MICRONUTRIENT MANAGEMENT OF SWEET CORN (*Zea mays* var. *saccharata*) HYBRIDS FOR YIELD AND QUALITY

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by

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"MICRONUTRIENT MANAGEMENT OF SWEET CORN (*Zea mays* var. *saccharata*) HYBRIDS FOR YIELD AND QUALITY"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**MICRONUTRIENT MANAGEMENT OF SWEET CORN (*Zea mays* var. *saccharata*) HYBRIDS FOR YIELD AND QUALITY**" is a record of research work done independently by Ms. Deepa Mary Varghese (2018-11-172) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

22.9.2020

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We, the undersigned members of the advisory committee of Ms. Deepa Mary Varghese., a candidate for the degree of **Master of Science in Agriculture** with major in Agronomy, agree that the thesis entitled **"Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality"** may be submitted by Ms. Deepa Mary Varghese, in partial fulfilment of the requirement for the degree.

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Deepa Mary Varghese

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LIST OF ABBREVIATIONS AND SYMBOLS

%	-	Per cent
@	-	At the rate of
ANOVA	-	Analysis of variance
BCR	-	Benefit – cost ratio
B	-	Boron
cm	-	Centi meter
Ca	-	Calcium
$CaCl_2$	-	Calcium chloride
Cu	-	Copper
CD	-	Critical difference
DAS	-	Days after sowing
dS m^{-1}	-	Deci Siemen per metre
dm	-	Deci metre
DAP	-	Di ammonium phosphate
DMSO	-	Di – methyl sulfoxide
EC	-	Electrical conductivity
et al	-	And others
Fe	-	Iron
$FeSO_4$	-	Ferrous sulphate
Fig.	-	Figure
FYM	-	Farm Yard manure
GOI	-	Government of India
g	-	Gram
g kg^{-1}	-	Gram per kilogram
g $plant^{-1}$	-	Gram per plant
g pot^{-1}	-	Gram per pot
g $100g^{-1}$	-	Gram per hundred gram
ha	-	Hectare
hrs.	-	Hours
H_2SO_4	-	Sulphuric acid

IARI	-	Indian Agricultural Research Institute
K	-	Potassium
K_2O	-	Potassium oxide
KAU	-	Kerala Agricultural University
kg	-	Kilogram
kg ha^{-1}	-	Kilogram per hectare
kg $plant^{-1}$	-	Kilogram per plant
kg $plot^{-1}$	-	Kilogram per plot
lakh ha^{-1}	-	Lakh per hectare
LAI	-	Leaf area index
L^{-1}	-	Per litre
L ha^{-1}	-	Litre per hectare
Mg	-	Magnesium
Mn	-	Manganese
m	-	Metre
M	-	Molar
meq L^{-1}	-	Milliequivalents per litre
µg	-	Microgram
µM	-	Micromolar
mM	-	Millimolar
mg g^{-1}	-	Milligram per gram
mg kg^{-1}	-	Milligram per kilogram
mg L^{-1}	-	Milligram per litre
mg $plant^{-1}$	-	Milligram per plant
mmol mg^{-1}	-	Millimole per milligram
MOP	-	Muriate of potash
N	-	Nitrogen
NaOH	-	Sodium hydroxide
NS	-	Not significant
˚C	-	Degree Celsius
˚E	-	Degree East
˚N	-	Degree North

P	-	Phosphorus
POP	-	Package of Practices
P_2O_5	-	Phosphorus pentoxide
ppm	-	Parts per million
q ha^{-1}	-	Quintal per hectare
RARS	-	Regional Agricultural Research Station
RBD	-	Randomized Block Design
RDF	-	Recommended dose of fertilizers
RDN	-	Recommended dose of nutrients
₹	-	Rupees
₹ ha^{-1}	-	Rupees per hectare
SE(m)	-	Standard error of means
var.	-	Variety
TNAU	-	Tamil Nadu Agricultural University
t	-	Tonnes
t ha^{-1}	-	Tonnes per hectare
UAS	-	University of Agricultural Sciences
Zn	-	Zinc
$ZnCl_2$	-	Zinc chloride
ZnO	-	Zinc oxide
$ZnSO_4$	-	Zinc sulphate

INTRODUCTION

1. INTRODUCTION

Maize known as the "Queen of cereals" is the third most important cereal crop in the world. It is a versatile crop as it can adapt to various agro- ecological conditions. The crop being a C_4 plant will help to adapt to dry and warm environments. In addition, maize can be raised as a forage crop and can be fed to cattle at any stage of growth due to its faster growth and high yielding ability.

