaction effect of using polythene mulch and different irrigation frequency showed significant differences (Figure 1) at 60, 90 DAS and at harvest. However, the effect was non-significant at 30 DAS. At all growth stages, the highest plant heights (46.93, 78.91, 196.6 and 200.8 cm) were observed from the combination of PI_4 treatment which were statistically similar with PI_3 treatment at 60, 90 DAS and harvesting stage. The lowest plant heights (27.67, 34.87, 99.67 and 104.1 cm) were observed in P_0I_0 treatment.

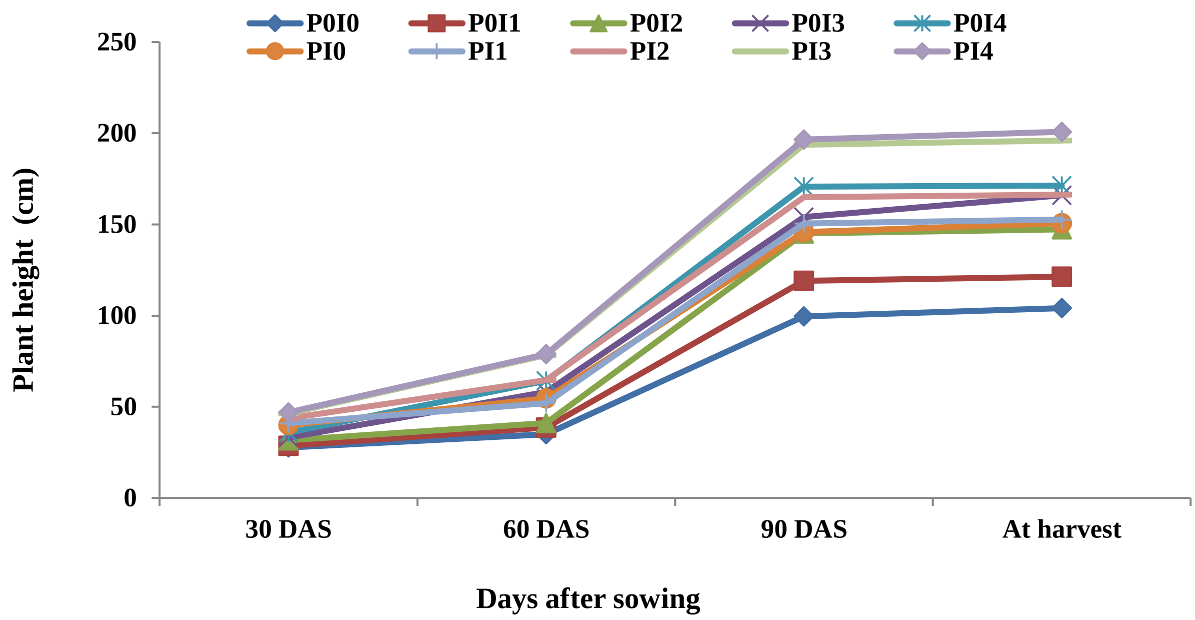

Figure 1: Interaction effect of polythene mulch and irrigation frequency on plant height of white maize [$LSD_{(0.05)}$= 3.67, 7.76 and 6.66 at 60, 90 DAS and harvest respectively]

P_0 = No polythene mulch. **P** = Polythene mulch, **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS**.**

4.1.2 Plant base diameter

4.1.2.1 Effect of polythene mulch

Base diameter is an important character in maize as it has an influence of lodging tendency of the plants when faces strong wind (storm). Significant difference was observed on the base diameter of white maize at 60 DAS (Table 3). Among the mulching and control, polythene mulching showed the highest base diameter (6.64 cm at 60 DAS) and the bare soil (no mulching) showed the lowest base diameter (4.91 cm at 60 DAS). Probably mulching helped conserve the soil moisture and the plenty supply of soil moister in turn helped the stem to increase the base diameter. At 90 DAS, significant difference was observed also on base diameter of maize. The highest base diameter (8.71 cm) was found on treatment P and the lowest (6.83 cm) was on P_0. This is similar to the findings of Duhr and Dubas (1990) who reported that mulched plants had enhanced growth and stem diameter in maize.

Table 3: Effect of polythene mulch on plant base diameter of white maize at different growth stages

Treatments	Plant base diameter (cm) at	
	60 DAS	**90DAS**
P_0	4.91 b	6.83 b
P	6.64 a	8.71 a
LSD $_{(0.05)}$	0.38	0.69
CV%	4.14	5.62

P_0 = No polythene mulch. **P** = Polythene mulch.

4.1.2.2 Effect of irrigation frequency

Irrigation frequency showed a significant variation on base diameter both at 60 and 90 DAS (Table 4). At 60 and 90 DAS, four frequent irrigation (I_4) showed the highest base diameter (7.60 and 9.355 cm) although which was statistically similar with treatment I_3.Whereas no irrigation treatment (I_0) showed the lowest base diameter (3.817 and 5.717 cm). Pandy *et al*. (2000) stated that applying drought stress at various growth stages of corn generally reduced stem diameter and plant height. This study shows that the irrigation water application increases the growth and stem diameter of maize.

Table 4: Effect of irrigation frequency on plant base diameter of white maize

Treatments	Plant base diameter (cm) at	
	60 DAS	**90DAS**
I_0	3.817 d	5.717 d
I_1	4.417 c	6.893 c
I_2	5.555 b	7.983 b
I_3	7.482 a	8.905 a
I_4	7.600 a	9.355 a
$LSD_{(0.05)}$	0.36	0.82
CV%	5.08	8.58

I_0 = No irrigation, I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.2.3 Interaction effect of polythene mulch and irrigation frequency

Interaction of polythene mulching and irrigation frequency showed significant variation in base diameter of white maize. The base diameter increased with the advances of growth period (Figure 2). At 60 DAS, the highest base diameter (9.0 cm) was observed in PI_4 which was statistically similar with PI_3; whereas the lowest base diameter (3.40 cm) was observed in P_0I_0. At 90 DAS, the highest base diameter (11.13 cm) was observed in PI_4 which was statistically similar with PI_3; whereas the lowest base diameter (5.20 cm) was observed in P_0I_0 which was statistically similar PI_0. Kalaghatagi*et al.* (1990) reported that irrigation with black polythene mulch spread between the rows significantly increased the dry matter and fodder yield as well as stem diameter also.

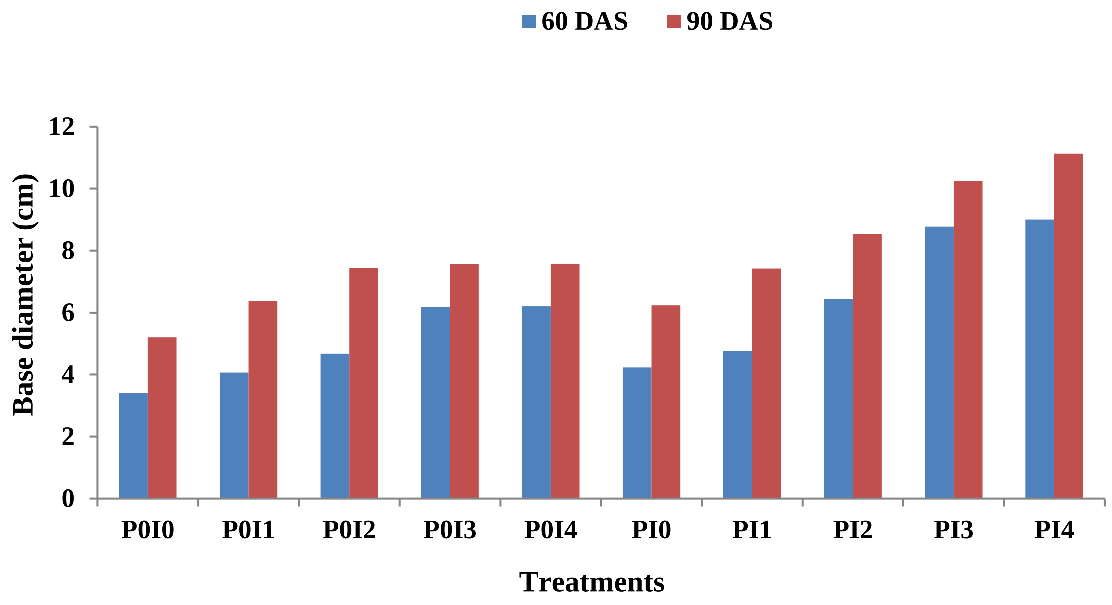

Figure 2: Interaction effect of polythene mulch and irrigation frequency on base diameter of white maize [LSD$_{(0.05)}$= 0.51 and 1.16 at 60 and 90 DAS respectively]

P_0 = No polythene mulch. **P** = Polythene mulch. **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.3 Dry matter content plant^{-1}

4.1.3.1 Effect of polythene mulch

Dry matter content plant^{-1} of maize showed statistically significant variation due to application of polythene mulch at 60, 90 DAS and at harvest stage (Table 5). At 30 DAS, the variation among the treatment was non significant. The highest (0.922 g) dry matter content plant^{-1} was recorded from treatment P and the lowest (0.744 g) was found in treatment P_0 at 30 DAS. At 60 DAS, the highest (22.16 g) dry weight plant^{-1} was found in P treatment. The lowest(14.62 g) dry weight plant^{-1}was found in P_0treatment**.**At 90 DAS, the highest (33.37 g) dry weight plant^{-1} was found in P treatment. The lowest (33.37 g) dry weight plant^{-1} was found in P_0 treatment**.** At harvesting stage, the highest (82.07 g) dry weight plant^{-1} was found in P treatment. The lowest (63.7 g) dry weight plant^{-1} was found in P_0 treatment**.** In consistent with the present study it has been reported that total dry weight production increased with the application of mulching compared to the bare plots (Kalaghatagi*et al.*, 1990).

