EVALUATING SEEDLING TRANSPLANTATION OF SAU WHITE MAIZE-3 UNDER VARYING SOIL MOISTURE AND SEEDLING LENGTHS

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DHAKA-1207

JUNE, 2022

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A Thesis
submitted to the Department of Agronomy, Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka-1207
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JANUARY- JUNE, 2022

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATING SEEDLING TRANSPLANTATION OF SAU WHITE MAIZE-3 UNDER VARYING SOIL MOISTURE AND SEEDLING LENGTHS."** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment 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* ***MD. MAMUNUR RASHID****, registration no.* **15-06494** *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:

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ACKNOWLEDGEMENTS

*All praise is bestowed upon the "**Almighty Allah**", who is the Supreme Creator, and bestowed her gracious blessing upon the Author to complete this study and to entrust him to the successful completion of thesis towards achieving the Master of Science degree.*

*The author would like to express his heartiest respect, deepest sense of gratitude, profound appreciation to his supervisor, **Professor Dr. Md. Jafar Ullah,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

*The author would like to express his heartiest respect and profound appreciation to his co-supervisor **Professor Dr. H.M.M. Tariq Hossain,** Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of land.*

*The author expresses his sincere respect **Professor Dr. Md. Abdullahil Baque ,** chairman, Department of Agronomy and all the teachers of the Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.*

The author wishes to extend his special thanks to all of his classmates and friends specially Puspo Chandra Dey, Md.Farhan Hossain, Aklima Akter, Md. Mizanur Rahman ,Muhib and Shayon. The whole journey might be very difficult without their encouragement and co-operation.

Mere diction is not enough to express his profound gratitude and deepest appreciation to his parents and family members specially his sister Aklima Akter for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate him to this level.

May Allah bless and protect them all.

The Author

EVALUATING SEEDLING TRANSPLANTATION OF SAU WHITE MAIZE-3 UNDER VARYING SOIL MOISTURE AND SEEDLING LENGTHS

ABSTRACT

The experiment was conducted at the central Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh to evaluate seedling transplantation of two SAU white maize-3 during the period from November- 2021 to March- 2022 under varying seedling length and soil moisture regime. The experiment was laid out in randomized complete block design with three replications. Eleven treatment combinations, *viz*. SSWLC = shorter seedlings waterlogged condition; SSPC = shorter seedlings transplanting at puddled condition; SS-SC = shorter seedlings transplanting at saturated condition; SSFc = shorter seedlings transplanting at field capacity condition; SSFcFw = shorter seedlings transplanting at field capacity by watering; SSDS = shorter seedlings at direct sowing; LSWLC = longer seedlings waterlogged condition; LSPC = longer seedlings transplanting at puddled condition; LS-SC = longer seedlings transplantation at saturated condition; LSFc = longer seedlings transplanting at field capacity condition; LSFcFw = longer seedlings transplanting at field capacity by watering were included in this study. Results indicated that seedling transplanting, and soil moisture had significant effect on growth, yield and yield contributing characters of SAU white maize 3. In the case of maximum value of growth were observed in LSFcFw treatment (Longer seedlings transplanting at field capacity by watering) compared to other treatments. In case of yield attributes, the maximum grain yield (11.76 t ha^{-1}), stover yield (10.60 t ha^{-1}) and biological yield (22.36 t ha^{-1}) were observed in LSFcFw treatment (longer seedlings transplanting at Field capacity by watering) compared to other treatments and harvest index (52.59%) was recorded from the treatment LSFcFw which was identically similar with all other treatments. Thus, for the cultivation of "SAU white maize 3 along with LSFcFw treatment (longer seedlings transplanting at field capacity by watering) can be used as recommended treatment for the production of highest grain yield in the AEZ 28 (Agro-ecological zone) soils of Bangladesh.

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SOME COMMONLY USED ABBREVIATIONS

ABBREVIATIONS	FULL WORD
%	Percent
@	At the rate of
0C	Degree celsius
AEZ	Agro-Ecological Zone
As	Arsenic
BRRI	Bangladesh Rice Research Institute
Cm	Centimeter
CRD	Completely Randomized Design
CV%	Percentage of Co-efficient of Variation
DAT	Days after transplanting
e.g.	As for example
et al.	and others
G	Gram
Ha	Hectare
i.e.	that is
K	Potassium
Kg	Kilogram
kg ha^{-1}	kg per hectare
LSD	Least Significant Difference
L	Liter
M	Meter
ml/L	Milliliter per Liter
mg/L	Milligram per Liter
MoP	Muriate of Potash
N	Nitrogen
Nm	Nano Meter
Ng	Nano Gram
P	Phosphorus
pH	Hydrogen ion concentration
Ppm	Parts Per Million
S	Sulphur
SAU	Sher-e-Bangla Agricultural University
t ha^{-1}	Ton per hectare
TSP	Triple Super Phosphate
µg/kg	Microgram per kg
Zn	Zinc

CHAPTER I

INTRODUCTION

Maize is grown as a fodder, feed and food crop. It is also used as raw material for manufacturing pharmaceutical and industrial products (Hamid *et al.,* 2019). Maize ranks second next to rice in Bangladesh although almost the sole of maize grains produced is used as livestock or poultry feed (USDA, 2017; Salam *et al*., 2010) due to reluctance of the consumers to enjoy its food products since its inception during 1960 although hill peoples of the Southern East of Bangladesh eats its fresh grains (Ullah *et al*., 2017a; Ullah *et al*., 2017b).

There are three types of maize based on the endosperm color; yellow, white and red (FAO, 2002). Yellow is mostly used as feed, while the white is used as a preferred staple mainly in Southern and Eastern Africa, Central America, and Mexico and the choice is associated with the perception of social status (Ranum *et al*., 2014). Being a C_4 plant, maize is highly productive than any other cereals, less rigorous to produce and adapts to a wide range of agro-ecological zones (Babatunde *et al*., 2008).

Since inception the maize species grown in Bangladesh was yellow ones which worldwide has been found suitable to be used as fodder as its grain contains 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100g (Nuss and Tanumihardjo, 2010). Since 2004 the popularity of growing maize among Bangladeshi farmers started to increase raising the acreage from 50 thousand hectare to 307 thousands hectare in 2012-13 with the total production of 2.12 million M tons (BBS, 2015).

Its world average yield is 27.80 q ha^{-1} and so it ranks first among the cereals in terms of productivity and is then followed by rice, wheat, and millets, with average grain yield of 22.5, 16.3 and 6.6 q ha^{-1}, respectively (Nasim *et al*., 2012; Jaliya *et al*., 2008).The yield variability depends on adopting improved agronomic managements (Salam *et al.,* 2010; Ranu *et al.,* 2018; *Mannan et al.,* 2019; Islam *et al.,* 2020a; Islam *et al.,* 2020b).

Maize grain contains 70% carbohydrate, 10% protein, 4% oil, 10.4% albumin, 2.3% crude fiber, 1.4% ash (Nasim *et al.*, 2012; Hotzand Gibson, 2001;). Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Chowdhury and Islam, 1993). Maize oil is used as the best quality edible oil.

There are two kinds of maize in respect of grain colour; yellow and white. Worldwide, the yellow maize is mainly used as fodder while the white ones are consumed as human food (FAO, 2002). The currently grown maize in this country is yellow type, which is mainly adapted importing genetic materials from CIMMYT. Again, although there are some indigenous local maize in the south east hills those have also not improved for having higher yields (Ullah *et al.*, 2016; Miah and Ullah, 2023).

Hybrid maize cultivation area has increased at the rate of about 20-25% per year since nineties as the yield potential of hybrid maize is greater than those of local races (Ullah *et al*., 2017a; Ullah *et al*. 2017b; Fatima *et al.*, 2019; Shompa *et al*., 2020; . Now-a-days, there are many government and non-government organizations are working for increasing maize production in Bangladesh.

Introduction of white maize in Bangladesh as human food can be a viable alternative for sustaining food security given the productivity of maize much higher than rice and wheat (Medina-Méndez *et al*., 1990; Hamid *et al*., 2015). In the recent years a number of production technologies has been developed both for hybrids and open pollinated ones such as varietal selection (Ullah et el., 2017a; Akhter *et al*., 2021;) fertilizer application (Raju, 2017; Ahmed *et al*., 2020; , planting configurations (Akbar *et al*., 2016; sowing time (Akhter *et al*., 2021; , seedling transplantation (Ullah *et al*., 2016; and methods of planting, irrigation (Ullah, *et al*., 2018a; Ullah *et al*., 2021; Ullah *et al*., 2022), water conservation (Ullah *et al*., 2018b; Ullah *et al*., 2018c), weed management (Mannan *et al*., 2019).

In general, the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic management (Malvar *et al*., 1996;Akter et a., 2021; Bithy and Ahamed, 2028; Fatima *et al*, 2019;. There are a number of well recognized biotic and abiotic factors like improved varieties, irrigation, sowing time, seedling transplanting, plant population and balanced use of fertilizers each has an effective role in enhancing the yield of crop.

There are different methods of planting among which direct sowing and transplanting the previously raised seedling are also implemented extensively in different field crops. The easiest way is to sow seeds in the seed bed directly in the field and cover it under the soil. This method is limited by the soil moisture status of the upper layer of the soil, soil compactness and soil physiochemical properties. So, it is advantageous to raise seedlings first in the nursery bed and then transplant them in the main field and at this system, the crops attains tolerance capability to endure the unfavorable condition of the field.

Method of planting determines the surrounding environment of the crop in the field favorable to its growth and development. Planting configuration estimates the population density which are set through adjusting row to row spacing and plant to plant spacing within a row. There are different methods of plant establishment of the crop in the field. The easiest way is to sow seeds in the seed bed directly in the field and cover it with the soil.

However, this method is limited by the soil moisture status of the upper layer of the soil, soil compactness and soil physiochemical properties. Another way is to raise seedlings first in the nursery and then transplant them in the main field when those are tolerant to endure the unfavorable condition of the field.

Maize is a tall statured crop having semi hard stem that stretches up to 2.5 meters. This tallness attribute exposes the plants to strong wind speeds that is a common prevalence in Bangladesh in the Kharif season. Maize lodging can occur at both the stalk and root. For this reason, short statured maize varieties are more suitable in a localities that in general are exposed to storms, especially in summer or Kharif season (Ullah *et al* 2018a).

There are evidences that seedling transplantation significantly influences yield, since it is ultimately correlated with plant population, root development, plant growth and fruiting (Ahmmed *et al.*, 2020; Akbar *et al.* 2016; Ullah *et al.*, 2016; Ullah *et al.*, 2018a).

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

Objectives:

1. To examine the performance of seedling transplantation of SAU white Maize 3 and another short stature line under varying soil moisture condition.

CHAPTER II

REVIEW OF LITERATURE

In industrialized countries, maize is largely used as livestock feed and as a raw material for industrial products, while in many developing countries, it is mainly used for human consumption. Maize is consumed mainly as second cycle produce in the form of meat, eggs and dairy products. The crop has immense potentiality for supporting food stuff of the huge population of Bangladesh in the near future when other crop's contribution will fall due to climate change. However, a huge number of research reports so far published on this crop have been reviewed and some of the reviews related to our topic have been embellished below:

Maize (*Zea mays* L.) is the world‟s widely grown highland cereal and primary staple food crop in many developing countries (Kandil, 2013). It was originated in America and first cultivated in the area of Mexico more than 7,000 years ago, and spread throughout North and South America (Hailare, 2000). This cereal crop belongs to the family Poaceae. It is a typical monoecious plant highly cross-pollinated (95%), self- pollination may reach up to 5% (Poehlman and Sleper, 1995). It has very high yield potential, there is no cereal on the earth, which has so immense potentiality and that is why it is called "Queen of cereals" (FAO, 2002). It ranks 1^{st} in respect of yield per unit area, 2^{nd} in respect total production and 3^{rd} after wheat and rice in respect of acreage in cereal crops (Zamir *et al.*, 2013).

Maize having much higher yield potential compared to rice and wheat. The current average yield potential is 2.047 – 3.964 t/ha in aus and boro rice respectively and that of wheat 3.085 t ha-1 while that of the maize is near about seven t ha-1 (BBS, 2015). To sustain the current food sufficiency white maize varieties need to be introduced in Bangladesh.

Introduction of maize in Bangladesh as human food can be a viable alternative for sustaining food security as the productivity of maize much higher than rice and wheat (Ray *et al.*, 2013). It provides many of the B vitamins and essential minerals along with fibre, but lacks some other nutrients, such as vitamin B_{12} and vitamin C. Maize has been a recent introduction in Bangladesh. Rice maize cropping system has been expanded

(Timsina *et al.*, 2010) rapidly in the northern districts of Bangladesh mainly in response to increasing demand for poultry feed (BBS, 2016). Maize production of Bangladesh increased from 3,000 tons in 1968 to 3.03 million tons in 2017 growing at an average annual rate of 28.35 % (FAO, 2019).

In general, the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic management. There are a number of well recognized biotic and abiotic factors like improved varieties, irrigation, sowing time, seedling transplanting, plant population and balanced use of fertilizers each has an effective role in enhancing the yield of crop.