India is the seventh largest producer of maize in the world where the total area cultivated is 9.47 million hectares, production of 28.72 million tonnes and productivity is 3032 kg per hectare (GOI, 2018).

Sweet corn (*Zea mays* var. *saccharata*) is a special type of maize bred for high sugar content. Sweet corn is the result of a naturally occurring recessive mutation in the genes which control conversion of sugar to starch inside the endosperm of the corn kernel. Sweet corn is harvested in the "milk stage", after pollination but before starch has formed. The fresh green cobs or kernels can be consumed raw, boiled or steamed and is a popular vegetable used in preparation of soup, salad and other recipes (Parihar *et al*., 2016). It is an excellent source of sugars, dietary fibre, vitamin-C, beta-carotene, niacin, in addition to calcium and potassium. Since the crop has high nutritional value, high sugar and low starch content, it is gaining popularity among the health-conscious urban population in India. Immature kernels can be parboiled to produce candy and crushed matured kernels can be used for the production of a fermented beverage, chichi. It also serves as a raw material for deriving large number of industrial products such as starch syrup, dextrose and dextrin (Dagla *et al*., 2014). Generally sweet corn is early in maturity and hence, it can be cultivated to fit in intensive cropping systems. Green cobs as well as nutritious green fodder help increase economic return. The importance of this crop is not much popular among Kerala farmers in spite of the fact that it a premium crop of future that can explore possibilities in peri-urban agriculture.

Nutrient management plays a key role in improving crop yield with maintenance of soil fertility for sustainable production. Crops when given the right form, amount and balance of essential nutrients, will develop and exhibit good growth performance and increase the yield potential (Canatoy, 2018). Micronutrients are required in small amounts and they affect directly and indirectly the vital processes in a plant. Micronutrients play an active role in the plant metabolic processes beginning from cell development to respiration, photosynthesis, chlorophyll formation, enzyme activity, nitrogen fixation etc. (Kumar *et al*., 2019). Intensified and optimum use of micronutrients will result in good yield and profit in the production process, considering the concept of sustainability (Abreu *et al*., 2007). High yielding crops and crops that produce large amounts of harvestable material remove greater amounts of nutrients from the soil. Maize requires large amount of nutrients and it exhausts both the major and micro nutrients for its growth, development and yield. Maize is sensitive to zinc and boron fertilization among the micronutrients.

Zinc is an essential micronutrient, involved in production of auxin, proteins and acts as a co factor in many catalytic reactions in all crops especially maize and hence, is considered to be the most critical micronutrient. Zinc is also crucial in taking part in plant development due to its catalytic action in metabolism for all crops especially maize (Cakmak, 2000).

Boron is essential for cell division because it is a constituent element of nucleoproteins which are involved in the cell reproduction process and crop maturation. Boron is relatively immobile in a corn plant and its availability is essential at all growth stages, particularly during fruit and seed development (Gupta, 1983). Boron application will improve growth, induce stress tolerance and improve grain production (Hussain *et al*., 2012). In boron deficient maize, poor grain setting can result in barren cobs (Vaughan, 1977).

The form in which the micronutrients are applied is of critical importance for correcting the deficiency most effectively and economically (Mortvedt, 1986). Foliar application will help in effective absorption, utilization and nutrient use efficiency thereby increasing the crop productivity and marketability (Manasa and Devaranavadagi, 2015). Increasing the micronutrient density in human plant foods is currently a high priority for human nutritionists worldwide (Anon., 1992; Anon., 1993).

In the light of the above facts, the present study entitled "Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality" was conducted with the following objectives:

1. To evaluate the performance of sweet corn hybrids for yield and quality

2. To study the role of zinc and boron in increasing the productivity of sweet corn

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Maize contributes to a large ratio of world's cereal production and has great importance to mankind. Sweet corn, a type of maize is grown in large area due to its market potential. Hence, many experimental works have been conducted to increase the production efficiency of maize. The present study entitled "Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality was conducted to identify the best hybrid and the role of micronutrients in sweet corn production. The literature on micronutrient management in sweet corn is meagre and more studies should be conducted and hence, various works carried out in maize are also presented.

To support the present study, results of various experiments are cited below under different titles.