Table 5: Effect of polythene mulch on dry matter content of white maize at different growth stages

Treatments	Dry weight plant^{-1}(g) at			
	30 DAS	**60DAS**	**90DAS**	**Harvest**
P_0	0.744	14.62 b	23.84 b	63.70 b
P	0.922	22.16 a	33.37 a	82.07 a
$LSD_{(0.05)}$	NS	1.58	1.88	1.50
CV%	22.75	5.13	2.45	1.34

P_0 = No polythene mulch. **P** = Polythene mulch.

4.1.3.2 Effect of irrigation frequency

Dry matter content plant^{-1} of white maize showed significant variation due to different levels of irrigation frequency at 60, 90 DAS and harvesting stages. However, it was not significant at 30 DAS (Table 6). At 30 DAS, the highest (0.922 g) dry weight plant^{-1} was recorded from treatment I_4 and the corresponding lowest dry weight 0.718 g which was found in treatment P_0. At 60 DAS, the highest (25.28 g) dry weight plant^{-1} was found in I_4 treatment which was statistically similar with I_3 (24.84 g). The lowest (8.78 g) dry weight plant^{-1} was found in I_0 treatment**.** At 90 DAS, the highest (37.40 g) dry weight plant^{-1} was also found in I_4 treatment which was statistically similar with I_3 (36.70 g). The lowest (18.28 g) dry weight plant^{-1} was found in I_0 treatment**.** At harvesting stage, the highest (91.80 g) dry weight plant^{-1} was found in I_4 treatment. The lowest dry weight plant^{-1} was found in I_0 (50.33 g) treatment**.**

In consistent with the present study it has been reported that total dry weight production in maize gradually increased with increasing the number of irrigation. Tomar *et al.* (1992) found significant increase in dry matter due to irrigation. Although in different crop, they found the maximum dry matter production of mustard was found to be the highest with two irrigations while one irrigation and control produced lower dry matter per plant.

Table 6: Effect of irrigation frequency on dry matter content of white maize at different growth stages

Treatments	Dry weight plant^{-1}(g) at			
	30 DAS	60DAS	90DAS	Harvest
I_0	0.718	8.78 d	18.28 d	50.33 e
I_1	0.768	13.83 c	23.33 c	60.23 d
I_2	0.841	19.22 b	27.33 b	72.23 c
I_3	0.915	24.84 a	36.70 a	89.80 b
I_4	0.922	25.28 a	37.40 a	91.80 a
$LSD_{(0.05)}$	NS	1.11	1.44	1.02
CV%	14.63	4.94	4.10	1.14

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.3.3 Interaction effect of polythene mulch and irrigation frequency:

Dry weight plant^{-1} was significantly influenced by interaction of polythene mulch and irrigation frequency at different days after sowing (DAS) except 30 DAS (Figure 3). At 30 DAS, the highest (1.024 g) dry weight plant^{-1} was found in PI_4 treatment. The lowest (0.637 g) dry weight plant^{-1} was found in P_0I_0. At 60 DAS, the highest (29.22 g) dry weight plant^{-1} was found in PI_4 treatment which was statistically similar with PI_3. On the other hand the lowest (6.78 g) dry weight plant^{-}1 was found in P_0I_0 treatment**.** At 90 DAS, the highest (43.67 g) dry weight plant^{-1} was found in PI_4 treatment which was statistically similar with PI_3 (43.33).The lowest (14.78 g) dry weight plant^{-1} was found in P_0I_0 treatment**.** At harvesting stage, the highest dry weight plant^{-1} was found in PI_4

treatment (98.50 g) which was statistically similar with PI_3 (97.23 g) treatment. The lowest (39.90 g) dry weight plant^{-1} was found in P_0I_0.

The finding of the present study is in consistent with that of Kalaghatagi*et al.* (1990) who reported that irrigation along with applying black polythene mulch in maize field spread between the adjacent rows significantly increased the dry matter at harvest.

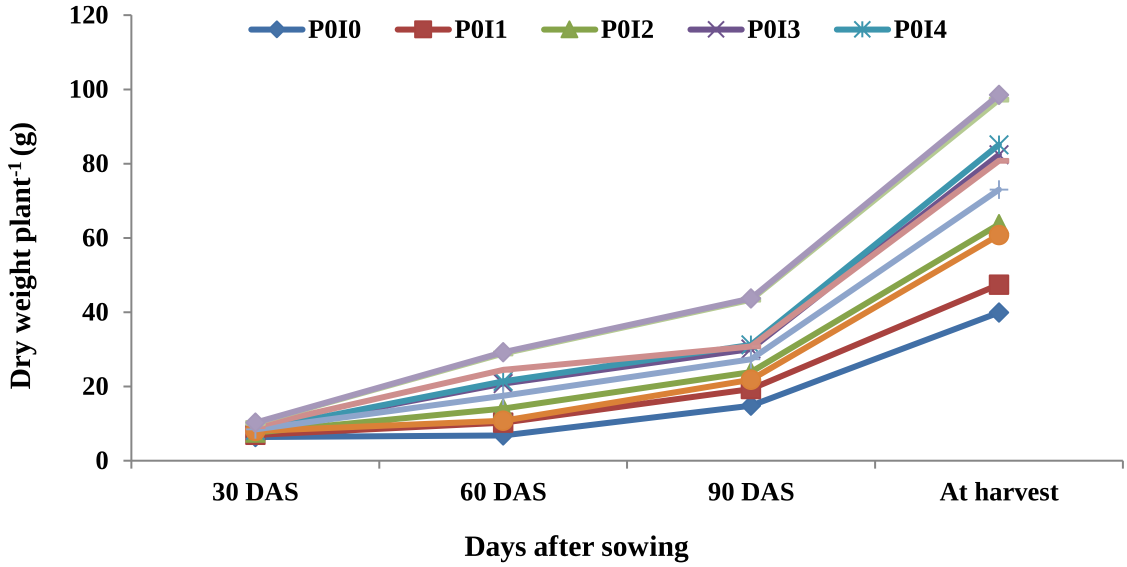

Figure 3: Interaction effect of polythene mulch and irrigation frequency on dry matter content of white maize at different growth stages [$LSD_{(0.05)}$ = 1.57, 2.03 and 1.44 at 60, 90 DAS and harvest respectively]

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.4 Leaf Area Index

4.1.4.1 Effect of polythene mulch

Maize variety exhibited significant difference on leaf area at 60 and 90 DAS and harvesting stage (Table 7). Among the polythene mulching and control treatment, polythene mulching (P) showed the maximum leaf area index (0.82, 2.09, 4.023 and 3.665 at 30, 60, 90 DAS and harvesting stage) and control (P_0) showed the minimum leaf area (0.58, 1.68, 3.094 and 2.727 at 30, 60, 90 DAS and harvesting stage). Kulkarni *et al*. (1998) also reported that the LAI of maize increased under black polythene mulch as compared to paddy straw mulch and no mulch treatment.

Table 7: Effect of polythene mulch on leaf area index (LAI) of white maize at different growth stages

Treatments	Leaf area index (LAI)			
	30 DAS	**60DAS**	**90DAS**	**At Harvest**
$\mathbf{P_0}$	0.58 b	1.68 b	3.094 b	2.727 b
P	0.82 a	2.09 a	4.023 a	3.665 a
$\mathbf{LSD_{(0.05)}}$	0.14	0.05	0.165	0.05
CV%	11.51	1.78	2.89	1.41

$\mathbf{P_0}$ = No polythene mulch. **P** = Polythene mulch.

4.1.4.2 Effect of irrigation frequency

Irrigation frequency showed a significant variation on leaf area index at 60, 90 DAS and harvesting stage and non significant variation at 30 DAS (Table 8). At 30 DAS, I_4 showed the maximum leaf area index (0.81) and I_0 showed the lowest leaf area index (0.57); whereas at 60, 90 DAS and harvesting stage, the highest leaf area index were (2.525, 4.295 and 3.777) at I_4 which were statistically similar with treatment I_3 and the lowest leaf area index were (1.292, 2.505 and 2.270). Lopes *et al.* (1988) reported that moisture deficiency resulted in lower number of leaves due to moisture deficit in the soil and thus the leaf area index is affected by irrigation.

Table 8: Effect of irrigation frequency on leaf area index (LAI) of white maize at different growth stages

Treatments	Leaf area index (LAI) at			
	30 DAS	**60DAS**	**90DAS**	**Harvest**
I_0	0.57	1.292 c	2.505 d	2.270 d
I_1	0.61	1.375 c	3.213 c	3.000 c
I_2	0.72	1.750 b	3.517 b	3.223 b
I_3	0.79	2.477 a	4.263 a	3.710 a
I_4	0.81	2.525 a	4.295 a	3.777 a
$LSD_{(0.05)}$	NS	0.14	0.194	0.145
CV%	15.69	6.2	4.47	3.74

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.1.4.3 Interaction effect of polythene mulch and irrigation frequency

Interaction of polythene mulching and irrigation frequency showed significant variation with advances of growth period in respect of leaf area index except at 30 DAS (Figure 4). At 30 DAS, the maximum leaf area index (0.94) was observed in PI_4 and the lowest leaf area index was observed in P_0I_0. At 60, 90 DAS and harvest stage, the maximum leaf area index (2.933, 4.817 and 4.413) was observed in PI_4 which was statistically similar with PI_3 and the minimum leaf area index (1.30, 2.243 and 2.047) was observed in P_0I_0 which was statistically similar with P_0I_1, PI_0 and PI_1 at 60 DAS. Kalaghatagi*et al.* (1990) also reported that irrigation with black polythene mulch spread between the rows significantly increased the dry matter at harvest, leaf area at 60 days after sowing in maize.