Bangladesh produces food grains of nearly 38.332 Million tons annually from rice and wheat which is enough for its 160 millions of people (BBS, 2015). However, due to the increased population of Bangladesh it is speculated that the current yield productivity of rice and wheat once upon a time may not be able to cope with the increased food demand leaving an uncertainty in sustaining food security. Being C3 in genetic nature these two crops have lower yield productivity compared to maize which is a C4 crop having two to three fold more productivity compared to rice and wheat.

Although concentrated in the North Bangladesh, maize is also grown in other regions. In the hilly areas of Chittagong (Chittagong hill tracts, CHT), the ethnic communities have been growing local races of maize for centuries to consume themselves. These varieties have different coloured grains ranging from black to red, yellow to pink including multicolored grains on the same cob. But in the other regions farmers produce the crop as a cash crop to feed cattle and poultry. The varieties grown excepting CHT’s ones are mostly hybrids with the average yield of 6.906 t/ha (BBS, 2015; Ullah *et al*., 2016).

At present farmers of Bangladesh produce hybrid yellow maize as a cash crop to feed cattle and poultry with an average yield of 6.906 t/ha (BBS, 2015) and there was no high yielding variety of white maize in this country excepting one Suvra having long duration tall stature plants with medium range of seed yield. But after 2018, some high yielding varieties of white maize have either been introduced or developed in the country that produce grains even over 10 tons per hectare (Ullah *et al*., 2017; Ullah *et al*., 2018).

White maize covers only 12% of the total acreage of the world which is mostly used as human food (FAO-CIMMYT, 1997). During 1970s the productivity of the grown white maize varieties was lower compared to those of yellow ones. With the advanced breeding approaches worldwide, recent reports demonstrate that the yield productivity of the white maize is almost at par with those of the yellow ones (Akbar *et al.*, 2016; Ullah *et al.*, 2017; Ullah *et al.*, 2018).

Once upon a time the white maize had lower productivity compared to that of the yellow ones but owing to continuous effort and its increase in use as human food, the research activities have been strengthened worldwide and now the white maize hybrids are at par in respect of per hectare production potentials (Akbar *et al*., 2016). Using high yielding variety adaptive to the local soil and environmental conditions is the easiest way of increasing production of a certain crop (Khehra *et al*. 1990). Choosing the proper variety through carrying out an adaptation trial is the way for achieving this objectives.

Manipulation of the available environments through agronomic measures is essential to exploit the maximum yield potentials of a certain crop species. Method of planting, one of the most agronomic approaches, determines the surrounding environment characteristics of the crop in the field which becomes favorable to its growth and development; and in turns the seed yield productivity.

Among the agronomic managements, setting optimum time to seedling transplanting at field are important agronomic operations. Potential higher yields of modern hybrids obtainable with higher population encouraged planting maize at narrower spacing (Khan *et al.*, 2005). In Bangladesh, a population density of 83,000 planted in rows at 60 cm x 20 cm configuration gave the highest grain yield. Optimum plant density, however, depends largely on genotype, season, available growth resources and agronomic management conditions significantly (Khan *et al.*, 2005).

Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties whose yield potentials are 5.50–7.00 t ha^{-1} and 7.40–12.00 t ha^{-1}, respectively, which are well above the world average of 3.19 t ha^{-1} (Nasim *et al*., 2012). Different varieties respond differently to input supply, cultivation practices and prevailing environment etc during the growing season (Ullah *et el.,* 2018a; Ullah *et el.*, 2018b; Ullah *et el.,* 2018; Bithy and Ahamed, 2018). The low productivity of maize is attributed to many factors like decline of soil fertility, poor agronomic practices (such as proper management of planting configuration, irrigation interval, weeding, thinning, earthing up etc), and limited use of input, insufficient technology generation, poor seed quality, disease, insect, pest and weeds. In general the yield productivity of any crop in this country is low which is generally attributed to the poor agronomic management (Ullah *et al.,* 2017).

Maize is directly sown everywhere in the field using much higher seed rates so as to having optimum plant density as there remains every possibility of having lesser and weaker plants due to drying of the surface soil. Moreover, there is every possibility of germination more than one seeds at each dibble which poses inter plant completion leading to yield reductions. To remove weaker seedling the extra plants are to be thinned which incurs an additional cost (Khan *et al.* 2003). Further using higher seed rates in direct sowing again incurs increased cost for buying seeds which reduces profit margin as the seeds of hybrid maize is very expensive. Raising seedlings prior to planting in the main field is the way of avoiding such disadvantages.

The transplanting seedling of maize has another implication of improving the existing cropping system where maize is grown in sequence with other field crops (Ullah *et al.*, 2016;). In Bangladesh, most of lands are under two crop systems growing almost two crops in a year. In this system of cropping pattern, lands remains fallow for certain time before sowing the next crop as the remaining fallow time not support life duration period of the third crop. Raising seedlings in a separate land needs one month’s time which is subtracted from the total life span of the third crop allowing the crop in the existing crop patter improving the pattern into three crop pattern which eventually increases the existing cropping intensity.

Transplanting maize seedling to accommodate more crops in the cropping system is already in practice (Badran, 2001; Basu *et al.*, 2003; Dale and Drennan, 1997a and 1997b; Ibrahim and Gopalasamy, 1989; Khehra *et al.*, 1990; Uy, 1996). In Vietnum maize is mostly direct sown after harvesting monsoon rice as is practiced in Bangladesh. For doing this farmers have to wait for several weeks until soil becomes dry.

To avoid delay, farmers prepare raised flat beds each for eight rows of maize keeping a 30 cm furrow between two adjacent beds (FFTC, 2004).

There are some benefits of seedling transplanting method over the direct seeding method as this method is has been proved better (Fanadzo *et al*., 2009) to preventing germinated seedlings from birds; obtaining more (96%) seedling establishment over the direct seeding (78%), attaining flowering time 11-15 days ahead and lowering N requirements (227 vs 240 kg ha-1 respectively) losing only 01% grain yield than that of the direct sown crop (10 and 9.9 t/ha in direct and transplanted crops respectively).

The other scope of introducing seedling transplantation is to utilizing the removed extra seedlings (the vigorous ones) from the over populated places of the direct sown fields. Transplanting 35 days old seedlings Kumar *et al*. (2014) obtained 6.71 tons of grains per hectare, however they did not compare the yield with the direct sowing method. This method has been found to be unique in Korea in reducing seedling mortality of the direct sowing and to select strong and healthy seedlings to ensure a better plant stand and economies in the seed rate (FAO, 2017) although the hand transplanting is labour intensive. It was calculated that a unit nursery of 231.40 m2 provides a number of seedlings sufficient for the transplantation of one hectare of land requiring 45-55 kg of seeds for a unit nursery raising 84ooo seedlings providing scope for selection to have the plant density per hectare being 66000.

An experiment was carried out by Khehra *et al*. (1990) transplanting different aged maize seedlings under different times and reported that transplanting 60 days old seedlings in late mid January gave higher grain yield (5.402 t ha-1) compared to transplanting 40 days old seedlings. Bendetto and Rattin (2008) implemented an experiment on sweet corn in Argentina transplanting seedlings at R3 stage of plant growth and found that transplanting resulted in reduced root length, plant height, leaf number, dry weight, kernel per row, but increased higher leaf area, light interception, radiation use efficiency, harvest index, rows per ear and number of kernel per ear. Likewise higher fresh cob weight was obtained due to transplanting (27.02 t ha-1) compared to the direct seeded crops (22.12 t ha-1).

Maize is generally directly sown in the field maintaining a proper density. BARI suggested to sow two seeds in each dibbling in case there is a doubt regarding to its viability or uncertain soil moisture condition and then to thin the weaker seedling at as early as possible after seedling emergence if both are germinated (Khan *et al*. 2003). This system incurs increased cost of seeds and cause farmers to suffer from reduced profit as the seeds of hybrid maize is very expensive. If the thinned seedlings could be transplanted to the other fields for growing another maize crop it would save the money to buy seeds for the second field. However, for the survival and subsequent proper growth of the seedling, this method needs to be optimized.

In Vietnum seeding maize after harvesting monsoon rice is a traditional practice and for doing this farmers have to wait for several weeks until soil becomes dry. To avoid delay, farmers prepare raised flat beds each for eight rows of maize keeping a 30 cm furrow between two adjacent beds (FFTC, 2004).

Fanadzo *et al*.. (2009) described the benefit of transplanting over direct seeding as preventing germinated seedligs from birds; and obtained 96% seedling establishment over the direct seeding (78%) in a trial, reaching flowering time 11-15 days ahead and lower N requirement (227 vs 240 kg ha-1 respectively) sacrifying only 01% grain yield (10 and 9.9 t/ha).

Kumar *et al*. (2014) transplanting 35 days old seedlings obtained 6.71 tons of grains per hectare, however they did not compare the yield with the direct sowing method. This method is a unique in Korea which farmers adopt to reduce seedling mortality in direct sowing and to select strong and healthy seedlings to ensure a better plant stand and economies in the seed rate (FAO, 1997) although the hand transplanting is labour intensive. A unit nursery of 231.40 m2 provides a number of seedlings sufficient for the transplantation of one hectare requiring 45-55 kg of seeds for a unit nursery raising 84ooo seedlings providing scope for selection to have the plant density per hectare being 66 000. Khehra *et al*.. (1990) mentioning the benefits of transplanting maize seedling to reduce the crop duration period by saving time raising seedling in the seed bed before transplanting in the main field, transplanting late in the December and January to fit the crop in the existing cropping system in India reported that transplanted 60 days old seedlings in late mid January gave higher grain yield (5.402 t ha-1) compared to transplanting 40 days old seedlings.

Sweet corn was transplanted at R3 stage of plant growth in Argentina (Bendetto and Rattin, 2008) and it was found that transplanting resulted in reduced root length, plant height, leaf number, dry weight, kernel per row, but increased higher leaf area, light interception, radiation use efficiency, harvest index, rows per ear and number of kernel per ear. Likewise higher fresh cob weight was obtained due to transplanting (27.02 t ha-1) compared to the direct seeded crops (22.12 t ha-1).

Irrigation application when does not support plant's need it may be either excessive or inadequate which may impose negative impact on growth, development and yield of crops (Jordan *et al*., 2003; Wan and Kang, 2006). Likewise soil moisture at sowing, planting or transplanting time influences seed germination and establishment of the emerged or transplanted seedling (Jabbari *et al*., 2013). While uprooting seedlings for transplantation, roots get damaged (Biswas *et al*., 2009) and generally needs enough soil moisture especially at the transplanting depth of the soil profile (Urbieta *et al*., 2008). At the deficient soil moisture just after transplantation continuous supply of moisture at the root zone must be needed to initiate and accelerate rooting of the seedlings so that the newly initiated roots can penetrate into the soil, can successfully acquire water and nutrient and hasten the establishment of the transplanted seedlings (Anon, 2019). At field capacity, seedlings may not uptake necessary amount of moisture as some or substantial number of roots become damaged while uprooting it from the seed bed wherein it was raised. Under such situation soil moisture above the field capacity near the saturation or even above the saturation level may encourage root development and uptake more soil moisture favourable for the subsequent establishment of the transplanted seedling. This aspect of moisture supply for the establishment of the transplanted seedlings needs to be evaluated.

Dale *et. al.* (1997) used four cultivars of maize (Bastion, Ace, Anko and Mirna) of different FAO maturity ratings seedling transplantation. In the main trials conducted in 1989 and 1990, seedlings were raised for 15–45 days in a glasshouse and planted in the field between early May and mid-June, at 10 plants/m^2. On each planting date, maize kernels of the same cultivars were also sown in the field. At the end of each growing season, transplanted and direct-seeded crops were assessed for grain maturity and grain yield components. Averaged over year and cultivar, transplants matured significantly earlier than direct-seeded maize and tended to give higher grain yields. Their grain dry weights (86% DM) averaged 7·0 t/ha in a preliminary study in 1988, 9·0 t/ha in 1989 and 6·1 t/ha in 1990, whereas those of direct-seeded maize averaged 4·0, 8·0 and 3·0 t/ha, respectively. The highest grain weights resulted from May plantings using 15-day-old seedlings of the late cv. Mirna, and from June plantings using 30-day-old seedlings. Yield benefits from transplanting were not significant in 1989, suggesting that in a very warm season transplant may not necessarily outyield direct-seeded crops. Differences in grain weight between transplanted and direct-seeded maize are discussed with respect to grain moisture content, 1000-grain weight, ear length, and number of grains and grain rows per ear; and applications of maize transplanting for cropping systems are outlined. It is concluded that suitable combinations of cultivar, transplant age at planting and planting date can meet the thermal time requirement for a grain harvest in southern England.