2.1 EFFECT OF BORON ON BIOMETRIC CHARACTERS

2.1.1 Plant height

Application of 0.5 per cent boric acid as foliar spray at early, mid and late whorl stages in maize resulted in taller (195 cm) plants (Soomro *et al*., 2011).

Highest plant height (109 cm) in maize was measured when B (0.5 kg ha^{-1}) and Zn (5.0 kg ha^{-1}) in combination was given to soil (Panhwar *et al*., 2011).

Tahir *et al.* (2012) concluded that foliar spray of boron (0.30 kg ha^{-1}) at 20 DAS in maize had increased the plant height (163.1 cm).

Soil applied nitrogen (90 kg ha^{-1}), phosphorus (20 kg ha^{-1}), potassium (25 kg ha^{-1}) and boron (5 kg ha^{-1}) with FYM gave taller plants (151.8 cm) in maize- potato-mung bean cropping system at IARI (Meena *et al.*, 2012).

Singh *et al*. (2017) declared that combined soil application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) gave the highest plant height (211.8 cm) in maize.

Maximum plant height (217 cm) was measured in maize when three foliar sprays of 0.5 per cent borax was given (Sarwar *et al*., 2018).

Kumar and Dawson (2019) observed that application of $ZnSO_4$ (15 kg ha^{-1}) to soil and Borax (0.5 %) as foliar spray at 30 DAS increased the plant height (215.87 cm) in sweet corn.

An experiment was conducted by Konuskan *et al*. (2019) in hybrid maize and foliar spray of boron (4 mg m^{-2}) at two leaf stage gave the highest plant height (240 cm).

Hassan *et al*. (2019) conducted an experiment to find out the effect of foliar application of boron in maize and reported that foliar application of borax (69 ppm) had given the highest plant height (196 cm).

2.1.2 Number of leaves

Results by Kunjir *et al.* (2009) indicated that spraying of micronutrient mixture (Fe- 2 %, Mn- 2 %, Zn- 2 %, Cu- 0.5 % and B- 0.5 %) increased the number of leaves per plant (7.57) in sweet corn

Foliar application of 0.5 per cent boric acid at vegetative stages recorded the maximum number of green leaves per plant (8) in maize (Soomro *et al*., 2011).

Salim (2014) found that foliar spray of boron (100 ppm) and silicon (500 ppm) in combination at 21 and 42 DAS, increased the number of green leaves (9.83) in maize.

2.1.3 Leaf area

The highest LAI was obtained when soil applied B (0.5 kg ha^{-1}) and Zn (5.0 kg ha^{-1}) was treated in maize (Panhwar *et al*., 2011).

Tahir *et al.* (2012) showed that foliar application of boron (0.30 kg ha^{-1}) at 20 DAS in maize had increased the leaf area (19 cm^2).

The maximum leaf area (3 m^2) was observed when boron (0.6 kg ha^{-1}) was given as foliar application, while minimum leaf area (2 m^2) was noted in control plot (Shabbir *et al*., 2017).

2.1.4 Days to 50 per cent tasseling

Jakati (2014) confirmed that least number of days taken for tassel emergence (46.67 DAS) was noted when zinc (0.2 %), boron (0.1 %) and iron (0.1 %) was treated as foliar spray in sweet corn.

2.1.5 Days to 50 per cent silking

According to Jakati (2014) least number of days taken for silk emergence (51.33 DAS) in sweet corn was recorded with foliar application of zinc (0.2 %), boron (0.1 %) and iron (0.1 %).

2.2 EFFECT OF ZINC ON BIOMETRIC CHARACTERS

2.2.1 Plant height

Gandahi *et al.* (2008) revealed that foliar application of zinc (3 %) at early, middle and late vegetative stage increased the plant height (137.6 cm) in fodder maize.

In an investigation made by Ashoka *et al*. (2008) in baby corn at Raichur noted that application of RDF, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (35 kg ha^{-1}) in combination increased the plant height (185.5 cm).

A study conducted by Kumar *et al*. (2010) concluded that combination of RDF and 4 kg ha^{-1} of zinc through pressmud increased the plant height (208.53 cm) at 60 DAS in maize.

Giving soil application of $ZnSO_4$ (7.50 kg ha^{-1}) increased the height of plant (255.1 cm) in maize. (Preetha and Stalin, 2014).

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1 %) during the peak vegetative growth stage of the maize resulted in taller plants (205.2 cm).