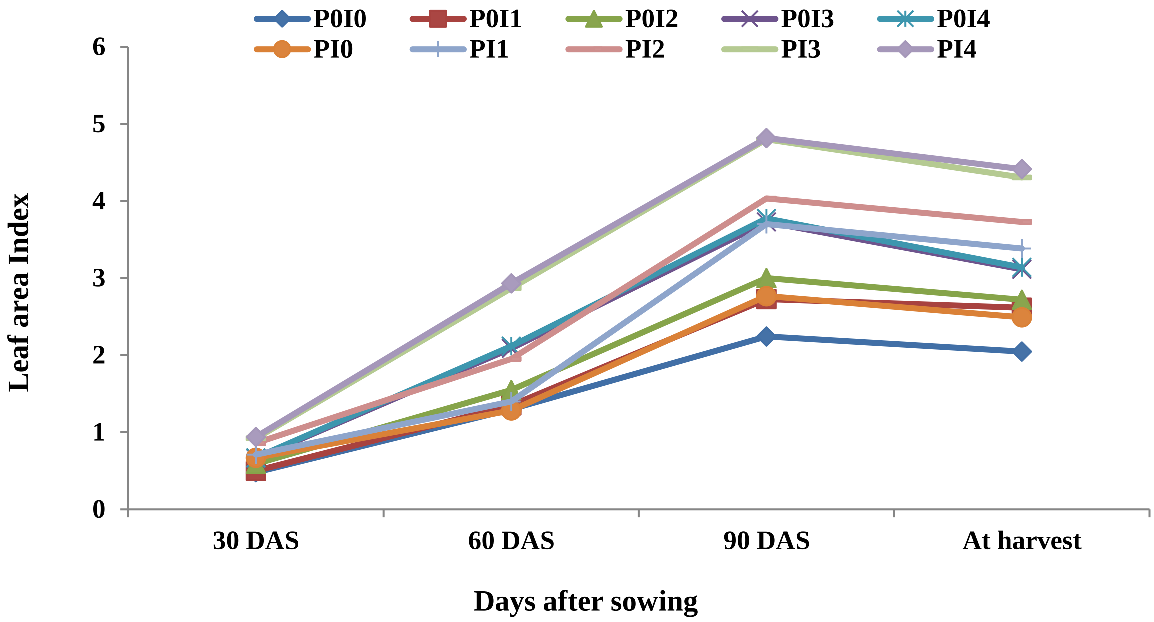

Figure 4: Interaction effect of polythene mulch and irrigation frequency on leaf area index of white maize at different growth stages [$LSD_{(0.05)}$ = 0.205, 0.274 and 0.205 at 60, 90 DAS and harvest respectively]

$\mathbf{P_0}$ = No polythene mulch. P = Polythene mulch. $\mathbf{I_0}$ = No irrigation, $\mathbf{I_1}$ = One irrigation at 15 DAS, $\mathbf{I_2}$ = Two irrigations at 15 and 30 DAS, $\mathbf{I_3}$ = Three irrigations at 15, 30 and 60 DAS, $\mathbf{I_4}$ = Four irrigations at 15, 30, 60 and 90 DAS.

4.2 Yield and Yield Contributing Parameters

4.2.1 Cob length

4.2.1.1 Effect of polythene mulch:

Significant variation was recorded for cob length of maize due to application of polythene mulch in (Table 9). The longest cob was recorded (24.58 cm) in P (polythene mulching) and the minimum (21.03cm) was found in control (P_0) treatment. This is similar to the findings of Pinjari (2007) who reported that the polythenemulch on sweet corn increased the cob length.

Table 9: Effect of polythene mulch on yield contributing characters of white maize

Treatments	Cob length (cm)	Cob diameter (cm)	No. of rows cob^{-1}	No. of seeds row^{-1}
P_0	21.03 b	15.96 b	12.73 b	23.17 b
P_1	24.58 a	17.37 a	13.68 a	27.10 a
$LSD_{(0.05)}$	1.24	0.14	0.186	1.324
CV (%)	3.46	3.55	1.89	3.35

P_0 = No polythene mulch. **P** = Polythene mulch.

4.2.1.2 Effect of irrigation frequency

Cob length of maize was significantly different due to the irrigation frequencies (Table 10). Cob length of maize ranged from 19.59 to 26.52 cm, longest cob was found in I_4 treatment which is not statistically similar to others treatments. The lowest cob length 19.59 cm was recorded treatment I_0. The treatment $I_4$was statistically superior to $I_{0,}$ I_1,I_3 treatments in terms of cob length. The grain yield of maize was positively correlated with cob length characters. The results obtained from the present study were similar to the findings of Mohapatra *et al.* (1998). He said soil moisture increase cob length.

Table 10: Effect of irrigation frequency on yield contributing characters of white maize

Treatments	Cob length (cm)	Cob diameter (cm)	No. of rows cob^{-1}	No. of seeds row^{-1}
I_0	19.59 e	13.22 d	11.30 d	16.50 d
I_1	21.14 d	15.57 c	12.51 c	21.58 c
I_2	22.11 c	16.80 b	12.87 b	25.33 b
I_3	24.66 b	18.84 a	14.61 a	30.97 a
I_4	26.52 a	18.89 a	14.73 a	31.28 a
$LSD_{(0.05)}$	0.58	0.27	0.17	1.67
CV (%)	2.06	1.3	1.08	5.43

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.1.3 Interaction effect of polythene mulch and irrigation frequency

From the value of cob length it was found that interaction effect of polythene mulching and irrigation frequency showed significant differences (Figure 5). The highest cob length (27.63 cm) was observed in PI_4 treatment which was statistically similar with PI_3. The lowest coblength (18.72 cm) was observed in P_0I_0 treatment combination which was statistically similar with P_0I_1 treatment. The results obtained from the present study were similar to those of Mohapatra *et al.* (1998).

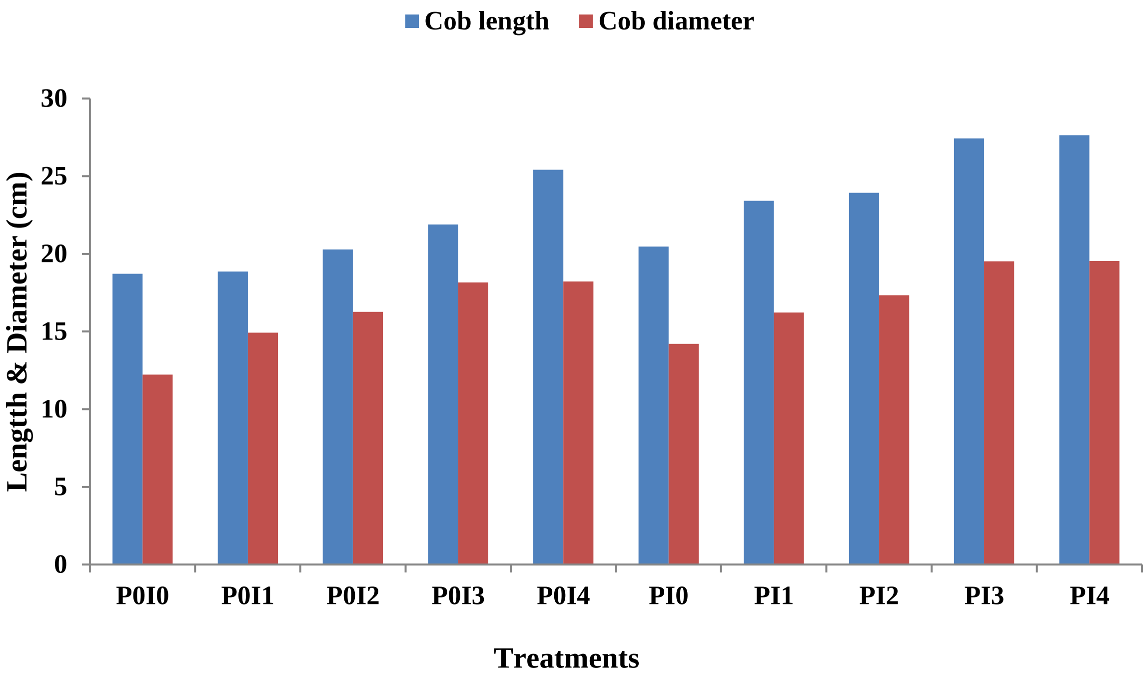

Figure 5: Interaction effect of polythene mulch and irrigation frequency on cob length and cob diameter of white maize [$LSD_{(0.05)}$ = 0.81 and 0.38 for cob length and diameter respectively]

$\mathbf{P_0}$ = No polythene mulch. P = Polythene mulch. $\mathbf{I_0}$ = No irrigation, $\mathbf{I_1}$ = One irrigation at 15 DAS, $\mathbf{I_2}$ = Two irrigations at 15 and 30 DAS, $\mathbf{I_3}$ = Three irrigations at 15, 30 and 60 DAS, $\mathbf{I_4}$ = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.2 Cob diameter

4.2.2.1 Effect polythene mulch

Significant variations in cob diameter was observed by the application of polythene mulch (Table 9). Results showed that the highest cob diameter (17.37 cm) was obtained from treatment P (polythene mulch). The lowest cob diameter (15.96) was observed with P_0 (control). The results are in line with the findings of Pinjari (2007) who reported that application of polythene mulch on sweet corn produced significantly higher cob diameter which ultimately increased the grain yields.

4.2.2.2 Effect of irrigation frequency

Cob diameter was significantly influenced by different irrigation frequency (Table 10). Results showed that the highest cob diameter (18.89 cm) was in I_4 which was statistically similar with I_3 and the lowest cob diameter (13.22 cm) with I_0 treatment.This result is in agreement with Mohapatra *et al.* (1998).