Sanjeev *et al.* (2014) conducted field experiments at ICAR Research Complex for Eastern Region Farm, Patna during winter(rabi) season of 2008-09, 2009 and 2010 to study the performance of maize (*Zea mays* L.) crop under transplanted condition as affected by different age of seedlings and methods of nursery raising. Transplantation of five weeks old seedlings and nursery raised on sand culture as well as on raised bed recorded more plant height, leaf length, dry matter accumulation/plant and yield attributes over other methods of raising seedlings and varying age group. After transplantation mortality of seedlings in the main field was minimum reported with 5 week old seedlings (5.8%) as well as seedlings raised under sand culture and raised bed method (5.2% and 5.8%, respectively) during the years of experimentation. Transplanting of five weeks old seedlings raised either in sand culture or on raised beds produced significantly higher grain yield (6.71 and 6.36 tonnes/ha, respectively) over other treatments. Root volume and leaf area index (LAI) at 90 days after transplanting (DAT) were also higher in seedlings raised under sand culture (1.03and 72.2 cm) and raised bed conditions (0.99 and 69.8 cm) in nurseries. However, 5 week old seedlings grown either on sand culture or on raised bed resulted higher net income (23074 and 22334/ha respectively). It was also observed that transplanted crop matured 10-12 days earlier than direct seeded maize.

Zhao *et. al.* (2016), in order to explore a new mulch-free maize planting mode and the best seedling age for maize transplantation in Shanxi early mature area, conducted a field experiment was carried out using completely randomized block design. Taking mulch based direct sowing as the control group, effects of transplantation in different seedling age on maize growing process, plant height, yield and composition factors of maize were analyzed. Results indicate that growing process of maize seedlings transplanted in different seedling age is slightly slower than the control group. Transplantation has effect of reducing plant height. Although the yield of transplanted maize in different seedling area is lower than the control group. Besides, with the growth of seedling age of transplantation, the gap is widening. However, through transplantation, it is expected to realize mulch-free maize planting in Shanxi early mature area. The yield of maize transplanted in two-leaf seedling age is not significantly different from the control group, and the yield is only 9% lower than the mulch-based direct sowing (CK). In conclusion, two-leaf period is the best seedling transplantation age for maize in Shanxi early mature area in this experiment condition.

Sardar et. al. (2020) found that transplanting is the technique of moving a plant from one location to another. This strategy is commonly practiced establishing crops when conditions are less favorable for direct seeding. Birds and squirrels damage to seedlings of maize is a serious problem resulting in poor crop stand and low yield. Delayed germination and plant growth receives a major setback due to late sowing of maize which reduces grain yield; however, reduction of yield can be compensated by transplantation technique. Transplanting of maize is a strategy that can be used to achieve optimum plant densities, better crop stands and obviously to get optimum yield. It reduces the nutrient requirement and also shortens the growth period of crop that helps farmers to harvest a third crop in intensive cropping system. Transplanted crop produces about 15.44% higher grain yield and can be harvested 10-12 days earlier that of direct seeding crop, so, late maturity high yielding cultivars can be fitted in to available growing season. Though, there are several advantages of transplanted maize, it is not popular in India due to lack of awareness, lacking in proper rational scientific technology and very little information about age of seedling and optimum dose of nutrient. Farmers can benefit if proper technology regarding age of seedling, process of transplanting and other cultivation techniques of raising transplanted maize is supplied to them.

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 0C. Polythene mulch conserved more moisture in the soil than control (Harris, 1965).

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).

Kunjir *et al.* (2007) determined a field experiment on sweet corn and observed that length of cob, rows cob^{-1} , girth of cob, weight of cob, weight of grains cob^{-1} , number of grain rows cob^{-1} , weight of grains cob^{-1} and 1000 grains weight increased significantly with wider spacing (75 cm × 20 cm) as compared to narrower spacing (45 cm × 20 cm and 60 cm × 20 cm). The experiment also showed that the close spacing of 45 cm × 20 cm reported significantly higher cob yield (114.99 qha^{-1}), stover yield (73.79 qha^{-1}) and total biomass yield (188.78 qha^{-1}) than the remaining broader spacing (60 × 20 cm and 75 × 20 cm).

Golada *et al.* (2013) determined a field experiment to study the effect of crop spacing (45 × 20, 60 × 15 and 90 × 10 cm) on yield attributes, yield and economics of baby corn. Yield attributes were greatly affected by the crop spacing of 60 x 15 cm. Maximum green cob yield, baby corn yield and green fodder yield was recorded at 60 × 15 cm spacing which was higher (14.0, 24.3 and 8.8%, respectively) over 90 × 10 cm. Bairagi *et al.* (2015) carried the study and observed that the effect of crop geometry impacts on growth and yield of baby corn (Var. G-5414). Three levels of plant population viz. 45 cm × 30 cm (S1), 45 cm × 20 cm (S2) and 45 cm × 10 cm (S3) were assigned. Corn yield and fodder yield were higher when baby corn planted in wider spacing of 45 cm × 30 cm. whereas, closer spacing of 45 cm × 10 cm resulted in reduction of both corn and fodder yield plant^{-1} . The yield parameters of baby corn were clearly indicative that they were thermo-sensitive and baby corn cobs and fodder yield are higher at closer spacing.

This study examines the interaction effects of six moisture and three nitrogen rates on dry matter production and nitrogen uptake by maize grown in a Vertisol from the Accra Plains of Ghana. A local maize variety (Obaatanpa) was grown in pots measuring 18 cm x 15 cm (inner diameter x high) and containing 3.6 kg of air dry soil. The pots were arranged in a randomized complete block design with four replications. The Nitrogen rates were 0 kg N ha 31, 40 kg N ha 31 and 80 kg N ha 31. The moisture were 30, 40, 50, 60, 80 and 100% of the field capacity (FC) of the soil. The interaction of 80 kg N ha 31 with 60%, 80% and 100% FC significantly increased ($p < 0.01$) biomass yield and nitrogen uptake. At moisture 80% and 100% FC, evapotranspiration from plants in the 80 kg N ha 31 was significantly greater ($p < 0.01$) than those in the 0 kg N ha 31 or 40 kg N ha 31. Maize response to the applied nitrogen was influenced by availability of water in the soil. It is important therefore that fertilizer application to maize on Vertisols be done when soil water content is close to field capacity (Quaye *et al.* 2009).

Plant height and stem diameter are essential traits in maize breeding. A study was carried out to estimate the extent of genetic variability in genotypes of Maize (*Zea mays* L.). Fifteen genotypes of maize were evaluated on season (2003/2004) across the two environments in Sudan, to obtain information on morphological and genetic diversity in plant height and stem diameter traits were estimated in a split-plot layout within randomized complete block design with three replications. Significant differences among genotypes were found in all traits, except stem diameter (45 days). High genotypic coefficient of variation, genetic advance and heritability were exhibited by plant height at 60 days and stem diameter at 60 days. Grain yield was significantly and positively associated, at the phenotypic level, with a plant height at 45 days and a stem diameter at 45 days (Salih *et al.* 2014).

The number of leaves in the modern varieties differed from 11.66 to 13.66 per plant with a mean value of 12.88 per plant. Notwithstanding, the varieties did not vary significantly in producing number of leaves though two more leaves were exhibited in Plough-202 and Suvra (over 13 leaves per plant) as compared to that (11.66) of the Plough-201. Unlike the leaf number per plant, the stem base circumference varied significantly over the modern varieties. Significantly the highest stem base circumference was observed in Suvra (10 cm) which although was identical to that (9 cm) of the Plough-202. The variety Plough- 201 had the narrowest stem showing significantly lower value (8.33 cm) than that of the Plough-202 but identical in comparison to that of the Plough-201 (Ullah *et al.* 2017).

A study was carried out by Ullah *et al.* (2016) at Sher-e-Bangla Agricultural University farm to evaluate the performance of seedling transplantation of four white maize hybrids (Changnuo^{-1}, Q-Xiannuo^{-1}, Changnuo-6 and Yangnuo-7) under two planting geometries (D1 =Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25). D1 had 55 whereas D2 had 66.666 thousands plants per hectare. Results showed that 16 varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135^{-1}37 days. Planting configuration D2 had significantly greater 100 seed weight (31.42 g) and the D1 had lower values (30.40 g).

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC-121) during winter 2015^{-1}6. Four irrigation frequencies constituted the irrigation treatment (I1 = One irrigation at 15 DAS, I2 = Two irrigations at 15 and 30 DAS, I3 = Three irrigations at 15, 30 and 60 DAS, I4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. Statistically significant variations were also observed in plant height except at 30 DAS by different irrigation timings (Table 2) having the longest plants (41.41, 71.62, 183.6 and 186.1 cm) with I4 and the shortest plants (33.83, 44.77, 122.7 and 127.4 cm) with I0 treatment at the respective growth stages. I3 treatment showed second highest plant height (38.88, 68.23, 173.9 and 181.1 cm) which was very close to I4 treatment.

Ullah *et al.* (2019) carried out an experiment at Sher-e-Bangla Agricultural University farm to study the effect of irrigation frequencies and polythene mulching on the growth and yield of white maize (PSC^{-1}21) during winter 2015^{-1}6. Four irrigation frequencies constituted the irrigation treatment (I1 = One irrigation at 15 DAS, I2 = Two irrigations at 15 and 30 DAS, I3 = Three irrigations at 15, 30 and 60 DAS, I4 = Four irrigations at 15, 30, 60 and 90 DAS) along with control. 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, I4 showed the maximum leaf area index (0.81) and I0 showed the lowest leaf area index (0.57); whereas at 60, 90 DAS and harvesting stage, the highest leaf area index was (2.525, 4.295 and 3.777) which were statistically similar with treatment I3 and the lowest leaf area index were (1.292, 2.505 and 2.270).

Alam *et al.* (2020) reported that the maximum morpho-physiological characters, yield attributes and yield was obtained with higher composition of nutrients by using technique of 60 cm×30 cm (T3). This treatment also showed the height grain weight cob^{-1} was 230.67g.

A study was carried out by Ullah *et al.* (2016) at Sher-e-Bangla Agricultural University farm to evaluate the performance of seedling transplantation of four white maize hybrids (Changnuo^{-1}, Q-Xiannuo^{-1}, Changnuo-6 and Yangnuo-7) under two planting geometries (D1 =Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25). D1 had 55 whereas D2 had 66.666 thousand plants per hectare. Results showed that varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135^{-1}37 days.

Ahmmed *et al.* (2020) reported that the highest grain yield (8.62 t ha^{-1}) was obtained with S2 (40 cm × 20 cm) where the lowest (7.30 t ha^{-1}) was with S1 (60 cm × 20 cm).

Belay (2019) conducted a field experiment under rainfed conditions in 2015 and 2016 during the main cropping season at Haramaya to determine the effects of inter and intra row spacing on growth, yield components, and yield of hybrid maize varieties. Result reviled that grain yield was significantly ($p < 0.01$) affected by the interactions of variety × inter-row spacing and inter-row × intra row spacing × year. Accordingly, the highest grain yield 11.67 t ha^{-1} was obtained in combination of 75 cm × 25 cm in 2016 cropping season, while the lowest grain yield 8.66 tha^{-1} was obtained at wider inter and widest intra row spacing combination (75 cm × 35 cm) in 2015 cropping season.

Ahmmed *et al.* (2020) reported that different spacing had significant effect on stover yield of maize Results revealed that highest stover yield 9.92 t ha^{-1} was attained with S2 where the lowest 7.28 t ha^{-1} was with S1.

Hasan *et al.* (2018) conducted an experiment to investigate the effect of variety and plant spacing on yield attributes and yield of maize. The experiment comprised 5 varieties viz., Khoi bhutta, BARI hybrid maize 7, BARI hybrid maize 9, C^{-1}921, P-3396 and five plants spacing viz., 75 cm × 20 cm, 75 cm × 25 cm, 75 cm × 30 cm, 75 cm × 35 cm and 75 cm × 40 cm. The maximum stover yield was observed in the spacing of 75 cm × 25 cm. In contrast, the spacing of 75 cm × 30 cm produced the lowest stover yield.

Ahmmed *et al.* (2020) reported that the highest biological yield (18.54 t ha^{-1}) was obtained with S2 (40cm × 20 cm) where the lowest (14.59 t ha^{-1}) was with S1 (60 cm × 20 cm). Gaire *et al.* (2020) reported that the variation in biological yield due to each increment in nitrogen level and spacing was significant ($p>0.01$). The highest biological yield (12.37 mt/ha) produced under 60×15 cm spacing and the lowest biological yield (9.24 mt/ha) produced under 60×25 cm spacing. Hossain (2015) reported that interaction of variety PSC- 121 with double rows of 50 cm × 25 cm plant spacing gave the highest biological yield (24.51 t ha^{-1}). On the other hand, interaction of variety PSC^{-1}21 with plant spacing of 40 cm × 25 cm showed the lowest result.

Ullah *et al.* (2016) carried out an experiment on the seedling transplantation of different white maize varieties under varying planting geometries. Four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D1=Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25) were tested. Results showed that varieties differed significantly in days to maturity showing the earliest (108 days) with the Yangnuo-7. Other varieties matured in between 135-137 days. Interaction effect of the variety with the planting configuration showed that the varieties Changnuo-6 and Changnuo-1 when transplanted at higher population densities (D2) showed identical seed yields (9.253 and 7.938 t/ha, respectively), but were significantly higher than others. Seedling leaf area had positive effects on grain number cob-1 and seed yield ha-1.