According to El-Azab (2015) maize treated with recommended dose of fertilizers and foliar application of $ZnSO_4$ (2 %) at six leaf stage, recorded the highest plant height (288 cm).

A study conducted by Amanulla *et al*. (2016) in maize confirmed that foliar application of zinc (0.3 %) at reproductive stage gave the highest plant height (188.1cm).

Tahir *et al.* (2016) noted that three foliar sprays of 0.5 per cent $ZnSO_4$ increased the plant height (159.73 cm) in maize.

Application of RDF, foliar application of $ZnSO_4$ (0.5 %) and $FeSO_4$ (0.2 %) at booting and silking improved the plant height (213 cm) in sweet corn (Karrimi *et al.*, 2018).

Amutham *et al.* (2019) concluded that combined application of $ZnSO_4$ (37.5 kg ha^{-1}) to soil and foliar application of zinc (0.5 %) at 20 and 40 DAS had recorded the highest plant height (211.6 cm) in baby corn.

2.2.2 Number of leaves

Gandahi *et al*. (2008) revealed that foliar application of zinc (3 %) at early, middle and late vegetative stage increased the number of leaves per plant (12.69).

Investigation made by Ashoka *et al.* (2008) in baby corn noted that combined application of RDF, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (35 kg ha^{-1}) increased the number of leaves per plant (13.63).

The number of leaves per plant increased by 72 per cent when 100 mg L^{-1} ZnO nano particles as foliar spray was treated in maize (Rizwan *et al*., 2019).

Significant effects on number of leaves per plant (16.67) were seen when zinc -chitosan nanoparticles (0.08 %) were given as foliar application to maize (Choudhary *et al.*, 2019).

2.2.3 Leaf area

A study conducted by Kumar *et al*. (2010) showed that combination of RDF and 4 kg ha^{-1} of zinc through pressmud compost resulted in higher leaf area (148.23 dm^2) at 60 DAS in maize.

Manasa and Devaranavadagi (2015) noted that foliar application of $ZnSO_4$ (1 %) during the vegetative growth stage increased the leaf area (93.28 dm^2) in maize.

According to El-Azab (2015) maize treated with recommended dose of fertilizers and foliar application of $ZnSO_4$ (2 %) at six leaf stage, resulted in highest leaf area (681.28 cm^2).

Foliar application of zinc (0.3%) at tasseling and silking stage resulted in highest LAI (2.80) in maize (Amanulla *et al*., 2016).

2.2.4 Days to 50 per cent tasseling

Debnath (2014) observed that soil application of $ZnSO_4$ (25 kg ha^{-1}) and two foliar sprays of $ZnSO_4$ (2 %) recorded the least number of days taken for 50 per cent tassel emergence (51 DAS) in maize.

The minimum number of days (80.33 DAS) for tasseling in maize hybrid Hycorn-8288 was noted when foliar application of $ZnSO_4$ (1 %) was given (Tariq *et al.,* 2014).

Least number of days for 50 per cent tasseling (50.33 DAS) was observed when treated with 0.08 per cent foliar application of zinc- chitosan nanoparticles in maize (Choudhary *et al*., 2019).

2.2.5 Days to 50 per cent silking

As reported by Debnath (2014) soil application of $ZnSO_4$ (25 kg ha^{-1}) and two foliar sprays of $ZnSO_4$ (2 %) noted early silk emergence (57 DAS).

Least number of days for 50 per cent silking (51.67) was seen when zinc-chitosan nanoparticles (0.12 %) was treated as foliar application in maize (Choudhary *et al*., 2019).

2.3 EFFECT OF BORON ON DRY MATTER PRODUCTION

Kanwal *et al*. (2008) showed that $CaCl_2$ (2 mM) and borax (25 µM) as foliar spray increased the dry matter content (3.25 g plant^{-1}) in hybrid maize.

Parasuraman (2008) studied the influence of interaction of nutrient requirement in hybrid maize and observed that total dry matter content (126.7 g plant^{-1}) increased when treated with recommended NPK (135: 62.5: 50) coupled with foliar feeding of DAP (1 %), MOP (1 %), $ZnSO_4$,(0.5 %), boron (0.2 %) and $FeSO_4$ (1 %) twice at knee height and tasseling stage.

Kunjir *et al.* (2009) tested the performance of sweet corn cultivar Sumadhur and indicated that spraying of micronutrient mixture (Fe- 2 %, Mn- 2 %, Zn- 2 %, Cu- 0.5 % and B- 0.5 %) increased dry matter accumulation (76.24 g plant^{-1}).