4.2.2.3 Interaction effect of polythene mulch and irrigation frequency

Cob diameter was significantly influenced by interaction effect of polythene mulching and irrigation frequency (Figure5). Results showed that highest cob diameter (19.55 cm) was found with the treatment combination of PI_4 although this was at par with PI_3 in this respect. On the other hand the lowest cob diameter was observed with P_0I_0 (12.23 cm). The results obtained from the present study were in conformity with the findings of Mohapatra*et al.* (1998). They found that mulching following the irrigation confirmed 50% available soil moisture which eventually increased the cob length.

4.2.3 Rows cob^{-1}

4.2.3.1 Effectof polythene mulch

Maize polythene mulch exhibited significant difference in respect of the number of row cob^{-1} (Table 9). Among the treatments, P (polythene mulch) showed the maximum number of row cob^{-1} (13.68) and no mulch (P_0) showed the minimum number of row cob^{-1} (12.73). Quayyum and Ahmed (1993) stated that the highest number of rows per cob was found by using rice straw mulching that enhanced conservation of soil moisture and polythene mulch also conserve soil moisture and increase the no. of grain rows per cob.

4.2.3.2 Effect of irrigation frequency

The irrigation frequency exerted a significant variation in respect of the no. of row cob^{-1} (Table 10). Irrigation frequency (I_4) showed the maximum no. of row cob^{-1}(14.73) which was statistically similar with treatment I_3 (14.61); whereas I_0 showed the minimum number of row cob^{-1} (11.30) which was statistically different from others. This is similar to the findings of Panda *et al.* (2004) who reported that the effect of different irrigation scheduling methods had effect on root zone soil moisture, growth, yield parameters and water use efficiency of corn.

4.2.3.3 Interaction effect of polythene mulch and irrigation frequency

Interaction of polythene mulching and irrigation frequency showed significant variation in respect of the number of row cob^{-1} (Figure 6). The maximum number of row cob^{-1} (15.43) was observed in PI_4 which was statistically similar with PI_3; whereas the minimum number of row cob^{-1} (10.90) was observed in P_0I_0 which was lowest in comparison to other combinations.Mohapatra *et al.* (1998) found that mulching with irrigation confired 50% available soil moisture which in turn increased the rows of grains/cob as well as grain yield over all.

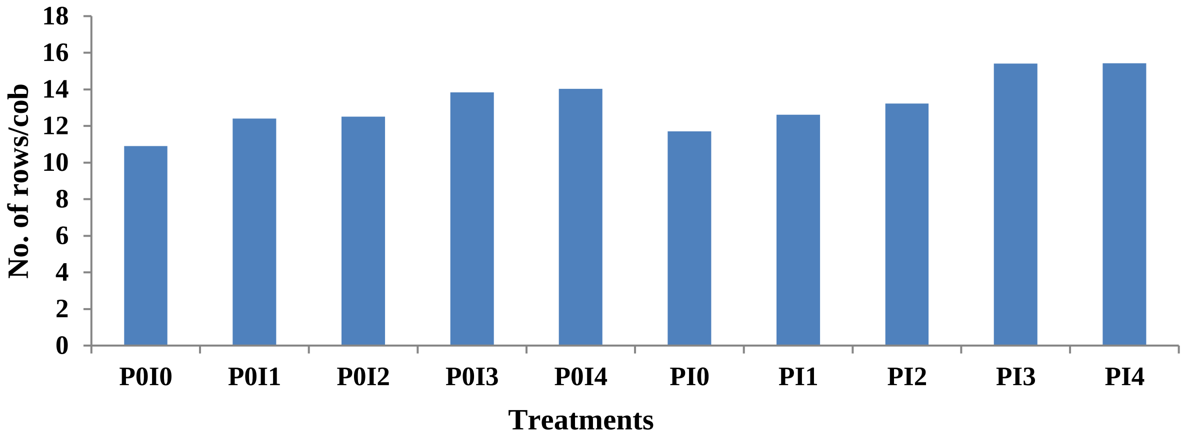

Figure 6: Interaction effect of polythene mulch and irrigation frequency on no. of rows per cob of white maize [$LSD_{(0.05)}$ = 0.24]

$\mathbf{P_0}$ = No polythene mulch. **P** = Polythene mulch. $\mathbf{I_0}$ = No irrigation, $\mathbf{I_1}$ = One irrigation at 15 DAS, $\mathbf{I_2}$ = Two irrigations at 15 and 30 DAS, $\mathbf{I_3}$ = Three irrigations at 15, 30 and 60 DAS, $\mathbf{I_4}$ = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.4 No of grains row^{-1}

4.2.4.1 Effect polythene mulch

Maize variety exhibited significant difference in respect of the no. of grain row^{-1} (Table 9) in response of polythene mulching. Among the treatment and control, polythene mulching showed the maximum no. of grain row^{-1} (27.10) and P_0 (control) showed the minimum no. of grain row^{-1} (23.17). Mohapatra *et al.* (1998) concluded that polythene mulching increased the intensity of cobbing, probably the increased available soil moisture as a result of mulching helped in increasing the cobs/plant, cob length, cob diameter, weight/cob, rows of grains/cob, grains/cob and grain yield/ha.

4.2.4.2 Effect of irrigation frequency

Irrigation frequency showed a significant variation in respect of the no. of grain row^{-1} (Table 10). Irrigation frequency (I_4) showed the maximum no. of grain row^{-1} (31.28) which was statistically similar with I_3; whereas Irrigation frequency (I_0) showed the minimum no. of grain row^{-1} (16.50) which was statistically different from others.

4.2.4.3 Interaction effect of polythene mulch and irrigation frequency

Interaction effect of polythene mulching and irrigation frequency showed significant variation in number of grains row^{-1} (Figure 7). The maximum number of grains row^{-1} (34.55) was observed in PI_4 which was statistically similar with PI_3; whereas the minimum number of grain row^{-1} (15.50) was observed in P_0I_0 which was statistically similar with PI_0.

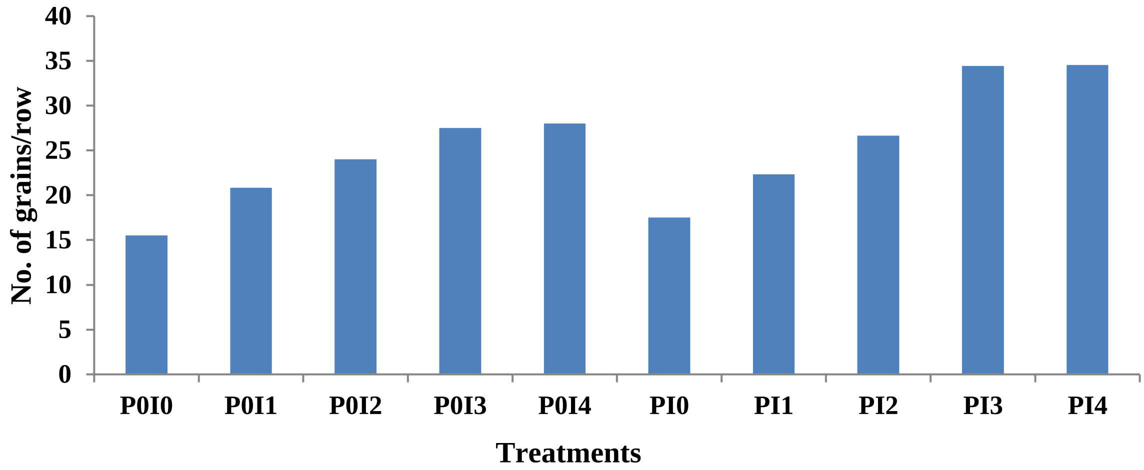

Figure 7: Interaction effect of polythene mulch and irrigation frequency on no. of grains per row of white maize [$LSD_{(0.05)}$ = 2.361]

$\mathbf{P_0}$ = No polythene mulch. **P** = Polythene mulch. $\mathbf{I_0}$ = No irrigation, $\mathbf{I_1}$ = One irrigation at 15 DAS, $\mathbf{I_2}$ = Two irrigations at 15 and 30 DAS, $\mathbf{I_3}$ = Three irrigations at 15, 30 and 60 DAS, $\mathbf{I_4}$ = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.5 Number of grains cob^{-1}

4.2.5.1Effect of polythene mulch

Number of grains cob^{-1} was significantly influenced by application of polythene mulch in the present study (Table 11). Results showed that the highest number of grains cob^{-1} (412.40) was recorded with P which was statistically dissimilar with P_0 and the lowest number of grains cob^{-1} (373.10) with treatment P_0. Pinjari (2007) found the similar result that number of grains per cob increased under polythene mulch over no mulch.

Table 11: Effect of polythene mulch on yield contributing characters of white maize

Treatments	No. of grains cob^{-1}	Grain weight cob^{-1} (g)	100 grain weight (g)
P_0	373.10 b	75.08 b	29.95
P_1	412.40 a	102.10 a	33.88
$LSD_{(0.05)}$	25.65	4.60	NS
CV (%)	4.16	3.30	9.04

P_0 = No polythene mulch. **P** = Polythene mulch.

4.2.5.2 Effect of irrigation frequency

Significant variation was observed on number of grains cob^{-1} in case of different frequency of irrigation (Table 12). The highest number of grains cob^{-1} was observed at I_4 treatment (467.40) which was statistically similar with I_3. The lowest number of grains cob^{-1}was observed at I_0 treatment (308.20) which was at par with I_1. Pandy *et al.* (2000) stated that applying drought stress at various growth stages of corn generally reduced seed yield, number of seeds/cob. The result was similar to the present study.