Ullah *et al.* (2016) conducted an experiment on the seedling transplantation of different white maize varieties under varying planting geometries. Four white maize hybrids (Changnuo-1, Q-

Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D1=Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25) were tested. Results showed that number of grains cob-1 was the highest with Changnuo-6 (419) whereas, the least with Yangnuo-7 (276).

Ullah *et al.* (2016) carried out an experiment on the seedling transplantation of different white maize varieties under varying planting geometries. Four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D1=Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25) were tested. Results showed that the variety Yangnuo-7 had the lowest 100-seed weight (24.33 g, other varieties showed 31.83-34.67 g).

Ullah *et al.* (2016) carried out an experiment on the seedling transplantation of different white maize varieties under varying planting geometries. Four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D1=Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25) were tested. Results showed that significantly the highest seed yield per hectare was observed with Changnuo-6 (8.198 tons) followed by Changnuo-1 (7.457 tons) and Q-Xinagnuo-1 (6.718 tons). Yangnuo-7 showed the lowest seed yield (4.393 tons) than others. Planting configuration D2 had significantly greater yield (7.551 t/ha) than that of D2 (5.832 t ha-1).

Ullah *et al.* (2016) carried out an experiment on the seedling transplantation of different white maize varieties under varying planting geometries. Four white maize hybrids (Changnuo-1, Q-Xiannuo-1, Changnuo-6 and Yangnuo-7) under two planting geometries (D1=Row to row spacing 75 cm and plant to plant spacing within each row 25 and D2 = Row to row spacing 60 cm and plant to plant spacing within each row 25) were tested. Results showed that the greater seed yield of D2 was attributed to the significantly higher grain number per cob of D2 (369.78) than D1 (337.29).

In another experiment, Ullah *et al.* (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested.

Results showed that

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that transplanting had no remarkable effect on plant height (205-225 cm) and SSFC and SSFL had the highest plant heights. The lowest height was manifested by LSWT (205 cm) which was slightly lower compared to that of LSFC. Irrespective of treatments SS had much longer plants (225 cm) which was 8% higher than LS (208 cm) (Fig. 1). Again FL had 2% higher plant height than FC and WT (217 and 214 cm).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that number of leaves per plant (14-16) varied due to the imposition of the treatments. the SSFC treatment had the most leaves per plant (16.6) which was significantly different than others that had identical leaf number of leaves per plant (15.22-15.83), the SSWT had the lowest leaf number (14.33). Irrespective of treatments, LS had about one more leaf (16.07) than SS

(15.04) per plant (Fig. 2). Again FC had most leaves (16.08) which was 10% higher than those of WT and FL (15.05-15.52).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that significant effect was seen on stem circumference at the base was affected showing reduced value in the SSWT (5.60 cm) showing the greatest in the treatment SSFC (6.85 cm) which at par with that of SS FL (6.50 cm) (Fig. 2). The treatment LSFC had the narrowest stem base (5.6 cm) which was significantly lower than others (6.19-6.46 cm). Irrespective of treatments SS had thicker stem base (6.60 cm) than LS (6.06 cm). Among the moisture treatments at transplanting, FL had the thickest (6.43 cm) which was slightly higher than WT (6.32 cm) and FC (6.22 cm).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that distance of cob position from the base showing the farthest with LSFC (102 cm) and the nearest (73 cm.) with SSWT. The distance of cob bearing node from soil surface varied from 72.89 cm to 102 33 cm, the highest with LSFC and the lowest with SSWT (Table 2).

Among other treatments LSWT had the lower distance (85.78 cm) and SS FL and LSFL had 87.89 cm which was lower than LS FL (96.94 cm). Across the treatments LS bore cobs at the topmost (95.02 cm). Plant characters of white maize varieties as influenced by seedling transplantation and soil moistening during seedling transplantation and the SS had cobs at 83.65 cm) from the soil surface (Fig. 2). The soil moisture treatment WT had cobs at the most below place on the stem (79.33 cm), the FC at 96.25 cm and FL at 92.42 cm.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation

= FL) and two methods of planting (sown and transplanting) were tested.

Results showed that Cob bearing node from the base was also affected showing cobs at the nearest (7.33) with SSWT while, farthest with LSFC (9.5). The position of cob bearing node varied from 7.33 to 9.5 where the treatments LSFC had cobs on 9.50 node while the SSWT had cob position at the lowest node (Table 2). Other treatments had cobs at the nodes between 8.22 to 8.83 node. Across the treatments LS had cobs at the farthest (on 8.94 node) while SS on the 8th node. Among the watering treatments FC had cobs at the farthest (9th node) while the WT at the nearest node from the soil surface (7.91th node). The FL had it cobs on 8.53 node.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested.

Results showed that Treatments also showed wide ranges of cob length (15.00-17.78 cm). The cobs of the treatment LSWT was the longest (17.78 cm) which was at par with those of SSFC, LSFC and LS FL (17.00-17.44 cm) (Table 3). the treatment SS FL had the shortest cob length (15 cm). Across the treatments LS had longer cobs (17.41 cm) than SS (16.22 cm). Likewise among the moisture regime FL had the shortest cobs (16.22 cm) which was remarkably shorter than FC and WT (17.07-17.17 cm).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that cob circumference (13.83-16.87). Cob circumference was the highest with SSFC (16.87 cm) while the lowest with LSFC (13.83 cm). LSWT had cob circumference of 14.92 cm and the LS

FL of 14.86 cm which were at par. Again the cob circumference of SSWT and SS FL were at par (15.56 and 15.44 cm). Across the treatments the cob circumference of SS was much higher (15.96 cm) than that of LS (14.54 cm). Likewise the cobs of FC were much thicker (17.17 cm) than FL (16.22 cm) which was remarkably thicker than the cobs with WT (15.24 cm).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested.

Results showed that number of grain rows per cob (12.00-13.33) and number of grains per grain rows (27.89-36.33). Number of grain rows per cob varied from 12.00-13.33, the highest was obtained with SSFC and the lowest with LSFC. SS FL had identical rows (13.00) with SSFC. Again LSWT had equivalent number of rows per cob (12.11) to LSFC. SSWT and

LS FL had higher rows (12.89) than LSWT. Over the treatments SS had more cob rows (13.07) than LS (12.33). Again FL had almost equivalent number of cob rows (12.89) to FC (12.67).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested.

Results showed that the individual ear had a wider range in number of grain (360-482). Number of grains per grain rows varied from 27.89 to 36.33 that is the treatments showed a wide range in the number of grains per rows, the most value was obtained with SSFC while the lowest with LS treatments. LSFC and LSWT had more or less same grains per rows (32-32.28) and likewise the SS FL had some lesser grains than SSWT (28.67). Across the treatments LS had higher grains per row (32.59) than SS (30.96). Among the watering treatments at transplanting or sowing, the

FC had most grains per rows (34.17) which were much less in WT and FL (30.48 and 30.70 respectively).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that grain weight (82.06-121.07 g/ear) was affected by the seedling transplantation. Grain weight per ear was affected greatly ranging from 82.06 to 121.07 g per ear, the greatest with SSFC while the lowest with LSWT (Table 4). SSWT and SS FL had identical grain weight (101.91 and 103.13 g per ear respectively). LSFC had 92.80 g grain weight which was significantly higher over those of LSWT but lower than those of SSFC, SSWT and SS FL. Across the varieties on an average, SS had about 7% more grain weight per ear over that of the LS (108.70 and 91.73 g respectively) (Fig. 4)). Across the watering regime the WT had the highest grain weight per ear (107 g), the FC the second highest value (106.94 g) and the FL had the (101.78 g).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that shell (rachis) weight (11.00-29.00 g) and Shell weight (rachis weight) varied significantly among the treatments showing the highest with SSFC (29 g) which was at par with those of SSWT and SS FL (27.11 and 28.78 g respectively) (Table 4). The shell weight value of these three treatments were significantly higher over those of LSFC and LSWT (13.60 and 11 g respectively). Across the combination treatments the shell weight of SS was 28.30g while that of LS was 13.49 g. That is LS had very lighter shell (below half) as compared to that of SS and SS had two times or 200% heavier shell than LS (Fig. 4). Over the watering regimes the FL had the heaviest shell (22.33 g) which however, not significantly heavier than that of FC (21.30 g). WT had significantly lighter shell weight (16%) than that of FL.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that chaff (husk) weight (6.4-13.78 g) was also observed. Chaff or husk weight was also greatly affected by the combination treatments showing highest with SSWT (13.78 g) which however, was not significantly higher than those of SSFC and SS FL (12.10 and 12.56 g respectively) (Table 4). LSFC and LSWT had 215% lower chaff weight than that of SS FL. Over the watering regimes SS had significantly much higher (over 80%) chaff weight (12.81 g) than that of the LS (7.13 g) (Fig. 4)). Across the watering regimes WT and FL had identical chaff weight (10.11 and 10.56 g) which were even much higher (14%) than that of FC (9.25 g).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that there was also wider ranges in per plant ear weight (99.50-162 g). Treatments significantly affected the ear weight (grain plus shell plus chaff) which was highest with SSFC (162 g). Significantly the lowest ear weight was obtained with LSFC (113 g) (Table 4). The SSWT and SS FL had identical ear weight (143 and 144 g) which however was higher than LSFC and LSWT (100-113 g). Across the treatments SS had 22% heavier ear (150 g) than that of LS (122 g) (Fig. 4). Again the heaviest ear was obtained with FL (150 g) which was 24% heavier than that of WT (121 g). The FC had significantly higher ear weight (137 g) than that of WT.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that stover dry weight (81.50-139.52 g). Treatments also affected the stover dry weight (leaf plus stem) which was highest with SS FL (140 g) although this value was at par with the values of SSFC and SSWT (135 and f136 g respectively). LSFC had the lowest stover dry matter (81.49 g) which was significantly lower than that of LSWT (108.64 g). Across the treatments and out of two varieties SS had 38% more stover dry matter (137 g) than that of LS (99 g). Plants in the WT and FL had identical stover dry weight (122 and 124 g respectively which were significantly higher than that of FC (108 g)

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that total dry weight (194-296 g). The total dry weight per plant (Table 4) also varied substantially showing significantly the greatest dry weight with SS FL (283.975 g) which however was significantly higher than the values of SSWT and SS FL (278 and 284 g respectively) showing 53% higher total dry over that of the lowest as was shown by the treatment LSFC (194 g). LSWT had also slightly higher total dry weight (208 g) than that of LSFC. Likewise the treatments SSWT and SS FL had similar total dry weights (284 and 278 g respectively). Across the treatments the variety SS produced 29% higher total dry matter (286 g) compared to that of LS (212 g) (Fig 5). Likewise across the treatments the FL had about 12% higher total dry weight over FC and WT (258 and 143 g respectively).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that Treatments significantly affected 100 seed weight (20.67-32.67 g). Hundred seed weight ranged from 20.67 g to 32.67 g, that is, there was remarkable difference in 100 seed weight of the treatments, the heaviest seeds were obtained with SSFC while the lightest with LSWT. LSFC and c1 FL had identical and second ranking 100 seed weight (29.67 and 28.67 g) (Table 5). SSWT has significantly higher 100 seed weight (27.33 g) than the LSWT. Irrespective of treatments the seeds of SS was heavier (29.56 g/100 seeds) which was over 9% higher than that of LS (27.00 g) (Fig. 6). Over the irrigation treatments FC had the highest values in 100 seed weight (31.17 g) which identical with that of FL (29.67 g). The WT had least values in 100 seed weight (24 g) which was about 30% lower in comparison to that of FC.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that seed yield per hectare ranged from 6.657 to 10.048 t/ha which showed a great variation in this parameter due to the combination effect of variety and soil moisture at the seedling stage (Table 5). The highest seed yield was obtained with SSFC while the lowest with

V 2WT. SS FL and LSWT had identical seed yields (6.657 and 6.565 t/ha). LSFC (7.702 t/ha) had significantly higher seed yield than LSWT. Across the treatments V 1 had 10% higher seed yield (8.286 t/ha) than that of LS (7.547 t/ ha) (Fig. 6). The watering at transplanting also affected the seed yield showing seed yield range of 7.359 to 8.875 t/ha the highest with FC and the lowest with WT. The FL had seed yield of 8.264 t/ha. That is, the FC had 21 and 7% higher seed yield than WT and FL. That means transplanting reduced seed yield by 7 to 21% in comparison to direct sowing. This was obvious as there might have been root injury during uprooting of the seedlings before transplanting. Besides root damage, the transplanted seedling required recovery time for the regeneration of the root growth which in turn reduced the life span of the transplanted plants in comparison to the sown ones. The wetted plots may be due to probable moisture stress which might have been imposed on the transplanted seedlings due to the drying up of the soil at the root zone (Jabbari *et al*., 2013; Anon, 2019). However the soil moisture was not measured in this study.