A pre-plant soil incorporated borax (3 kg ha^{-1}) had greater effect on corn growth and average dry matter accumulation (Palta and Karadavut, 2011).

Foliar feeding of 0.5 per cent boric acid at early, mid and late whorl stages recorded the maximum dry fodder yield (18 t ha^{-1}) in maize (Soomro *et al*., 2011).

Maximum dry matter in maize (23.83 g pot^{-1}) was accumulated when borax (5 ppm) was added to soil in a pot culture experiment (Celik *et al*., 2019).

2.4 EFFECT OF ZINC ON DRY MATTER PRODUCTION

Maize treated with zinc had positive effects on dry matter production due to increase in leaf chlorophyll content (Sharafi *et al*., 2002).

Naidu and Venkateswarlu (2006) revealed that high dry matter accumulation was observed with 100 per cent recommended dose of nitrogen + azotobacter + 0.5 per cent $ZnSO_4$ foliar spray at 30 DAS.

Application of 10 ppm of $ZnSO_4$ to soil accumulated highest dry matter (3.83 g pot^{-1}) in maize (Adiloglu and Adiloglu, 2006).

Kanwal *et al.* (2009) noted that maize genotype (FHY-421) had the maximum shoot dry weight (5.61 g pot^{-1}) when zinc (9 ppm) application as foliar spray was given.

Ashoka *et al.* (2008) studied that RDF, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (35 kg ha^{-1}) in combination increased the total dry matter accumulation (300 g $plant^{-1}$) in baby corn.

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1 %) during the peak vegetative growth in maize increased the dry matter production (409.95 g $plant^{-1}$).

When maize was treated with foliar application of zinc (1%), the total dry matter per plant (5.23 g) was recorded the highest at 50 DAS (Deswal and Pandurangam, 2018).

Application of recommended dose of fertilizer, foliar spray of $ZnSO_4$ (0.5 %) and $FeSO_4$ (0.2 %) at booting and silking stage improved the dry matter production (11 t ha^{-1}) in sweet corn (Karrimi *et al*., 2018).

Amutham *et al.* (2019) concluded that baby corn treated with $ZnSO_4$ (37.5 kg ha^{-1}) in soil and foliar application of zinc (0.5 %) at 20 and 40 DAS had resulted in high dry matter production (12 t ha^{-1}).

2.5 EFFECT OF BORON ON YIELD CHARACTERS

2.5.1 Number of cobs per plant

Maximum number of cobs per plant (1.53) was recorded when soil application of boron (3 kg ha^{-1}) was given (Anjum *et al.*, 2017).

Latkar *et al.* (2017) showed that soil test based fertilizer application of NPK, Cu (3 kg ha^{-1}), Zn (6.25 kg ha^{-1}) and B (1.25kg ha^{-1}) had higher number of cobs per hectare (77323).

2.5.2 Cob length

In an experiment conducted by Sujatha (2005) highest cob length (19.2 cm) was observed when boron (2 kg ha^{-1}) was given as soil application along with recommended dose of fertilizers.

Parasuraman (2008) studied that cob length (13.5 cm) was highest in maize treated with recommended NPK (135: 62.5: 50 kg ha^{-1}) coupled with foliar feeding of DAP (1 %), MOP (1 %), $ZnSO_4$, (0.5 %), boron (0.2 %) and $FeSO_4$ (1 %) twice at knee height and tasseling stage.

Kunjir *et al.* (2009) indicated that spraying of micronutrient mixture (Fe- 2%, Mn- 2%, Zn- 2%, Cu- 0.5% and B- 0.5%) recorded higher cob length (13.9 cm) in sweet corn.

Tahir *et al*. (2012) reported that foliar spray of boron (0.30 kg ha^{-1}) at 20 DAS in maize increased the cob length (1.53 cm).

According to Jakati (2014) cob length (16.6 cm) increased when zinc (0.2 %), boron (0.1%) and iron (0.1 %) were given as foliar spray in sweet corn.

Singh *et al.* (2017) reported that combined application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) to soil resulted in long cobs (33 cm) in maize.

According to Anjum *et al.* (2017) maize treated with foliar application of Zn (1 %) and B (0.5 %) resulted in higher cob length (22.6 cm).

The highest cob length (17.68 cm) was observed when foliar application of boron (0.6 kg ha^{-1}) was given to maize (Shabbir *et al*., 2017).