Table 12: Effect of irrigation frequency on yield contributing characters of white maize

Treatments	No. of grains cob^{-1}	Grain weight cob^{-1} (g)	100 grain weight (g)
I_0	308.20 c	54.10 d	29.68 b
I_1	332.90 c	63.43 c	30.59 b
I_2	393.20 b	85.27 b	31.55 b
I_3	462.00 a	118.50 a	33.83 a
I_4	467.40 a	121.70 a	33.90 a
$LSD_{(0.05)}$	25.7	5.54	2.27
CV (%)	5.35	5.11	5.82

I_0 = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.5.3 Interaction effect of polythene mulch and irrigation frequency

Number of grains cob^{-1} was significantly influenced by interaction effect of polythene mulching and irrigation frequency (Figure 8). Results showed that the highest number of grains cob^{-1} (510.10) was found with the treatment combination of PI_4 which was however similar with that of PI_3 (500.30). On the other hand, the lowest number of grains cob^{-1} (306.0) was observed with P_0I_0 which was again statistically similar with P_0I_1, PI_0, PI_1. Mohapatra *et al.* (1998) stated that the number of grains per cob depended on the available soil moisture in the soil which was increased by mulching with irrigation.

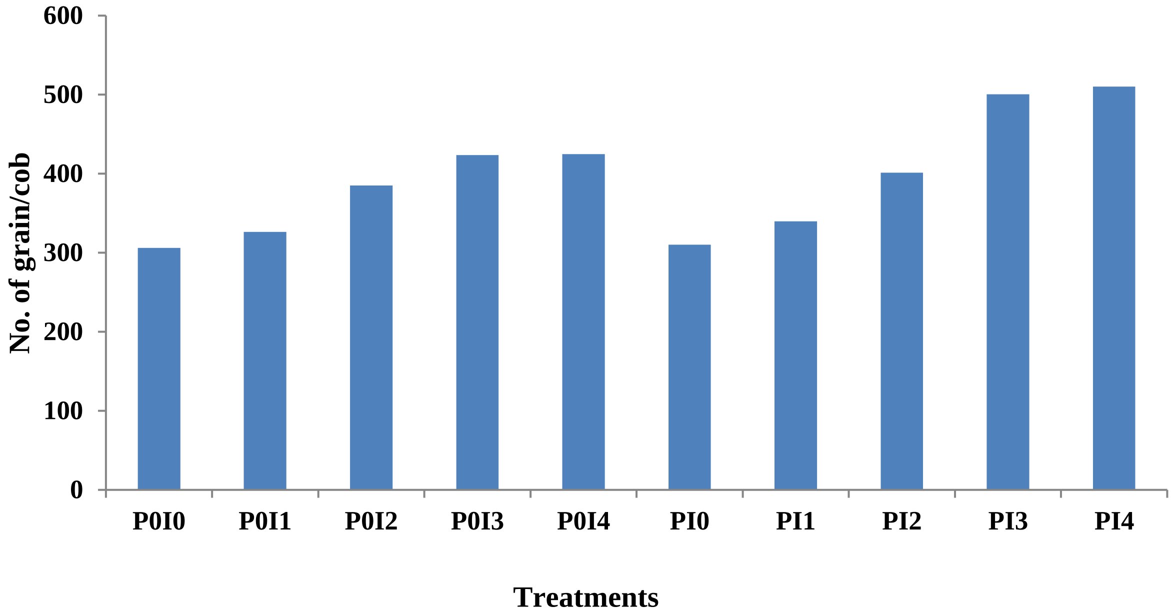

Figure 8: Interaction effect of polythene mulch and irrigation frequency on no. of grain per cob of white maize [$LSD_{(0.05)}$ = 36.34]

P_0 = No polythene mulch. **P** = Polythene mulch. **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.6 Grain weight cob^{-1}

4.2.6.1 Effect of polythene mulch

Statistically significant variations in grain weight cob^{-1} was observed due to mulching with polythene(Table 11). The maximum grain weight cob^{-1} (102.10 g) was found in P treatment and the weight of grain cob^{-1} (75.08 g) in P_0 treatment (Table 6). Pinjari (2007) found the effect of polythene mulch in sweet corn revealing that the different yield attributes *viz*. weight of grains per cob and weight per cob were significantly superior under polythene mulch over no mulch.

4.2.6.2 Effect of irrigation frequency

Irrigation frequency showed significant effect on weight of grain cob^{-1} (Table 12). The highest grain weight cob^{-1} was observed for the treatment I_4 (121.7g) which was statistically similar with treatment I_3 (118.5g) and the lowest grain weight cob^{-1} (54.1g) observed in I_0 treatment. Pandy *et al*. (2000) reported that applying drought stress at various growth stages of corn generally reduced seed yield, number of seeds cob^{-1}, 100-seed weight as well as grain weight per cob. This study emphases that irrigation scheduling is very effective at various growth stage of maize for increasing the grain weight in a cob.

4.2.6.3 Interaction effect of polythene mulch and irrigation frequency

The grain weight cob^{-1} was also shown significantly variation due to interection effect of the treatments (Figure 9). The grain weight cob^{-1} of maize ranged from 48.20 to 140.6 g. The highest grain weight cob^{-1} was found in PI_4 (140.6 g) which was statistically similar with PI_3 (138 g). The lowest grain weight cob^{-1} was recorded with P_0I_0 treatment (48.2 g) which was statistically similar with P_0I_1 (50.2 g). Mohapatra *et al.* (1998) concluded that mulching with irrigation helped to save 50% available soil moisture which in tern increased the grain weight cob^{-1} as well as grain yield of maize.

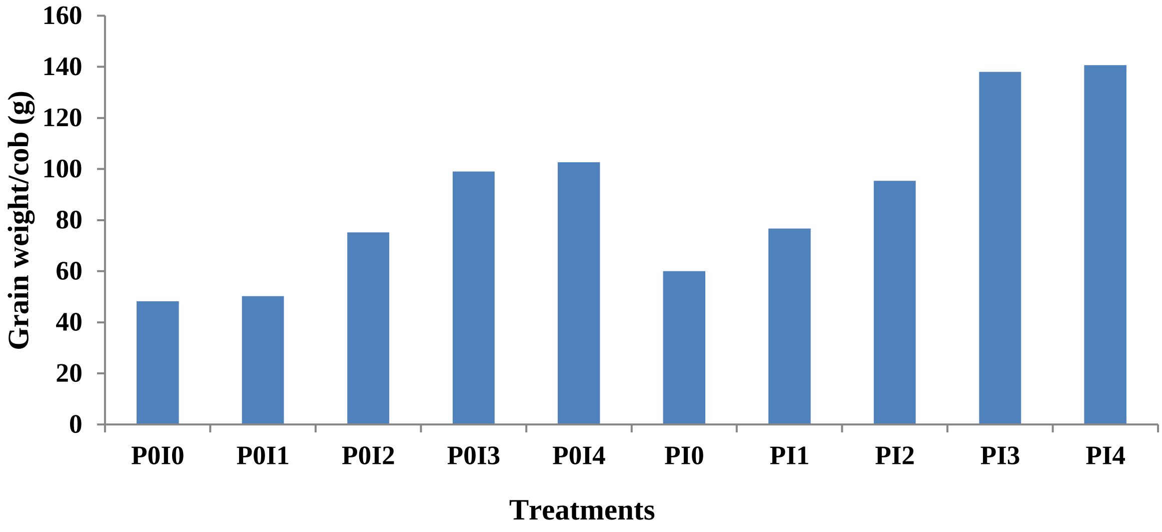

Figure 9: Interaction effect of polythene mulch and irrigation frequency on grain weight per cob of white maize [$LSD_{(0.05)}$ = 7.836]

P_0 = No polythene mulch. **P** = Polythene mulch. **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.7 100-grain weight

4.2.7.1 Effect of polythene mulch

No significant variations in number of 100-grain weight was observed due to the application of polythene mulch (Table 11). The treatment P showed the highest 100-grain weight of 33.88 g and the treatment P_0 showed the lowest 100-grain weight of 29.95 g. The 100 seeds weight and grain yield of maize was affected due to moisture conservation properties soil. This result is agreed with Kulkarni *et al*. (1998) who reported that mulching increased soil moisture content and the increased availability of soil moisture probably helped to increase the 1000 grain weight of maize.

4.2.7.2 Effect of irrigation frequency

Significant variation was recorded in weight of 100-grain of maize due to different irrigation frequency (Table 12). The treatment I_4 produced significantly the highest 100-grain weight of 33.90 g which was similar with I_3

while I_0 produced significantly the lowest 100-grain weight of 29.68 g which was at par with I_1 and I_2 (30.59 and 31.55 g). Pandy *et al*. (2000) reported that applying drought stress at various growth stages of corn generally reduced seed yield and 1000-seed weight. This happened due to the continued supply of soil moisture which increased the 1000-seed weight as well as seed yield.

4.2.7.3 Interaction effect of polythene mulch and irrigation frequency

Interaction effect of polythene mulching and irrigation frequency showed significant effect on weight of 100-grain weight of maize (Figure 10). The highest weight of 100 grain (36.33 g) was observed from PI_4 which was statistically similar with PI_3. The 100-seed weight from PI_3 was not significantly higher than those of PI_2 and PI_0 treatments. While the lowest 100-grain weight (26.51 g) was recorded from P_0I_0. It appeared that the mulching with irrigation increased the availability of soil moisture which increased the values of yield components and consequently that of yield in maize. Kalaghatagi *et al.* (1990) reported that irrigation with black polythene mulch spread between the rows significantly increased the number of grains/cob, grain weight/cob, 1000 grain weight of maize.