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested. Results showed that harvest index (36.32-49.96%). Harvest index (HI) of white maize ranged from 39.42 to 49.96% due to the treatment variations, the highest was shown with LS FL while the

lowest with SS FL (Table 5). The treatment SSWT had identical HI value (39.42%) to that of SSFL. SSFL had higher HI (42.52%) which was identical to that of LSWT (39.42%) but was significantly higher over that of those of SSWT and SS FL. LSFC had also identical HI (53.16%) to that of LS FL (Fig. 6). Across the treatments the variety LS had 21% higher HI value (43.45%) than that of SS (37.91%). Across the soil moisture regime FC and FL had identical HI (44.29 and 39.74% respectively) which were much higher than that of WT (38.01). That is, the plots having lesser water supply just after transplantation might have suffered from water stress during the recovery stage although we did not monitor soil moisture status after transplantation. Probably this moisture stress at the seedling's recovery stage reduced vigour of the transplanted seedlings in these plots which in turn affected dry matter partitioning towards grain. The harvest index of maize in this study was found to be in the range of the previous records of other workers. In one study, the average values of the harvest index of different hybrid maize varied between 20 to 56%, more frequently between 30 and 50% under varying climate, soil and agronomic conditions (Ion, *et al*., 2015).

In another experiment, Ullah *et al*. (2018) observed that when transplanted seedlings of white maize under varying soil moisture . Six treatments combining two varieties (PSC-121= SS and Yangnuo-3000=LS), three moisture (field capacity at sowing of the sown treatment = FC, wetting surface up to saturation of the soil at transplanting = WT and flooding at transplantation = FL) and two methods of planting (sown and transplanting) were tested.

Results showed that The highest seed yield was observed with the treatment SSFC which was attributed to the heaviest seed of this treatment (32.67 g) and number of grains per ear (483). LS FL had second highest seed yield (8.374 t/ha) showing 20% reduced seed yield due to transplantation. SS out yielded LS showing 10% higher yields which was attributed to bolder seeds of SS and 12% higher harvest index than LS. SS had 16% heavier grain weight per cob compared to LS. However, this variety had also over 200 and 80% heavier shell and chaffs respectively compared to that of LS. Likewise FC had 20 and 7% higher seed yields as compared to those of WT and FL. Transplanting remarkably reduced 100 seed weight (30%) which was attributed to the reduced seed yields due to seedling transplanting.

CHAPTER III

MATERIALS AND METHODS

This section presents a brief description about the duration of the experimental period, site description, climatic condition of the area, crop or planting materials that are being used in the experiment, treatments, experimental design, crop growing procedure, intercultural operations, data collection and statistical analyses.

3.1. Experimental period

The experiment was conducted during the period from November- 2021 to March- 2022 in Rabi season.

3.2. Site description

3.2.1. Geographical location

The study was carried out at Sher-e-Bangla Agricultural University Farm which is situated at $23^{0}41'$ N latitude, 90^{o} $22'$ E longitude, 8.6 m altitude above the sea level (Bay of Bengal), belonging to the Agro-Ecological Zone "AEZ-28" of Madhupur Tract having brown terrace soil (FAO/UNDP, 1988).

3.2.2. Agro-Ecological Zone

The experimental field belongs to the Agro-Ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as „islands‟ surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I. (Banglapedia, 2014)

3.3. Climate

The study was done in Rabi season of 2021. In Bangladesh, the winter season's temperature is generally low and there is a plenty of sunshine. The temperature tends to increase from February as the season proceeds towards summer season. Rainfall seldom occurs during winter in the period from November to January and scanty in February to March. Meteorological data related to the temperature, relative humidity and rainfall during the experiment period of was collected from Bangladesh Meteorological Department (Climate Division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix- II.

3.4. Soil

The soil status at SAU was low in terms of potassium and boron (0.16% and 0.06 ppm respectively), optimum in terms of calcium (4.52%), medium in terms of magnesium and Sulphur (0.85% and 15.70 ppm) but higher in terms of phosphours (37.12 ppm), copper (4.21 ppm), iron (236.85 ppm), manganese (42.20 ppm) and Zinc (4.07 ppm) (Ullah *et al.*, 2016 & 2017).

3.5. Planting materials

In this study, "SAU White Maize 3; White Longer seedlingsline " genotype variety of white maize seed was used as planting materials, which was collected from Department of Agronomy, Sher- e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

3.6. Description of the variety

"**SAU White Maize-3**" genotype of white maize used as planting material for the present study. These variety was recommended for Rabi and kharif season. The feature of this variety was presented below:

Name of Variety: SAU White Maize-3	
Identifying character: Bold grain quality and drought tolerant	**Suitable area:** All over Bangladesh
Type: Medium duration, open pollinated	**Number of cobs plant-^{1}:** Mainly one
Height: 180–200 cm	**Cob colour:** White colour.
Crop duration: 110–120 days	**Grain colour:** White
Leaf colour at maturity: Light green color at maturity	**Yield:** 9-9.50 t ha^{-1}

Source: Personal Communication: Prof. Dr. Md. Jafar Ullah, Dept. Of Agronomy, SAU, Dhaka.

3.7. Major insect/pest and management

Insect pests: Cut worm and stem borer attacked at vegetative stage of maize. Earworm attacked in cob at reproductive stage in maize.

Management

For cutworm: The larvae were killed after collecting from soil near the cut plants in morning. Dursban or Pyrifos 20 EC 5 ml liter^{-1} water sprayed especially at the base of plants to control cutworms.

For ear worm: The larvae were killed after collecting from the infested cobs. Cypermethrin (Ripcord 10 EC/Cymbush 10 EC) @ 2 ml litre^{-1} water sprayed to control this pest.

For stem borer: Marshall 20 EC or Diazinon 60 EC @ 2 ml litre^{-1} water sprayed properly to control the pest. Furadan 5 G or Carbofuran 5 G @ 20kg ha^{-1} applied on top of the plants in such a way so that the granules stay between the stem and leaf base. Such type of application of insecticides is known as whorl application.

3.8. Major diseases and management

Diseases: At vegetative stage of white maize leaf blight disease occurs.

Management: Clean cultivation with timely sowing and maintain balance fertilizer application. Seed treatment with vitavax-200 @ 2.50 g kg^{-1} seed, spraying with Tilt or Folicure @ 0.5% and burning of crop residues.

3.9. Experimental details

Land preparation Date: 24 November 2021

Seed Sowing Date: 25 November 2021

Date of transplanting: 17 December 2021

Spacing: According to the treatment requirement

Fertilizer application Date: All the fertilizers were applied at 24 November 2021 at final land preparation except total urea

Flowering date: first week of January

Silking Date: last week of January

Harvesting Date: March 2022

3.10. Experimental treatment details

There were eleven treatments in the experiment. The treatments were shown below:

Treatments:	
SAU White Maize-3 (SS) White Longer seedlings(LS**)**	DS = Direct sowing FC = transplanted under field capacity of soil moisture condition FCFW = transplanted under field capacity but wetting the bottom of furrow PC = transplanted under puddling condition SC = transplanted under saturated condition WLC = transplanted under water logged condition
Treatment combinations	There were eleven treatment combinations as follows; 1. SSWLC = Shorter seedlings transplanted under Waterlogged condition. 2. SSPC = Shorter seedlings transplanted under puddled condition; 3. SS-SC = Shorter seedlings transplanted under saturated soil moisture condition; 4. SSFc = Shorter seedlings transplanted under Field capacity condition; 5. SSFcFw = Shorter seedlings transplanted under Field capacity but wetted the bottom of furrow; 6. SSDS = Shorter seedlings at direct sowing with conventional irrigation management. 7. LSWLC = Longer seedlings transplanted under waterlogged condition. 8. LSPC = Longer seedlings transplanting at puddled condition. 9. LS-SC = Longer seedlings transplanting at saturated condition. 10. LSFc = Longer seedlings transplanting at Field capacity condition. **11.** LSFcFw = Longer seedlings transplanting at Field capacity but wetted the bottom of furrow

3.11. Experimental design

The experiment was laid out in the randomized complete blacked design with three replications. The field was divided into 3 blocks to represent 3 replications. Total 33-unit plots were made for the experiment with 11 treatments. The size of each unit plot was 2.40 m^2 (2.4 m × 1 m). Distance maintained between replication and plots were 1.0 m and 0.50 m, respectively. Layout of the experimental field was presented in Appendix IV.

3.12. Production methodology

Land preparation

The experiment field was first disc-ploughed and harrowed. Final land preparation was made by a tiller followed by leveling with scrapper. Clods were broken and weeds were removed from the field to obtain desirable tilth. The basal doses of manures and fertilizers were added and mixed into the soil during final land preparation. Then the experimental area was layout as per design of experiment.Irrigation channels were made around each plot.

Application of manures and fertilizers

Fertilizers were applied following the recommendation of BARI (2011), which has been presented in the following Table. All the fertilizers and one third of urea were applied at the final land preparation. The rest of Urea was applied as top dressing in two equal instillments at 15 and 30 days after sowing.

Table 1. Manures and fertilizer with BARI recommended dose along with plot wise application dose

SL No.	Manures/ fertilizers	Recommended dose/ha.	Recommended dose/unit plot area
1	cow dung	10 t	200 kg
2	Urea	200 kg	4 kg
3	TSP	150 kg	3 kg
4	MoP	100 kg	2 kg
5	Gypsum	100 kg	2 kg
6	Boron	10 kg	200 gm
7	Zinc	15 kg	300 gm

Seed sowing

Seeds were air-dried before sowing since water soaked to facilitate germination. Subsequently, the collected variety seeds for the experiment were sown on the nursery bed.

Seedling Transplanting

Maize seedlings are usually grown for up to 22 days in the nursery before being transplanted to the main field. Seedlings along with their root-balls are transplanted by hand in furrows drawn by bullock-drawn ploughs.

3.13. Intercultural operations

While experimenting, The following intercultural operations were done:

Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully from the field after complete emergence of sprouts and afterwards when necessary.

Earthing up

Earthing up was done on (date and year) which was 30 days after sowing. It was done to protect the plant from lodging and for better irrigation management and nutrition uptake.

Top dressing

Top dressing of the urea was done on both sides of plant rows and mixed with the soil by spade.

Pest control

In general, the crop was not badly affected by insects and disease. However, in case of minor attack approved insecticides were sprayed.

Harvesting

The crop was harvested depending upon the maturity of each variety. Maturity was determined examining the black layer at the base of grains at the attachment point with the shell.

3.14. Data collection

Data were collected in respect of following parameters:

A. Crop growth characters

i. Moisture meter reading

ii. Plant height (cm)

iii. Number of leaves plant^{-1}

iv. Leaf length plant^{-1} (cm)

v. Leaf width plant^{-1} (cm)

vi. Plant alive from 40 DAT

B. **Yield contributing characters**

i. Cob length plant^{-1} (cm)

ii. Cob circumference plant^{-1} (cm)

iii. Number of rows cob^{-1} (no.)

iv. Number of grains row^{-1} (no)

v. Dry weight plant^{-1} (g)

vi. 100 grains weight cob^{-1} (g)

vii. Whole cob weight plant^{-1} (g)

viii. Whole cob weight plot^{-1} (g)

C. **Yield characters**

i. Grain yield (t ha^{-1})

ii. Stover yield (t ha^{-1})

iii. Biological yield (t ha^{-1})

iv. Harvest index (%)

3.15. Procedure of recording data

Five plants were randomly selected from each plot to take data on per plant basis, whereas for the community data, 10 plants were collected from three linear meter at the central point each plot (yield attributes and yield). Data on plant height, number of rows per cob, number of seeds per row in a cob, cob length and circumference, grain weight per cob, grain yield per hectare, 100 seed weight and harvest index were taken.

A brief outline on data recording procedure followed during the study is given below:

3.15.1. Moisture meter (%) reading at different DAT (10 DAT and 20 DAT)

Moisture meter reading has taken by the using moisture meter tools at 10 DAT and 20 DAT. At first tools has inject between plant than machine shown value that are moisture meter reading.

Plate 1. Moisture meter reading has taken by using the moisture meter tools

3.15.2. Plant height (cm) at different DAT (45 DAT and 70 DAT)

At different stages of crop growth (45 DAT and 70 DAT), the height of five randomly selected plants from the inner rows plot^{-1} was measured from ground level to the tip of the plant portion and the mean value of plant height was recorded in cm.

3.15.3. Number of leaves plant^{-1} (No.)

At different stages of crop growth (45 DAT and 70 DAT) the number of leaves of five randomly selected plants from the inner rows per plot was measured by counting the number of leaves of the plant and the mean value of the number of leaves was recorded.

3.15.4. Leaf length plant^{-1} (cm) at different DAT (45 DAT and 70 DAT)

Leaf length was estimated manually by counting the total number of leaves plant^{-1} and measuring the length leaf. It was done 45 DAT and 70 days after transplanting respectively.

3.15.5. Leaf width plant^{-1} (cm) at different DAT (45 DAT and 70 DAT)

Leaf width was estimated manually by counting the total number of leaves plant^{-1} and measuring the length leaf. It was done 45 DAT and 70 days after transplanting respectively.