Kumar and Dawson (2019) reported that soil treated with $ZnSO_4$ (15 kg ha^{-1}) borax (0.5 %) as foliar spray at 30 DAS increased the cob length (25.81 cm) in sweet corn.

2.5.3 Cob girth

Parasuraman (2008) noted maximum cob girth (12.8 cm) in maize hybrid treated with NPK (135: 62.5: 50 kg ha^{-1}) coupled with foliar feeding of DAP (1 %), MOP (1 %), $ZnSO_4$ (0.5 %), boron (0.2 %) and $FeSO_4$ (1 %) twice at knee height and tasseling stage.

Higher cob girth (4.1 cm) was recorded when foliar treatment of Zn (0.2 %), boron (0.1 %) and iron (0.1 %) was given in sweet corn (Jakati 2014).

Shabbir *et al.* (2017) observed that cob diameter (6.69 cm) was high when boron @ 0.6 kg ha^{-1} was applied in maize.

Hassan *et al.* (2019) in an experiment reported that foliar application of borax (69 ppm) had given the maximum cob girth (4.51 cm).

Konuskan *et al.* (2019) measured high cob girth (4.3 cm) in hybrid maize when treated with foliar application of boron (6 mg m^{-2}) at four leaf stage.

2.5.4 Number of kernel rows per cob

As reported by Ghaffari *et al.* (2011) application of basal dose of recommended fertilizers (200: 120: 125 kg N P_2O_5 K_2O ha^{-1}) and a single spray of multi nutrient mixture (Zn-2 %, Fe-1 %, B-1 %, Mn-1 %, Cu- 0.2 %,) increased the kernel rows per cob (17) in maize.

Tahir *et al.* (2012) reported that foliar application of boron (0.30 kg ha^{-1}) at 20 DAS in maize had increased the number of kernel rows per cob (15.54).

According to Jakati (2014) kernel rows per cob (14.67) had increased when combined foliar application of Zn (0.2 %) + B (0.1%) + Fe (0.1 %) was given to sweet corn.

2.5.5 Number of kernels per cob

In maize, boron deficiency caused barren ears and blank stalks when boron concentration was below 0.05 ppm (Shorrocks and Blaza, 1973).

Highest number of kernels (545) was observed when boron (2 kg ha^{-1}) and recommended dose of fertilizers was treated in maize (Sujatha 2005).

Ghaffari *et al.* (2011) recorded highest number of kernels per cob (450.6) in maize treated with recommended fertilizers (200:120:125) and a single spray of multi nutrient mixture (Zn-2 %, Fe-1 %, B-1 %, Mn-1 %, Cu- 0.2).

According to Jakati (2014) maximum number of kernels (590.76) was recorded when foliar treatment of Zn (0.2 %) + B (0.1%) + Fe (0.1 %) was given to sweet corn.

Singh *et al.* (2017) observed that combined soil application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) resulted in highest number of kernels per cob (320.7) in maize.

The maximum number of kernels per cob (527.16) was obtained when foliar application of boron (0.6 kg ha^{-1}) was given to maize (Shabbir *et al.*, 2017).

Highest number of kernels per cob (481) was noted when three foliar sprays of 0.5 per cent borax was applied as foliar spray to maize (Sarwar *et al.*, 2018).

2.5.6 Hundred fresh kernel weight

In an experiment conducted by Sujatha (2005) significant effects in hundred seed weight (23.5 g) was observed when treated with boron (2 kg ha^{-1}) as soil application coupled with recommended dose of fertilizers.

Combined soil application of boron (6 kg ha^{-1}) and zinc (16 kg ha^{-1}) significantly improved the thousand grain weight (362 g) in maize (Ziaeyan and Rajaie, 2009).

According to Jakati (2014) high test weight (12.03 g) was noted when combined foliar application of Zn (0.2 %) + B (0.1%) + Fe (0.1 %) was given to sweet corn.

Singh *et al.* (2017) confirmed that application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) to soil resulted in higher 1000 seed weight (322.5 g) in maize.

According to Anjum *et al.* (2017) foliar application of Zn (1 %) and B (0.5 %) gave maximum 1000 grain weight (313.33 g) in maize.

Three foliar sprays of 0.5 per cent borax yielded maximum 1000 grain weight (333.00 g) in maize compared to the control (Sarwar *et al.*, 2018).