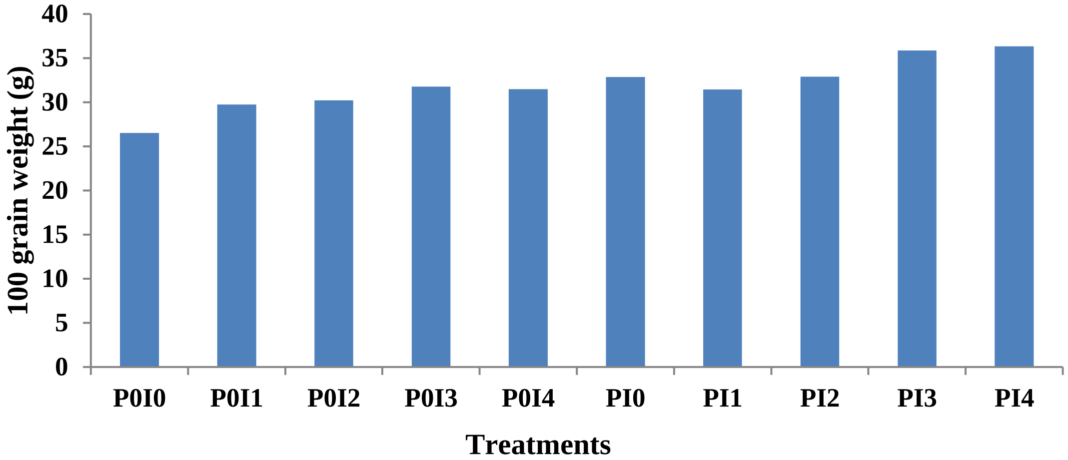

Figure 10: Interaction effect of polythene mulch and irrigation frequency on 100-grain weight of white maize [$LSD_{(0.05)}$ = 3.21]

P_0 = No polythene mulch. **P** = Polythene mulch. **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.8 Grain yield

4.2.8.1 Effect of polythene mulch

Grain yield was significantly influenced by application of polythene mulching used in the present study (Table 13). Results showed that the highest grain yield (9.400 t ha^{-1}) was found in P. On the other hand the lowest grain yield (6.970 t $ha^{-1)}$. Probably the grain yield of maize was affected by changes in soil moisture conservation due to mulching with polythene sheet. From this study it appeares that polythene mulching increased soil moisture percentage and also the availability of nutrients which eventually increased the values of yield components as well as that of yield of maize. Liu *et al*. (2002) reported that the transplanting spring maize with plastic film mulching improved the ecological environment of the soil, increased soil temperature and soil water contents, promoted the growth and maturation of maize and increased crop yield. Kwabiah (2004) found that the plastic mulch increased the total cob yield by 8-17% over no mulch. Plastic mulching increased grain yield from 2 to 4 t ha^{-1} in maize as was reported by Easson (2000). Similar result was also found by

Shelly (2002) in maize who observed that among the polythene mulches, black polythene showed the highest yield.

Table 13: Effect of polythene mulch on yield parameters of white maize

Treatments	**Grain yield (t ha^{-1})**	**Straw yield (t ha^{-1})**	**Biological yield (t ha^{-1})**	**Harvest Index (%)**
P_0	6.970 b	10.930 b	17.900 b	38.88
P_1	9.400 a	13.900 a	23.300 a	39.76
$LSD_{(0.05)}$	0.400	0.350	0.570	NS
CV (%)	3.09	1.81	1.76	1.74

P_0 = No polythene mulch. **P** = Polythene mulch.

4.2.8.2 Effect of irrigation frequency

Significant variation was observed on grain yield in case of frequent irrigation in the field (Table 14). It was found that the highest grain yield (10.610 t ha^{-1}) was achieved from I_4 and it was statistically similar with I_3 treatment showing the grain yield of 10.540 t ha^{-1}. On the other hand, the lowest grain yield (5.000 t ha^{-1}) was found in I_0 (control). The results obtained from all other treatments gave intermediate results. Panda *et al.* (2004) evaluated the effect of different irrigation scheduling methods and reported improvement in root zone soil moisture, growth, yield parameters and water use efficiency of corn. They concluded that under water scarcity conditions, irrigation should be scheduled at 45% of the maximum allowable depletion of available soil water of corn to obtain high yield parameters.

Table 14: Effect of irrigation frequency on yield parameters of white maize

Treatments	Grain yield ($t\ ha^{-1}$)	Straw yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest Index(%)
I_0	5.000 d	8.580 d	13.580 d	36.93 c
I_1	6.885c	11.150 c	18.030 c	38.25 bc
I_2	7.892 b	12.140 b	20.030 b	39.46 ab
I_3	10.540a	15.060 a	25.600 a	40.97 a
I_4	10.610a	15.130 a	25.750 a	40.98 a
$LSD_{(0.05)}$	0.280	0.900	0.96	2.13
CV (%)	2.76	5.9	3.82	4.42

I_0 = No irrigation, I_1 = One irrigation at 15 DAS, I_2 = Two irrigations at 15 and 30 DAS, I_3 = Three irrigations at 15, 30 and 60 DAS, I_4 = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.8.3 Interaction effect of polythene mulch and irrigation frequency

Grain yield was significantly influenced by interaction effect of polythene mulching and irrigation frequency (Figure 11). Results showed that the highest grain yield (12.810 t ha^{-1}) was found with the treatment combination of PI_4 which was statistically similar with PI_3. On the other hand the lowest grain yield (4.767 t ha^{-1}) was observed with P_0I_0. PI_2, P_0I_3 and P_0I_4 treatments gave statistically similar yield. Mohapatra *et al*. (1998) and Kalaghatagi *et al.* (1990) also found the similar finding relation to grain yield which was increased due to soil moisture availability as a result of polythene mulching.

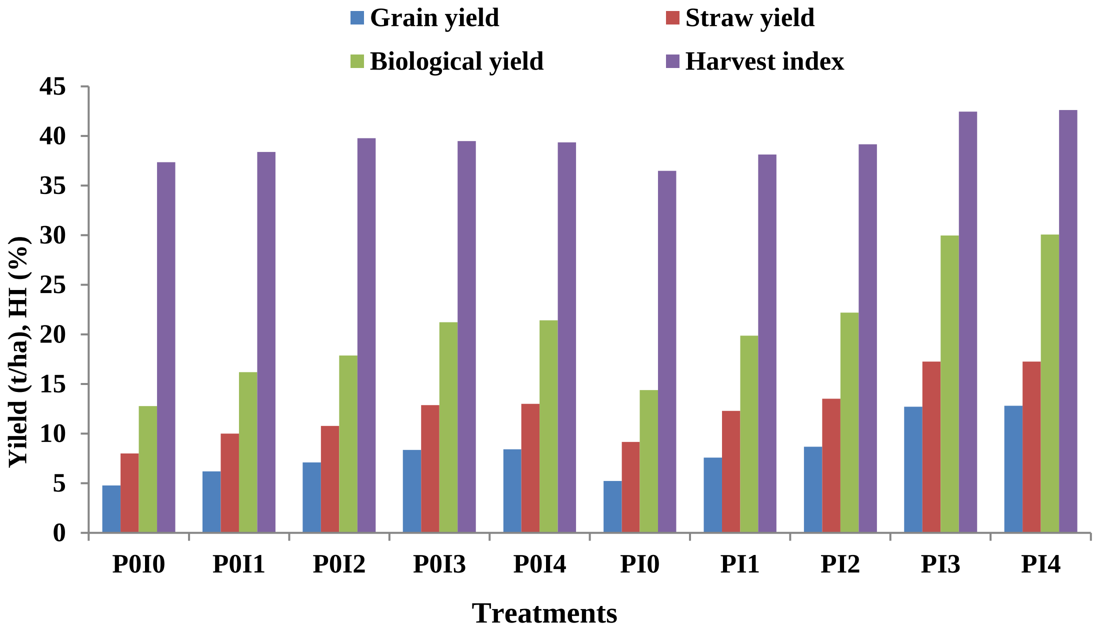

Figure 11: Interaction effect of polythene mulch and irrigation frequency on grain yield, straw yield, biological yield and harvest index of white maize [$LSD_{(0.05)}$ = 0.39, 1.27, 1.36 and 3.01 for grain yield, straw yield, biological yield and harvest index respectively]

P_0 = No polythene mulch. **P** = Polythene mulch. **I_0** = No irrigation, **I_1** = One irrigation at 15 DAS, **I_2** = Two irrigations at 15 and 30 DAS, **I_3** = Three irrigations at 15, 30 and 60 DAS, **I_4** = Four irrigations at 15, 30, 60 and 90 DAS.

4.2.9 Straw yield (t ha^{-1})

4.2.9.1 Effect of polythene mulch

Straw yield of maize showed statistically significant variation due to mulching with polythene sheet (Table 13). The highest straw yield of 13.900 t ha^{-1} was recorded from P treatment. On the other hand, the lowest straw yield 10.930 t ha^{-1} was observed from P_0 treatment. Bhatt *et al*. (2004) reported increased soil moisture which was conserved following mulching practice. The application of mulching increased soil moisture helping to increase the grain and straw yield. Gosavi (2006) also reported that significantly highest green cob and stover yield under polythene mulch than control.

4.2.9.2 Effect of irrigation frequency

Straw yield of maize showed statistically significant variation due to different levels of irrigations (Table 14). The highest straw yield of 15.130 t ha^{-1} was recorded from I_4 treatment which was statistically similar with I_3 treatment. On the other hand, the lowest straw yield 8.583 t ha^{-1} was observed from I_0 treatment.

4.2.9.3 Interaction effect of polythene mulch and irrigation frequency

Interaction effect of polythene mulching and irrigation frequency showed significant differences on straw yield of maize (Figure 11). The highest straw yield (17.270 t ha^{-1}) was observed from PI_4 which was at par with $PI_{3,}$while the lowest straw yield (8.000 t ha^{-1}) was obtained from P_0I_0 which was again at par with PI_0 treatment. The results obtained from the present study were in conformity with the findings of Kalaghatagi *et al.* (1990) who reported that irrigation followed by polythene mulching significantly increased the fodder yield.

4.2.10 Biological yield (t ha^{-1})

4.2.10.1 Effect of polythene mulch

It was revealed from the experiment that biological yield of maize showed significant variation due to application of polythene mulching (Table 13). The highest biological yield (23.300 t ha^{-1}) was observed from P treatment. On the other hand, the lowest biological yield (17.900 t ha^{-1}) was observed from P_0 treatment. The results obtained from the present study is in consistent with the findings of Kwabiah (2004) who reported that the plastic mulch increased the total biomass yield by 3-6% over that of no mulch.