3.15.6. Cob length plant^{-1} (cm)

Cob length was measured in centimeter. Cob length was measured from the base to the tip of the cob of the five selected plants in each plot with the help of a centimeter scale then average data were recorded.

3.15.7. Cob circumference plant^{-1} (cm)

Five cobs were randomly selected per plot and the circumference was taken from each cob. Then the average result was recorded in cm.

3.15.8. Number of grain rows cob^{-1}

Five cobs from each plot were selected randomly and the number of grain rows per cob was counted. Then the average result was recorded.

3.15.9. Number of grains row^{-1} in cob

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

3.15.10. Dry matter weight plant $^{-1}$

Five plants from each plot were uprooted randomly. Then the plant was cut into pieces. Then the various pieces of the plant were put into a paper packet ,in case of harvesting, cob was also put into a packet and placed in oven maintaining 70^0 C for 72 hours. Then the sample was transferred into desiccators and allowed to cool down at room temperature. Then the sample weight was taken and then calculate the total dry matter of a plant for each plot.

3.15.11. Weight of 100 grains

After removing the grain from each cob from each plot grains are stored in a specific grain stock or pot. From the seed stock of each plot 1000 seeds were calculated and the weight was measured by an electrical balance. It was recorded in gram.

3.15.12. Cob weight plant-^{1} (g)

Cob weight (Includes chaff, shell and total grain weight of a cob) of five randomly selected cobs from the five selected plants in each plot was taken in an electrical balance and the average weight was recorded in gram.

3.15.13. Cob weight plot-^{1} (g)

Cob weight (Includes chaff, shell and total grain weight of a cob) of five randomly selected cobs from each plot was taken in an electrical balance and the average weight was recorded in gram.

3.15.14. Grain yield (t ha^{-1})

After removing the grain from the cob grain yield was calculated. Grain yield was calculated from cleaned and well dried grains collected from 1m^2 area of each plot and expressed as t ha^{-1}. Finally grain yield was adjusted at 14% moisture. The grain yield t ha^{-1} was measured by the following formula

$$\text{Grain yield (t ha}^{-1}\text{)} = \frac{\text{Grain yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.15.15. Stover yield (t ha^{-1})

After removing the grains from the cob various parts of the plants without grain part was weighted and well dried stover were collected from each plot were taken and converted into hectare and were expressed in t ha^{-1}The straw yield t ha^{-1} was measured by the following formula:

$$\text{Stover yield (t ha}^{-1}\text{)} = \frac{\text{Stover yield per plot (kg)} \times 10000}{\text{Area of plot in square meter} \times 1000}$$

3.15.16. Biological yield (t ha^{-1})

Grain yield alone with stover yield was regarded as biological yield and calculated with the following formula:

Biological yield (t ha^{-1}) = grain weight (t ha^{-1}) + stover yield (t ha^{-1})

3.15.17. Harvest Index (%)

Harvest Index indicate the ratio of economic yield (grain yield) to biological yield and was calculated with the following formula:

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (Grain weight)}}{\text{Biological yield (Biological weight)}\times 100}$$

3.16. Statistical data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program Statistix 10 software .The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

Results obtained from the study "Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels" have been presented and discussed in this chapter. Treatments effect of SAU maize 3 and moisture levels on all the studied parameters have been presented in various tables and figures and discussed below under the following sub-headings.

4.1. Plant growth parameters

4.1.1. Moisture meter (%) reading

From the results in table 1 showed significant variation due to the effect of seedling transplanting on moisture meter reading at different days after transplanting (DAT).

Moisture meter reading is an important device that acts as a potential indicator of availability of moisture in soil. The effect of seedling transplanting on moisture meter reading is represented in the table 1. At the early growth stage (10 DAT), moisture meter reading ranged from 16.63 to 11.60, where plants belong to SSWLC (Shorter seedlings with Waterlogged condition) treatment appeared as (16.63) the maximum moisture meter reading which was significant difference among all others treatment value and followed by (15.17) in LSWLC (Longer seedlings Waterlogged condition). On the other hand, the minimum value of moisture was observed from (11.60) in SSDS (Shorter seedlings at direct sowing) which was identically similar with the plants belong to (11.67) in LSFc (Longer seedlings transplanting at Field capacity condition) and all others treatment.

But after 20 DAT, it was found in SSWLC (Shorter seedlings with Waterlogged condition) treatment appeared as (14.33) the maximum moisture meter reading value which was identically similar with SS-SC and LSWLC treatment and followed by (13.97) in SSPC (shorter seedlings transplanting at puddled condition) and LSPC. On the other hand, the minimum moisture value was observed from (10.67) in SSDS (Shorter seedlings at direct sowing) which was identically similar with the plants belong to LSFcFw and SSFcFw and closely followed by all others treatment.

From the results in Table (1) showed significant variations at total growing stage under varying seedling length and soil moisture levels. Among different treatments, SSWLC (Shorter seedlings with Waterlogged condition) showed best performance in growth of Moisture meter reading and supported to make sure the more yield of SAU white maize 3.

4.1.2. Plant height (cm)

The results in table 1 showed significant variation due to the effect of seedling transplanting on plant height at different days after transplanting (DAT).

Plant height is an important morphological character that acts as a potential indicator of availability of growth resources in its approach. The effect of seedling transplanting on plant height is represented in the table 1. At the early growth stage (45 DAT), plant height ranged from 105.33 to 133.00 cm, where plants belong to SSDS (Shorter seedlings at direct sowing) treatment appeared as (152 cm) the tallest plant height which was significant difference among all others treatment and followed by (115.33 cm) in LSPC (Longer seedlings transplanting at puddled condition). On the other hand, the shortest in height was observed from (102.33 cm) in SSFcFw (Shorter seedlings transplanting at Field capacity by watering) which was closely followed by the plants belong to (103.00 cm) in LSFc (Longer seedlings transplanting at Field capacity condition) and all others treatment.

But after 70 DAT, it was found in SSDS (Shorter seedlings at direct sowing) treatment appeared as (174.67 cm) the tallest plant height which was significant difference among all others treatment and followed by (148.33 cm) in LSPC (Longer seedlings transplanting at puddled condition) and LSFcFw. On the other hand, the shortest in height was observed from (128.00 cm) in SSFcFw (Shorter seedlings transplanting at Field capacity by watering) which was identically similar with the plants belong to (128.33 cm) in LSFc (Longer seedlings transplanting at Field capacity condition) and closely followed by all others treatment.

From the results in Table (1) showed significant variations at total growing stage under varying seedling length and soil moisture levels. Among different treatments, SSDS

(Shorter seedlings at direct sowing) showed best performance in growth of plant height and supported to make sure the more yield of SAU white maize 3.

Table 1. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels in terms of plant heights at total growing stage

Treatment	Moisture meter reading (%)		Plant height (cm)	
	10 DAT	20 DAT	45 DAT	70 DAT
SSWLC	16.63 a	14.33 a	105.33 bc	133.00 bc
SSPC	14.87 ab	13.97 ab	107.00 bc	137.67 bc
SS-SC	15.13 ab	14.23 a	109.67 bc	138.67 bc
SSFc	12.53 cd	11.50 cd	104.67 bc	131.33 bc
SSFcFw	12.97 b-d	11.20 d	102.33 c	128.00 c
SSDS	11.60 d	10.67 d	152.00 a	174.67 a
LSWLC	15.17 ab	14.13 a	109.67 bc	141.67 bc
LSPC	14.27 bc	13.27 ab	115.33 b	148.33 b
LS-SC	13.73 b-d	12.67 bc	104.33 bc	130.00 c
LSFc	11.67 d	10.90 d	103.00 bc	128.33 c
LSFcFw	12.30 cd	11.57 cd	113.33 bc	148.33 b
$LSD_{(0.05)}$	**2.32**	**1.33**	**12.47**	**17.08**
CV (%)	**9.94**	**6.24**	**6.56**	**7.16**

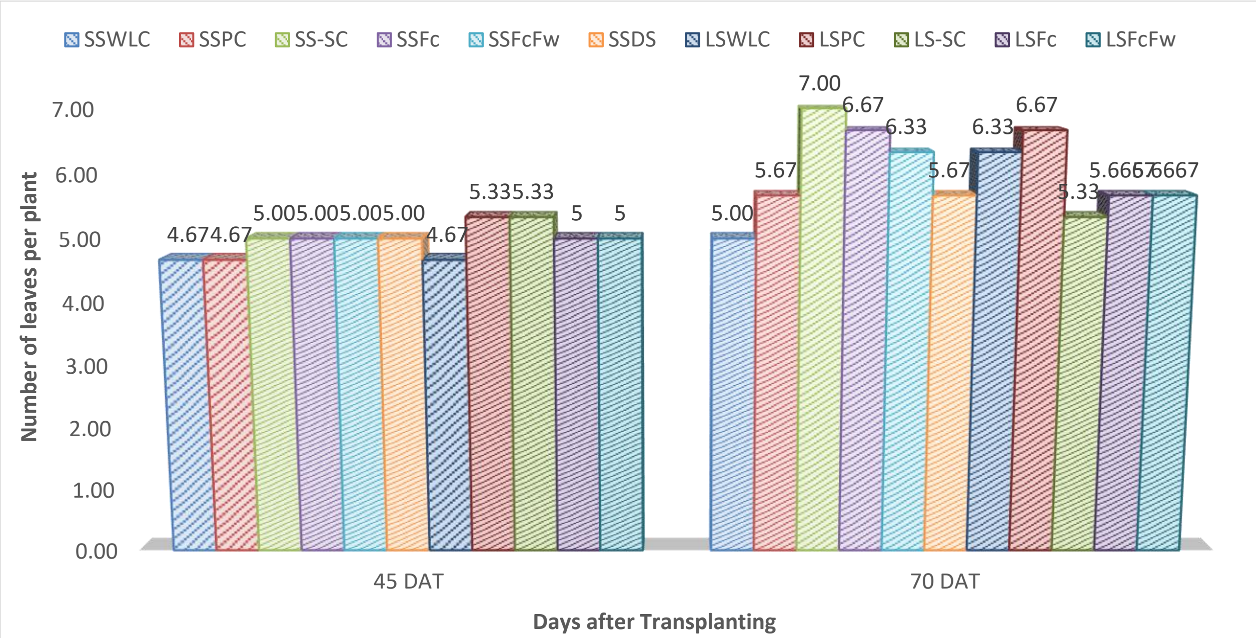
[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

4.1.3. Number of leaves per plant

From the results in Figure 1 showed significant variation due to the effect of seedling transplanting on number of leaves per plant at different days after transplanting (DAT).

The number of leaves per plant is an important morphological characteristic that acts as a potential indicator of availability of growth resources in its approach. The effect of seedling transplanting on the number of leaves per plant is represented in the Figure 1. At the early growth stage (45 DAT), number of leaves per plant ranged from 4.67 to 5.33, where plants belong to LSPS treatment appeared as (5.33) and LS-SC the highest number of leaves per plant which was identically similar with all others treatment. On the other hand, the lowest number of leaves was observed from (4.67) in SSWLC, SSPC and LSWLC treatment. There was no significant difference among all others treatment.

After 70 DAT, it was found in SS-SC (Shorter seedlings transplanting at saturated condition) treatment appeared as (7.00) the highest number of leaves per plant which was identically similar with all others treatment and followed by (6.67) in LS-SC (Longer seedlings transplanting at saturated condition) and SSFc. On the other hand, the lowest number was observed from (5.00) in SSPc which was identically similar with all others treatment. There also was no significant difference among all others treatment.



[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

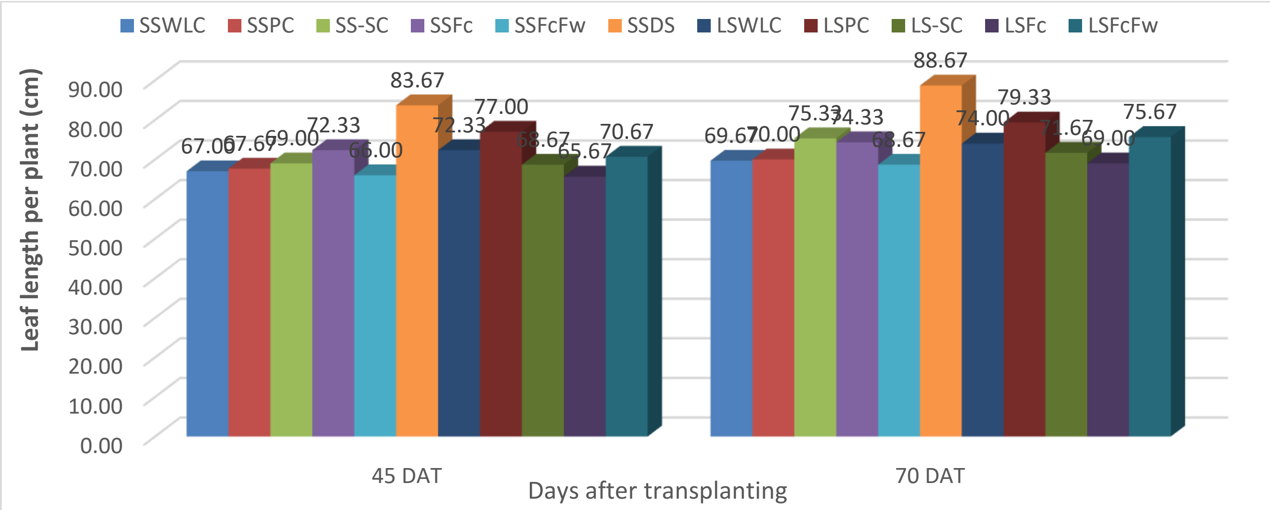
Figure 1. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels on number of leaves per plant at different days after transplanting (LSD $_{(0.05)}$ = 0.86) (LSD $_{(0.05)}$ = 2.11) for 45 DAT and 70 DAT, respectively.