Hassan *et al.* (2019) observed that foliar application of borax (69 ppm) had resulted in highest 100 grain weight (34.09 g) in maize.

2.5.7 Cob weight with husk

As reported by Meena *et al.* (2012) significant effects on cob weight with husk (238 g $plant^{-1}$) was noted when B (5 kg ha^{-1}) to soil was given along with 90: 20:25 kg N P_2O_5 K_2O ha^{-1} in maize.

2.5.8 Cob weight without husk

No significant effects were seen on cob weight with husk when boron was treated to maize. However, highest cob weight without husk (60 g plot^{-1}) was recorded when boron (15 kg ha^{-1}) was given as soil application (Salimi *et al.*, 2013).

2.5.9 Total cob yield

Woodruff *et al.* (1987) reported an increase in cob yield when foliar application of boron (2.24 kg ha^{-1}) under high potassium fertilizer was given to maize.

Parasuraman (2008) noted that the highest cob yield (3498 kg ha^{-1}) was obtained in maize treated with NPK (135: 62.5: 50 kg ha^{-1}) coupled with foliar feeding of DAP (1 %), MOP (1 %), $ZnSO_4$ (0.5 %), boron (0.2 %) and $FeSO_4$ (1 %) twice at knee height and tasseling stage.

Soil application of boron (6 kg ha^{-1}) and zinc (16 kg ha^{-1}) significantly improved the cob yield (10083 kg ha^{-1}) in maize (Ziaeyan and Rajaie, 2009).

According to Sekar *et al.* (2009) maize treated with foliar application of boric acid (0.3 %) produced higher cob yield (6 t ha^{-1}).

Tahir *et al.* (2012) observed that foliar treatment of boron (0.30 kg ha^{-1}) at 20 DAS in maize resulted in maximum cob yield (7 t ha^{-1}).

In an experiment conducted by Kaur and Nelson (2015) maize hybrids treated with foliar application of boron (2.24 kg ha^{-1}) at six leaf stage increased the cob yield (1196 kg ha^{-1}).

Singh *et al.* (2017) concluded that combined soil application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) resulted in highest cob yield (28 q ha^{-1}) in maize.

When boron (1 kg ha^{-1}) was applied to soil, maximum cob yield (8 t ha^{-1}) was recorded in maize (Jegadeeswari and Muthumanickam, 2017).

Latkar *et al.* (2017) observed that soil test based fertilizer application of NPK, Cu (3 kg ha^{-1}), Zn (6.25 kg ha^{-1}), B (1.25 kg ha^{-1}) improved cob yield (2 t ha^{-1}) in sweet corn.

According to Kumar *et al*. (2018) combined application of borax at 1.0 kg ha^{-1} to soil and two foliar application of borax (0.2 %) showed significant high grain yield in maize.

Hassan *et al.* (2019) concluded that foliar application of borax (69 ppm) in maize resulted in highest cob yield (2741 kg ha^{-1}).

2.5.10 Green stover yield

Sakal *et al.* (1989) noticed maximum green stover yield in maize when borax (15 kg ha^{-1}) was applied in a boron deficient sandy loam calcareous soil in Bihar.

Gandahi *et al.* (2008) revealed that foliar application of zinc (3 %) at early, middle and late vegetative stage increased the green stover yield (10 t ha^{-1}) in fodder maize.

Combined soil application of boron (6 kg ha^{-1}) and zinc (16 kg ha^{-1}) significantly improved the green stover yield (16778 kg ha^{-1}) in maize (Ziaeyan and Rajaie, 2009).

When boron (1 kg ha^{-1}) was applied to soil, maximum stover yield (7 t ha^{-1}) was recorded in maize (Jegadeeswari and Muthumanickam, 2017).

Latkar *et al.* (2017) in sweet corn (Sugar 75) noted that soil test based fertilizer application of NPK, Cu (3 kg ha^{-1}), Zn (6.25 kg ha^{-1}), B (1.25 kg ha^{-1}) had given the maximum green stover yield (4 t ha^{-1}).

Hassan *et al.* (2019) observed that foliar application of borax (69 ppm) had resulted in highest green stover yield (2576 kg ha^{-1}).

2.6 EFFECT OF ZINC ON YIELD CHARACTERS

2.6.1 Number of cobs per plant

Kumar and Bohra (2014) at Varanasi reported that soil application of $ZnSO_4$ (10 kg ha^{-1}) recorded maximum number of cobs per plant (2.4) in baby corn.