4.2.10.2 Effect of irrigation frequency

Statistically significant variation was observed in biological yield of maize due to irrigations frequencies (Table 14). The highest biological yield (25.750 t ha^{-1}) was observed from I_4 treatment which was statistically similar with I_3 treatment (25.600 t ha^{-1}) while the lowest biological yield (13.580 t ha^{-1}) was recorded from I_0 treatment. The results obtained from the present study were in agreement with the findings of Panda *et al*. (2004) who evaluated the effect of different irrigation scheduling methods on root zone soil moisture, growth, yield parameters and water use efficiency of corn which is related to grain and straw yield.

4.2.10.3 Interaction effect of polythene mulch and irrigation frequency

Interaction effect of polythene mulching and irrigation frequency showed significant differences on biological yield of maize (Figure 11). The highest biological yield (30.080 t ha^{-1}) was observed from PI_4 treatment which was statistically similar with PI_3 (29.970 t ha^{-1}) and the lowest biological yield (12.770 t ha^{-1}) was recorded from P_0I_0 treatment.

4.2.11 Harvest index (%)

4.2.11.1 Effect of polythene mulch

Harvest index of maize showed statistically significant variation due to application of polythene mulching (Table 13). Numerically, the highest harvest index (39.76%) was recorded from P treatment and the lowest harvest index (38.88%) was obtained from P_0 treatment. Gosavi (2006) reported that significantly highest green cob and stover yield were recorded under polythene mulch than control and harvest index of crop fully depends on grain yield and biological yield of crop.

4.2.11.2 Effect of irrigation frequency

Data revealed that there was significant variation in harvest index of maize due to different irrigation frequeny (Table 14). Numerically, the highest harvest index (40.98%) was observed from I_4 treatment which was statistically similar with I_3 and I_2 treatments and the lowest 36.93% was from I_0 treatment which was statistically similar with I_1 treatment.

4.2.11.3 Interaction effect of polythene mulch and irrigation frequency

Interaction effect of polythene mulching and irrigation frequency showed significant differences on harvest index of maize (Figure 11). The highest harvest index (42.60%) was observed from PI_4 treatment which was statistically similar with PI_3 and P_0I_2, while the lowest harvest index (36.49%) was recorded from PI_0 which was statistically similar with P_0I_0, P_0I_1, P_0I_3, P_0I_4, PI_1 and PI_2 treatments. Harvest index of crop fully depends on grain yield and biological yield of crop. Grain yield and fodder yield increased with the polythene mulching with irrigation stated by Kalaghatagi *et al.* (1990).

CHAPTER 5

SUMMARY AND CONCLUSION

An experiment was carried out at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka-1207 during November 27, 2015 to May 2013 to evaluate the effect of polythene mulching and irrigation frequency on growth and yield of white maize. The experiment comprised two factors. One is polythene mulching (P_0 = no polythene mulching, P = polythene mulching) and another is irrigation frequency (I_0 = no irrigation, I_1 = one irrigation at 15 DAS, I_2 = two irrigations at 15 and 30 DAS, I_3 = three irrigations at 15, 30 and 60 DAS, I_4 = four irrigations at 15, 30, 60 and 90 DAS). The experiment was laid out in a split-plot design with three replications.

Results showed that at 30, 60, 90 DAS and harvest stage, highest plant heights viz., 37.92, 65.71, 170.3 and 173.3 cm were obtained from treatment P (polythene mulch). The highest plant base diameter was also obtained from P treatmentat at 60 and 90 DAS (6.64 cm and 8.71 cm). This treatment also showed the highest dry matter content plant^{-1} at 30, 60, 90 DAS and harvesting stage (0.922 g, 22.16 g, 33.37 g and 82.07 g). Likewise, the highest values at the corresponding growth stages in LAI (0.82, 2.09, 4.023 and 3.665) was obtained with Polythene application. The highest cob length (24.58 cm), cob diameter (17.37 cm), number of rows cob^{-1} (13.68), number of grains row^{-1} (27.10), number of grains cob^{-1} (412.40), grain weight cob^{-1} (102.10 g) and 100-grain weight (33.88 g) was also found in treatment Polythene mulch. Polythene mulching also showed the highest values in grain yield (9.400 t ha^{-1}), straw yield (13.900 t ha^{-1}), biological yield (23.300 t ha^{-1}) and harvest index (39.76%).

In this trial the highest plant heights of maize (41.41, 71.62, 183.60 and 186.10 cm) at 30, 60, 90 DAS and harvest stage were recorded from I_4 (four irrigations at 15, 30, 60 and 90 DAS). At 60 and 90 DAS, this treatment (I_4) also showed the highest base diameter (7.60 and 9.355 cm), dry matter at 30, 60, 90 DAS and harvest stages (0.922 g, 25.28 g, 37.40 g and 91.80 g) and LAI (0.81, 2.525, 3.777 and 4.295). Similarly the highest cob length (26.52 cm), cob diameter (18.89 cm), number of rows cob^{-1} (14.73), number of grains row^{-1} (31.28), number of grains cob^{-1} (467.40), grain weight cob^{-1} (121.70 g), 100-grain weight (33.90 g), grain yield (10.610 t ha^{-1}), straw yield (15.130 t ha^{-1}), biological yield (25.750 t ha^{-1}) and harvest index (40.98 %) was found in treatment I_4 and the lowest results were found in treatment I_0.

The interaction treatment PI_4 also showed the highest results but there was no significant difference found between PI_3 and PI_4 treatments. Results obtained from PI_3 and PI_4 were, cob length (27.44 and 27.63 cm), cob diameter (19.52 and 19.55 cm), number of rows cob^{-1} (15.40 and 15.43), number of grains row^{-1} (34.44 and 34.55), number of grains cob^{-1} (500.30 and 510.10), grain weight cob^{-1} (138.0 and 140.6 g) and 100-grain weight (35.86 and 36.33 g), grain yield (12.72 and 12.810 t ha^{-1}), straw yield (17.25 and 17.270 t ha^{-1}), biological yield (29.97 and 30.080 t ha^{-1}) and harvest index (42.45 and 42.60%). The grain yield per hectare were significantly higher in treatment PI_4 than others but was identical to PI_3.

Application of polythene mulching and irrigation frequency offer a large scope for better performance of white maize. Most of the growth and yield contributing parameters were observed to be the highest at polythene mulching along with four irrigations but the results were almost similar to three irrigations with polythene mulching. From this study it may be concluded that white maize can be grown using polythene mulch along with three irrigations.

Recommendations

The study was undertaken at the environment of Sher-e-Bangla Agricultural University farm which may not be similar to those of the rural farmer’s field environment. Moreover, the temperature of the Sher-e-Bangla Agricultural University is much higher than the farmer’s ones. So, finding obtained in this study may not be applicable in the farmer’s field. To optimize the obtained technology in this study, the trial must be repeated on-farm in the farmer’s field at different ecological regions of Bangladeh.