4.1.4. Leaf length per plant (cm)

From the results in Figure 2 showed significant variation due to the effect of seedling transplanting on leaf length per plant (cm) at different days after transplanting (DAT).

The leaf length per plant (cm) is an important morphological characteristic that acts as a potential indicator of availability of growth resources in its approach. The effect of seedling transplanting on the leaf length per plant (cm) is represented in Figure 2. At the early growth stage (45 DAT), leaf length per plant (cm) ranged from 65.67 to 83.67 cm, where plants belong to LSDS treatment appeared as (83.67 cm) the highest leaf length per plant (cm) which was closely followed by (77.00 cm) in LSPS and significantly difference all others treatment. On the other hand, the lowest length of leaves was observed from (65.67 cm) in LSFc treatment which was identically similar with SSFcFw, SSWLC, SSPC, LS-SC and SS-SC.

After 70 DAT, it was found in LSDS treatment appeared as (88.67 cm) the highest leaf length per plant (cm) which was significantly difference all others treatment and followed by LSPS and LSFcFw. On the other hand, the lowest length of leaves was observed from (68.67 cm) in SSFcFw treatment which was identically similar with LSFc, SSWLC, SSPC and LS-SC treatment.



[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

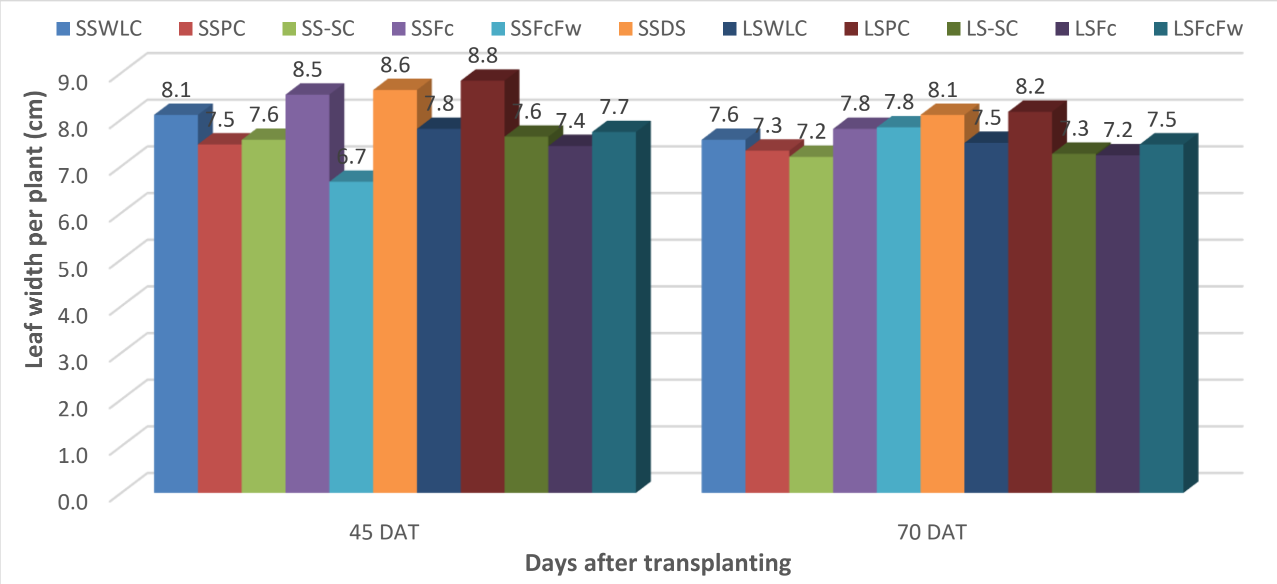
Figure 2. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels on Leaf length per plant (cm) at different days after transplanting (LSD $_{(0.05)}$ = 7.06) (LSD $_{(0.05)}$ = 7.63) for 45 DAT and 70 DAT, respectively.

4.1.5. Leaf width per plant (cm)

From the results in Figure 3 showed significant variation due to the effect of seedling transplanting on leaf width per plant (cm) at different days after transplanting (DAT).

The leaf width per plant (cm) is an important morphological characteristic that acts as a potential indicator of availability of growth resources in its approach. The effect of seedling transplanting on the leaf width per plant (cm) is represented in Figure 3. At the early growth stage (45 DAT), leaf width per plant (cm) ranged from 6.67 to 8.83 cm, where plants belong to LSPC treatment appeared as (8.83 cm) the highest leaf width per plant (cm) which was closely followed by (8.63) in SSDS and significantly difference all others treatment. On the other hand, the lowest width of leaves was observed from (6.67) in LSFcFw treatment which was significantly difference from all other treatments and closely followed by LSFc and LS-SC treatment.

After 70 DAT, it was found in LSPC treatment appeared as (8.17) the highest leaf width per plant (cm) which was identically similar with SSDS and significantly difference all others treatment and followed by LSFc and SSFcFw. On the other hand, the lowest width of leaves was observed from (7.20) in SS-SC treatment which was identically similar with LSFc, LS-SC and SSPC treatment.



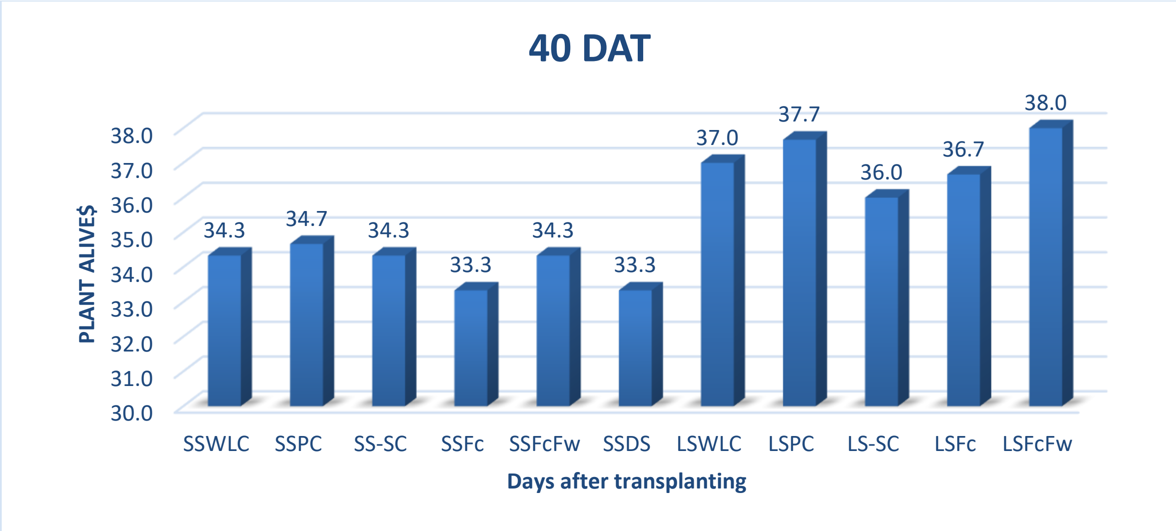
[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

Figure 3. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels on Leaf length per plant (cm) at different days after transplanting (LSD $_{(0.05)}$ = 1.15) (LSD $_{(0.05)}$ = 0.73) for 45 DAT and 70 DAT, respectively.

4.1.6. Plant alive at DAT

The results in Figure 4 showed significant variation due to the effect of seedling transplanting on plants alive at different days after transplanting (DAT).

The effect of seedling transplanting on the plant alive at 40 is represented in Figure 4. At the early growth stage (40 DAT), plants alive after 40 DAT ranged from 33.33 to 38.00 from 40 plants, the maximum number plant alive at 40 DAT (38.00 alive from 40 plant) in LSFcFw which was closely followed by (37.67 alive from 40 plant) in LSPC and significantly difference all others treatment. On the other hand, the minimum number of plants alive was observed from (33.33 alive from 40 plant) in SSDS treatment which was identically similar with SSFc and closely followed by SSFcFw treatment and others.



[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

Figure 4. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels on plants alive at different days after transplanting (LSD $_{(0.05)}$ = 3.46) (LSD $_{(0.05)}$ = 5.26) for 40 DAT and 80 DAT, respectively.

4.2. Yield contributing characteristics

4.2.1. Cob length plant^{-1} (cm)

A significant influence was recorded on cob length per plant of maize as affected by different planting configurations (Table 2). Results showed that the highest cob length (23.33 cm) was recorded from the treatment LSWLC and closely followed by all others treatment except SSDS. The lowest cob length (20.10 cm) was found from the treatment SSDS which was statistically difference from others treatment. Similar results were also observed by Koirala *et al*. (2020) and Zeleke *et al*. (2018).

4.2.2. Cob circumference plant^{-1} (cm)

A significant influence was recorded on cob circumference per plant of maize as affected by different planting configurations (Table 2). Results showed that the highest cob circumference (16.97 cm) was recorded from the treatment LSFc which was significantly different from all other treatments and closely followed by LSWLC, SS-SC. The lowest cob circumference (14.30 cm) was found from the treatment LSPS which was statistically difference from others treatment and closely followed by SSDS, SSPC treatment.

4.2.3. Number of rows cob^{-1}

A significant influence was recorded on number of rows cob^{-1} of maize as affected by different planting configurations (Table 2). Results showed that the highest number of rows cob^{-1} (13.33) was recorded from the treatment LSFc which was identically similar with all other treatments. The lowest number of rows cob^{-1} (12.00) was found from the treatment SSPC treatment. There was no significant difference among all treatment.

4.2.4. Number of grains cob^{-1}

A significant influence was recorded on number of grains cob^{-1} of maize as affected by different planting configurations (Table 2). Results showed that the highest number of grains cob^{-1} (27.67) was recorded from the treatment LS-SC and SSPC which was identically similar with all other treatments. The lowest number of grains cob^{-1} (24.33) was found from the treatment SSDS treatment. There was no significant difference among all treatment.

Table 2. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels in terms of cob length plant^{-1} (cm), cob circumference plant^{-1} (cm), number of rows cob^{-1} and number of grains row^{-1} at total growing stage

Treatment	Cob length plant^{-1} (cm)	Cob circumference plant^{-1} (cm)	Number of rows cob^{-1}	Number of grains row^{-1}
SSWLC	21.73 ab	15.97 a-c	13.00 a	26.33 a
SSPC	21.83 ab	15.13 bc	12.00 a	26.00 a
SS-SC	20.87 ab	16.30 ab	13.00 a	27.67 a
SSFc	20.23 ab	15.80 a-c	13.00 a	25.33 a
SSFcFw	22.53 ab	15.93 a-c	13.00 a	27.00 a
SSDS	20.10 b	14.80 bc	13.33 a	24.33 a
LSWLC	23.33 a	16.43 ab	12.33 a	24.67 a
LSPC	21.70 ab	14.30 c	12.67 a	27.00 a
LS-SC	21.60 ab	15.77 a-c	12.33 a	27.67 a
LSFc	21.13 ab	16.97 a	13.33 a	24.67 a
LSFcFw	21.00 ab	15.47 a-c	12.67 a	25.33 a
$LSD_{(0.05)}$	**3.15**	**1.77**	**2.34**	**5.39**
CV (%)	**8.62**	**6.62**	**10.74**	**12.18**

[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

4.2.5. Dry stover weight plant^{-1} (g)

A significant influence was recorded on dry stover weight plant^{-1} (g)of maize as affected by different planting configurations (Table 3). Results showed that the highest dry weight stover plant^{-1} (g) (32.67 gm) was recorded from the treatment LSFC which was identically similar with all others treatment. The lowest dry weight stover plant^{-1} (g) (23.43 gm) was found from the treatment SS-SC and LSPC treatment. Similar results were also observed by Koirala *et al*. (2020) and Zeleke *et al*. (2018). There was no significant difference among all treatment.

4.2.6. 100 grains weight cob^{-1} (g)

A significant influence was recorded on 100 grains weight cob^{-1} (g)of maize as affected by different planting configurations (Table 3). Results showed that the highest 100 grains weight cob^{-1} (g) (26.67 gm) was recorded from the treatment LSFcFw which was identically similar with all others treatment. The lowest 100 grains weight cob^{-1} (g) (24.00 gm) was found from the treatment LSWLC treatment. Similar results were also observed by Koirala *et al*. (2020) and Zeleke *et al*. (2018). There was no significant difference among all treatment.

4.2.7. Whole cob weight plant^{-1} (g)

A significant influence was recorded on whole cob weight plant^{-1} (g) of maize as affected by different planting configurations (Table 3). Results showed that the highest whole cob weight plant^{-1} (89.67 g) was recorded from the treatment LSFcFw which was closely followed by LS-SC and all other treatments except LSWLC, LSPC, SSFcFw. The lowest whole cob weight plant^{-1} (66.33 g) was found from the treatment LSWLC treatment.

4.2.8. Dry stover weight plot^{-1} (kg)

A significant influence was recorded on dry stover weight plot^{-1} (kg) of maize as affected by different planting configurations (Table 3). Results showed that the highest dry stover weight plot^{-1} (2.26 kg) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest dry stover weight plot^{-1} (1.24 kg) was found from the treatment SSFc treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc.

4.2.9. Cob weight (g)/plot

A significant influence was recorded on cob weight (g)/plot of maize as affected by different planting configurations (Table 3). Results showed that the highest cob weight (g)/plot (864.67 g) was recorded from the treatment LSFcFw which was closely followed by all other treatments except SS-SC. The lowest cob weight (g)/plot (699.00 g) was found from the treatment SS-SC treatment.

Table 3. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels in terms of dry weight plant^{-1} (g), 100 grains weight cob^{-1} (g), whole cob weight plant^{-1} (g), whole cob weight plot^{-1} (kg) and dry matter weight (g)/plot at total growing stage under varying seedling length and soil moisture levels

Treatment	Dry stover weight plant^{-1} (g)	100 grains weight cob^{-1} (g)	Whole cob weight plant^{-1} (g)	Dry stover weight plot^{-1} (kg)	Cob weight (g)/plot
SSWLC	24.92 de	25.00 a	74.33 a-c	1.30 b	720.67 ab
SSPC	27.67 cd	27.00 a	78.67 a-c	1.48 b	750.00 ab
SS-SC	26.33 cd	24.67 a	78.00 a-c	1.43 b	699.00 b
SSFc	23.43 e	25.33 a	74.33 a-c	1.24 b	740.33 ab
SSFcFw	23.83 e	24.33 a	73.67 bc	1.28 b	765.67 ab
SSDS	25.33 d	26.00 a	79.67 a-c	1.40 b	709.67 ab
LSWLC	24.33 de	24.00 a	66.33 c	1.27 b	789.33 ab
LSPC	25.33 d	25.33 a	68.33 bc	1.40 b	766.33 ab
LS-SC	30.67 ab	24.67 a	83.00 ab	1.77 ab	812.33 ab
LSFc	28.30 bc	25.00 a	74.67 a-c	1.55 ab	842.00 ab
LSFcFw	32.67 a	26.67 a	89.67 a	2.26 a	864.67 a
LSD$_{(0.05)}$	**3.53**	**4.01**	**15.55**	**0.32**	**157.29**
CV (%)	**9.55**	**9.31**	**9.27**	**12.06**	**12.01**

[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

4.3. Yield characters

4.3.1. Grain yield (ton/ha)

A significant influence was recorded on grain yield (ton/ha of maize as affected by different planting configurations (Table 4). Results revealed that the highest grain yield (11.76 ton/ha) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest grain yield (7.50 ton/ha) was found from the treatment SSFc treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc. Golla *et al.* (2018) and Hasan *et al.* (2018) also found similar results which supported the present finding.

4.3.2. Stover yield (ton/ha)

A significant influence was recorded on stover yield (ton/ha) of maize as affected by different planting configurations (Table 4). Results revealed that the highest stover yield (11.89 ton/ha) was recorded from the treatment LSWLC which was significant difference all other treatments and closely followed by all treatment except SSDS. The lowest stover yield (9.96 ton/ha) was found from the treatment LS-SC treatment. Golla *et al.* (2018) and Hasan *et al.* (2018) also found similar results which supported the present finding.

4.3.3. Biological yield (ton/ha)

A significant influence was recorded on biological yield (ton/ha of maize as affected by different planting configurations (Table 4). Results revealed that the highest biological yield (22.36 ton/ha) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest biological yield (17.77 ton/ha) was found from the treatment SSWLC treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc. Golla *et al.* (2018) and Hasan *et al.* (2018) also found similar results which supported the present finding.

4.3.4. Harvest index (%)

A significant influence was recorded on the harvest index of maize as affected by different planting configurations (Table 4). Results showed that the highest harvest index (52.59%) was recorded from the treatment LSFcFw which was a significant difference all other treatments. The lowest harvest index (39.03%) was found from the treatment LSWLC treatment and closely followed by all others treatment except LSFcFw.

Table 4. Performance of seedling transplantation of SAU white maize-3 under varying seedling length and soil moisture levels in terms of grain yield (ton/ha), stover yield (ton/ha), biological yield (ton/ha) harvest index (%) at total growing stage under varying seedling length and soil moisture levels

Treatment	Grain yield (ton/ha)	Stover yield (ton/ha)	Biological yield (ton/ha)	Harvest index (%)
SSWLC	8.77 b	11.00 ab	17.77 b	44.36 bc
SSPC	8.52 b	10.13 ab	18.65 b	45.68 bc
SS-SC	8.30 b	10.91 b	19.21 b	43.21 bc
SSFc	7.50 b	11.08 ab	18.58 b	40.37 c
SSFcFw	7.67 b	11.19 ab	18.86 b	40.67 c
SSDS	8.18 b	9.96 ab	18.14 b	45.09 bc
LSWLC	7.61 b	11.89 ab	19.50 b	39.03 c
LSPC	8.19 b	10.19 ab	18.38 b	44.56 bc
LS-SC	9.73 ab	11.38 ab	20.11 ab	46.09 bc
LSFc	8.78 ab	10.50 ab	19.28 ab	45.54 bc
LSFcFw	11.76 a	10.60 a	22.36 a	52.59 a
$LSD_{(0.05)}$	**2.99**	**0.66**	**3.30**	**3.46**
CV (%)	**12.06**	**12.01**	**10.90**	**2.48**

[SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanted at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering]

CHAPTER V

SUMMARY AND CONCLUSION

The present piece of work was carried out at the Research Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2021 to April 2022, to investigate the evaluating seedling transplantation of SAU white maize-3 under varying soil moisture and seedling lengths. The experimental field belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment consists of different saturation as treatment and they SSWLC = shorter seedlings Waterlogged condition; SSPC = Shorter seedlings transplanting at puddled condition; SS-SC = Shorter seedlings transplanting at saturated condition; SSFc = shorter seedlings transplanting at Field capacity condition; SSFcFw = Shorter seedlings transplanting at Field capacity by watering; SSDS = Shorter seedlings at direct sowing; LSWLC = Longer seedlings Waterlogged condition; LSPC = Longer seedlings transplanting at puddled condition; LS-SC = Longer seedlings trans. at saturated condition; LSFc = Longer seedlings transplanting at Field capacity condition; LSFcFw = Longer seedlings transplanting at Field capacity by watering. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing characters and yield were recorded to find out the seedling transplantation and water saturation level for the highest yield of SAU White maize 3.

Growth, yield and yield contributing characters were significantly influenced by different seedling transplanting with moisture level. At 45 DAT and 70 DAT the maximum plant height (152 cm and 174.67 cm) was observed in SSDS (Shorter seedlings at direct sowing) treatment. On the other hand, the shortest in height was observed from (102.33 cm and 128 cm) in SSFcFw (Shorter seedlings transplanting at Field capacity by watering) treatment. The maximum number of leaves plant^{-1} (5.33 and 7.00 at 45 and 70 DAT) was observed in LS-SC treatment. On the other hand, the minimum number of leaves plant^{-1} was observed from (4.67 and 5.00 at 45 and 70 DAT) SSWLC and SSPc. The maximum leaf length per plant (cm) (83.67 cm and 88.67 at 45 and 70 DAT) was observed in LSDS treatment. On the other hand, the minimum leaf length plant^{-1} (65.67 cm at 45 DAT) from LSFc and (68.67 cm at 70 DAT) from SSFcFw treatment was observed.

The maximum leaf width per plant (cm) (8.83 cm and 8.17 cm at 45 and 70 DAT) was observed in LSPC treatment. On the other hand, the minimum leaf width plant^{-1} (6.67 cm at 45 DAT) from LSFcFw and (7.20 cm at 70 DAT) from SS-SC treatment was observed.

At the early growth stage (40 DAT), the maximum number plant alive at 40 DAT (38.00 alive from 40 plant) in LSFcFw which was closely followed by (37.67 alive from 40 plant) in LSPC and significantly difference all others treatment. On the other hand, the minimum number of plants alive was observed from (33.33 alive from 40 plant) in SSDS treatment which was identically similar with SSFc and closely followed by SSFcFw treatment and others.

After 80 DAT, the maximum number plant alive at 80 DAT (13.33 alive from 40 plant) in SSDS which was significantly difference from all others treatment. On the other hand, the minimum number of plants alive was observed from (2.00 alive from 40 plant) in SS-SC treatment which was identically similar with all other treatment except SSDS treatment.

For yield contributing characteristics, Results showed that the highest cob length (23.33 cm) was recorded from the treatment LSWLC and closely followed by all others treatment except SSDS. The lowest cob length (20.10 cm) was found from the treatment SSDS which was statistically difference from others treatment. the highest cob circumference (16.97 cm) was recorded from the treatment LSFc which was significantly different from all other treatments and closely followed by LSWLC, SS-SC. The lowest cob circumference (14.30 cm) was found from the treatment LSPS which was statistically difference from others treatment. And the highest number of rows cob^{-1} (13.33) was recorded from the treatment LSFc which was identically similar with all other treatments. The lowest number of rows cob^{-1} (12.00) was found from the treatment SSPC treatment. There was no significant difference among all treatment.

Results showed that the highest number of grains cob^{-1} (27.67) was recorded from the treatment LS-SC and SSPC which was identically similar with all other treatments. The lowest number of grains cob^{-1} (24.33) was found from the treatment SSDS treatment. There was no significant difference among all treatment. The highest dry weight plant^{-1} (g) (32.67 gm) was recorded from the treatment LSFC which was identically similar with all others treatment. The lowest dry weight plant^{-1} (g) (23.43 gm) was found from the treatment SS-SC and LSPC treatment. The highest 100 grains weight cob^{-1} (g) (26.67 gm) was recorded from the treatment LSFcFw which was identically similar with all others treatment. The lowest 100 grains weight cob^{-1} (g) (24.00 gm) was found from the treatment LSWLC treatment. the highest whole cob weight plant^{-1} (89.67 g) was recorded from the treatment LSFcFw which was closely followed by LS-SC and all other treatments except LSWLC, LSPC, SSFcFw. The lowest whole cob weight plant^{-1} (66.33 g) was found from the treatment LSWLC treatment. Results showed that the highest whole cob weight plot^{-1} (4.26 kg) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest whole cob weight plot^{-1} (3.24 kg) was found from the treatment SSFc treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc. The highest dry matter weight (g)/plot (864.67 g) was recorded from the treatment LSFcFw which was closely followed by all other treatments except SS-SC. The lowest dry matter weight (g)/plot (699.00 g) was found from the treatment SS-SC treatment.

For Yield characteristics, Results revealed that the results revealed that the highest grain yield (17.76 ton/ha) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest grain yield (13.50 ton/ha) was found from the treatment SSFc treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc. From stover yield (ton/ha), highest stover yield (3.60 ton/ha) was recorded from the treatment LSFcFw which was significant difference all other treatments and closely followed by all treatment except SS-SC. The lowest stover yield (2.91 ton/ha) was found from the treatment LS-SC treatment. Results revealed that the highest biological yield (21.36 ton/ha) was recorded from the treatment LSFcFw which was closely followed by LS-SC and LSFc and significant difference all other treatments. The lowest biological yield

(16.58 ton/ha) was found from the treatment SSFc treatment which was identically similar with all others treatment except LSFcFw, LS-SC, LSFc. finally the highest harvest index (52.59%) was recorded from the treatment LSFcFw which was identically similar with all other treatments. The lowest harvest index (39.03%) was found from the treatment SSFcFw treatment. There was no significant difference among all treatment.

CONCLUSION

Based on the above results of the present study, the following conclusions may be drawn-

- ✓ Maximum value of growth, yield and yield contributing characters were observed in LSFcFw treatment (Longer seedlings transplanting at field capacity by watering) compared to other treatments.
- ✓ Maximum grain yield (11.76 t ha^{-1}), stover yield (10.60 t ha^{-1}) and biological yield (22.36 t ha^{-1}) were observed in LSFcFw treatment (Longer seedlings transplanting at Field capacity by watering) compared to other treatments.

Thus, for the cultivation of "SAU white maize 3 along with LSFcFw treatment (Longer seedlings transplanting at field capacity by watering) can be used as recommended treatment for the production of highest grain yield in the AEZ 28 (Agro-ecological zone) soils of Bangladesh.

Recommendations

- ❖ Studies of similar nature could be carried out in different Agro Ecological Zones (AEZ) in different seasons of Bangladesh for the evaluation of zonal adaptability.

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