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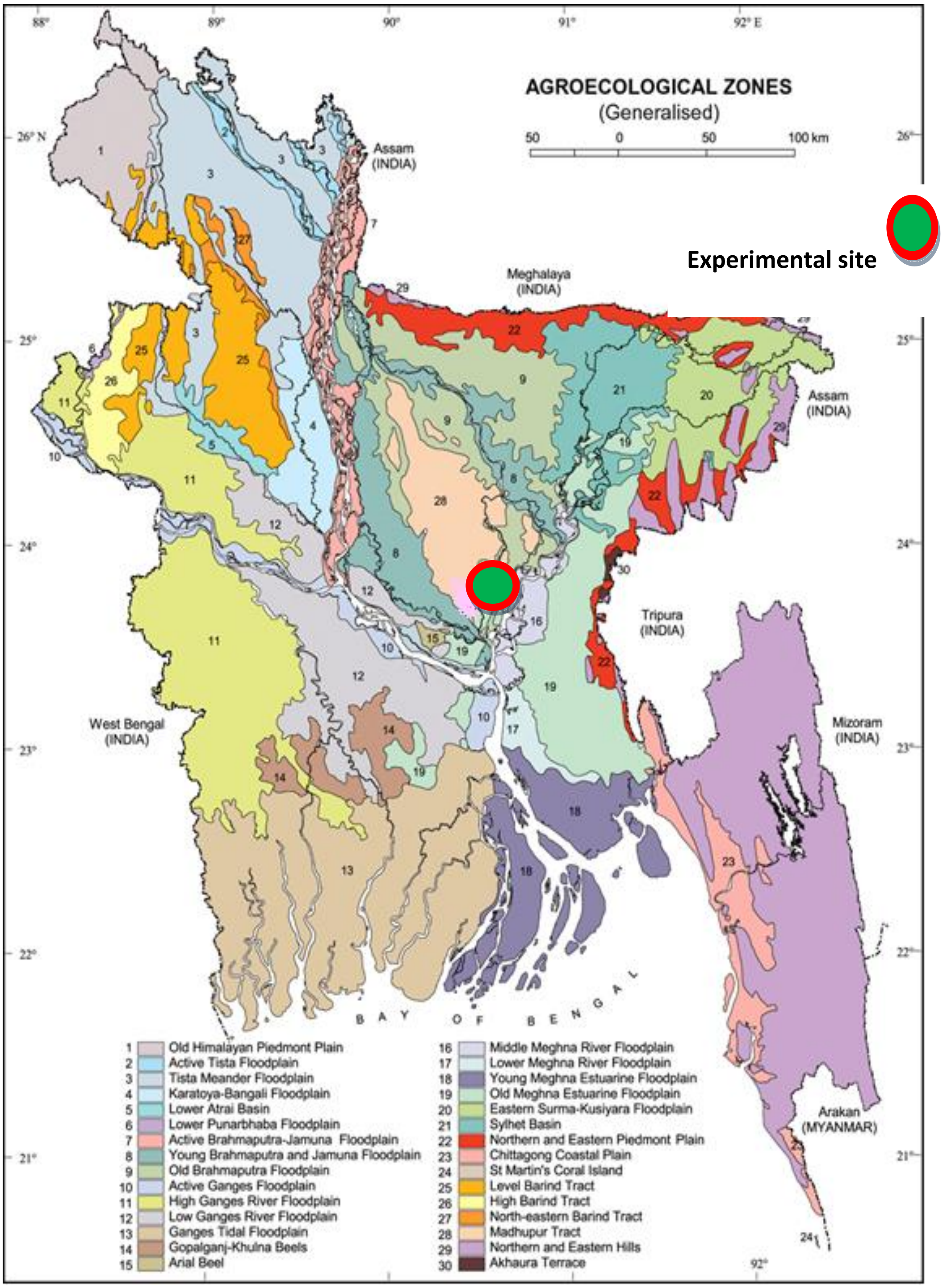
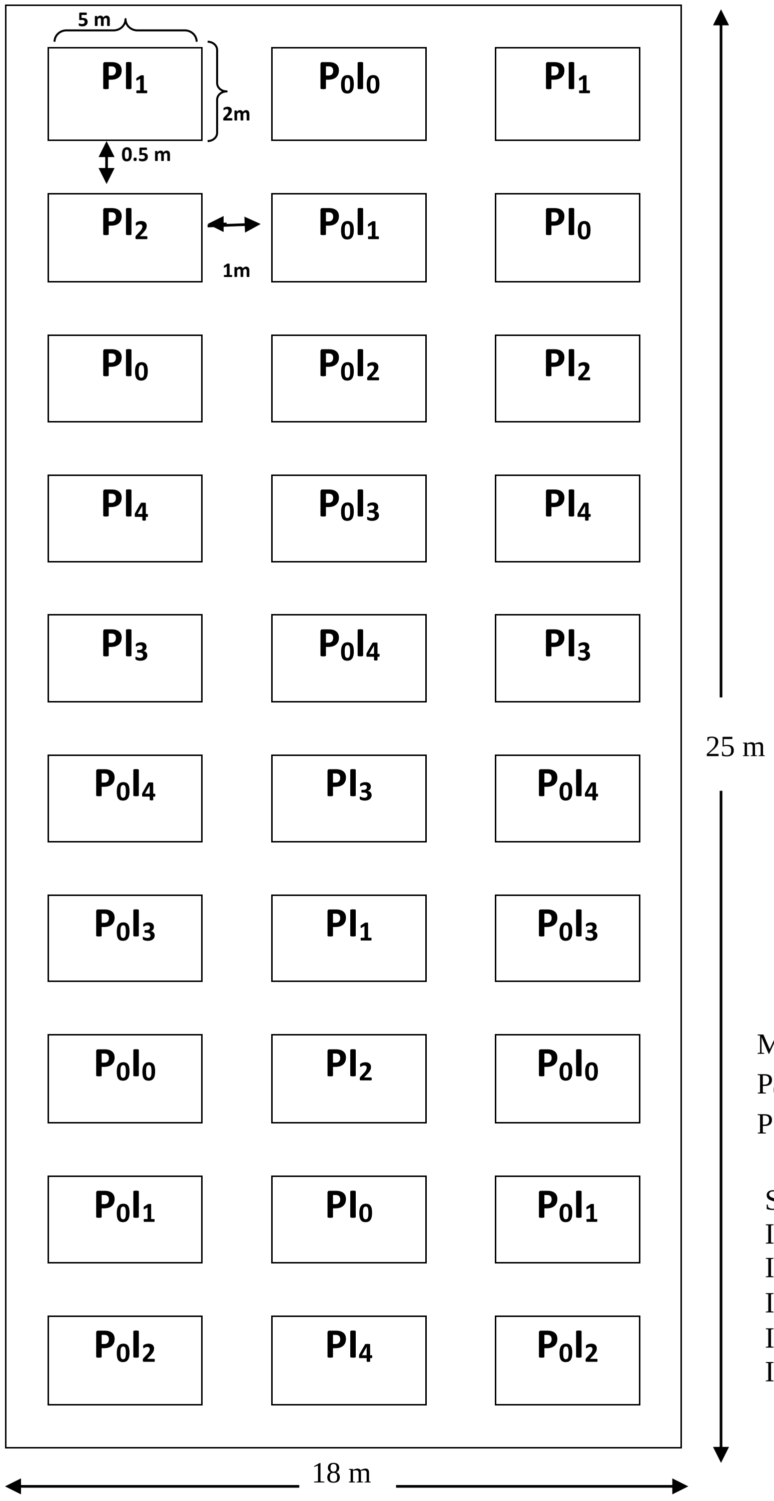
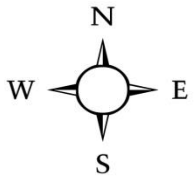
APPENDICES

Appendix I. Map showing the experimental site under study



Appendix II. Layout of the experiment





Main plot:
P_0 = No polythene mulch
P = Polythene mulch

Sub plot:
I_0 = No irrigation
I_1 = One irrigation at 15 DAS
I_2 = Two irrigations at 15 and 30 DAS
I_3 = Three irrigations at 15, 30 and 60 DAS
I_4 = Four irrigations at 15, 30, 60 and 90 DAS

Appendix III. Analysis of variance (ANOVA) on plant height at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of			
		Plant Height at 30 DAS	Plant Height at 60 DAS	Plant Height at 90 DAS	Plant Height at harvest
Replication	2	165.132	10.055	17.086	3.489
Polythene	1	1111.4253**	2514.604**	7976.569**	7336.099**
Error(a)	2	7.6292	24.65	22.696	35.667
Irrigation	4	61.2048	963.363**	3934.162**	4044.354**
Polythene:Irrigation	4	0.8772	27.456**	164.18**	146.443**
Error(b)	16	68.8235	4.493	20.103	14.8

** Significant at 1%

* Significant at 5%

Appendix IV. Analysis of variance (ANOVA) on plant base diameter at different DAS of white maize

Source of variation	Mean square value of		
	Degrees of freedom	Plant Base Diameter at 60 DAS	Plant Base Diameter 90 at DAS
Replication	2	0.161	0.697
Polythene	1	22.603**	26.621**
Error(a)	2	0.057	0.191
Irrigation	4	17.958**	13.246**
Polythene:Irrigation	4	1.406**	2.045*
Error(b)	16	0.086	0.445

** Significant at 1%

* Significant at 5%

Appendix V. Analysis of variance (ANOVA) on leaf area index (LAI) at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of			
		LAI at 30 DAS	LAI at 60 DAS	LAI at 90 DAS	LAI at harvest stage
Replication	2	0.006	0.029	0.015	0.008
Polythene	1	0.4638**	1.236**	6.477**	6.589**
Error(a)	2	0.0075	0.001	0.011	0.000
Irrigation	4	0.012	2.085**	3.405**	2.247**
Polythene:Irrigation	4	0.001	0.23**	0.079*	0.17**
Error(b)	16	0.014	0.014	0.025	0.014

** Significant at 1%

* Significant at 5%

Appendix VI. Analysis of variance (ANOVA) on dry weight at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of			
		Dry Weight 30 DAS	Dry Weight 60 DAS	Dry Weight 90 DAS	Dry Weight at harvest stage
Replication	2	0.0149	0.0722	0.6351	1.2976
Polythene	1	0.2359	425.8594**	682.4916**	2527.2541**
Error(a)	2	0.055	0.8906	0.4929	0.9506
Irrigation	4	0.0476	304.3265**	418.2763**	1971.1592**
Polythene:Irrigation	4	0.0008	8.0609**	14.5447**	36.34**
Error(b)	16	0.0285	0.8245	1.379	0.6946

** Significant at 1%

* Significant at 5%

Appendix VII. Analysis of variance (ANOVA) on cob length, cob diameter and no. of rows cob^{-1} at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of		
		Cob length	Cob diameter	No. of rows cob^{-1}
Replication	2	0.697	0.088	0.016
Polythene	1	94.27**	14.798**	6.655**
Error(a)	2	0.622	0.008	0.014
Irrigation	4	46.239**	34.189**	12.81**
Polythene:Irrigation	4	3.759**	0.167**	0.441**
Error(b)	16	0.221	0.047	0.02

** Significant at 1%

* Significant at 5%

Appendix VIII. Analysis of variance (ANOVA) on No. of grains row^{-1}, No. of grain cob^{-1} and Grain weight cob^{-1} at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of		
		No. of grains row^{-1}	No. of grain cob^{-1}	Grain weight cob^{-1}
Replication	2	2.142	48.981	20.596
Polythene	1	115.994**	11537.347*	5483.712**
Error(a)	2	0.71	266.454	8.572
Irrigation	4	238.505**	31668.882**	5736.197**
Polythene:Irrigation	4	10.195**	2225.385**	202.109**
Error(b)	16	1.861	440.846	20.496

** Significant at 1%

* Significant at 5%

Appendix IX. Analysis of variance (ANOVA) on 100 Grain weight, Grain yield, Straw yield, Biological yield and Harvest Index at different DAS of white maize

Source of variation	Degrees of freedom	Mean square value of				
		100 Grain weight	Grain yield	Straw yield	Biological yield	Harvest Index
Replication	2	0.035	0.066	4.156	5.209	13.081
Polythene	1	115.797	44.335**	66.305**	219.078**	5.887
Error(a)	2	8.327	0.064	0.05	0.132	0.474
Irrigation	4	21.708**	35.08**	46.1**	161.484**	18.524**
Polythene:Irrigation	4	5.016*	4.969**	2.786**	15.03**	6.206*
Error(b)	16	3.444	0.051	0.536	0.621	3.023

** Significant at 1%

* Significant at 5%