2.6.2 Cob length

Kumar *et al.* (2008) observed that application of RDF (150: 75: 40 kg N, P_2O_5, K_2O ha^{-1}), $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (25 q ha^{-1}) increased the cob length (7.0 cm) in sweet corn.

Shivay and Prasad (2014) noted that application of $ZnSO_4$ (5 kg ha^{-1}) to soil and foliar application of $ZnSO_4$ (1 kg ha^{-1}) resulted in longer cobs (15.2 cm) in maize.

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1%) at vegetative growth stage gave the highest cob length (20.1 cm).

2.6.3 Cob girth

An experiment conducted by Ashoka *et al*. (2008) in baby corn reported that application of recommended dose of fertilizer, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (35 kg ha^{-1}) to soil increased the cob girth (4.99 cm).

Kumar *et al.* (2008) concluded that combined application of RDF (150 : 75 : 40 kg N, P_2O_5, K_2O ha^{-1}), $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (25 q ha^{-1}) resulted in higher cob diameter (4.99 cm) in sweet corn.

Maize treated with soil application of 250: 60: 25: 10 kg NPKZn ha^{-1} increased the cob girth (Paramasivan *et al*., 2011).

Highest cob diameter (3.73 cm) was observed when soil (5 kg ha^{-1}) and foliar application of $ZnSO_4$ (1 kg ha^{-1}) was treated in maize (Shivay and Prasad, 2014).

An experiment conducted by Kumar and Bohra (2014) reported that soil application of $ZnSO_4$ (10 kg ha^{-1}) resulted in maximum cob girth (3.7 cm) in baby corn.

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1%) during the peak vegetative growth stage of the maize crop recorded the highest cob length (20.1 cm).

2.6.4 Number of kernel rows per cob

Channakeshava *et al.* (2007) conducted a field experiment in African tall fodder maize and reported that application of $ZnSO_4$ (10 kg ha^{-1}) to soil had yielded highest number of kernel rows per cob.

Highest kernel rows per cob (15.04) was recorded when foliar application of $ZnSO_4$ (1.5 kg ha^{-1}) was given to maize (Potarzycki and Grzebisz, 2009).

Foliar application of zinc (0.2 %) at stem and cob elongation stage significantly increased the number of kernel rows per cob (15.9) in maize (Ghazvineh and Yousefi, 2012).

As reported by Debnath (2014), soil application of $ZnSO_4$ (25 kg ha^{-1}) and two foliar sprays of $ZnSO_4$ (2 %) had given higher kernel rows per cob (14.36) in maize.

2.6.5 Number of kernels per cob

Highest kernels per cob (479.5) was noted in maize treated with foliar application of $ZnSO_4$ (Potarzycki and Grzebisz, 2009).

Tariq *et al*. (2014) in an experiment observed that foliar application of $ZnSO_4$ (1 %) gave the maximum number of kernels per cob (506.22) in maize.

Tahir *et al*. (2016) reported that three foliar sprays of 0.5 per cent $ZnSO_4$ to maize had resulted in maximum number of kernels (401.83).

2.6.6 Hundred fresh kernel weight

Giving soil application of $ZnSO_4$ (7.50 kg ha^{-1}) had resulted in maximum 1000 grain weight (295 g) in maize (Preetha and Stalin, 2014).

An experiment conducted by Khasragi and Yarnia (2014) reported that combined soil application of $ZnSO_4$ (25 kg ha^{-1}) as basal and foliar application of $ZnSO_4$ (0.5 %) at six leaf stage and tasseling, had resulted in highest 100 kernel weight (43.91 g) in sweet corn.

Shivay and Prasad (2014) reported that combined soil application of $ZnSO_4$ (5 kg ha^{-1}) and foliar application of $ZnSO_4$ (1 kg ha^{-1}) had resulted in highest hundred grain weight (76.5 g) in maize.

According to El-Azab (2015) maize treated with recommended dose of fertilizers and foliar application of $ZnSO_4$ (2 %) at six leaf stage, recorded the maximum hundred grain weight (14.35 g).

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1 %) during vegetative growth stage of maize crop recorded the maximum thousand grain weight (38.73 g). Similar findings were also reported by Tahir *et al*. (2016) concluding that three foliar sprays of 0.5 per cent $ZnSO_4$ resulted in highest thousand grain weight (294.90 g).

2.6.7 Cob weight with husk

Baby corn treated with recommended dose of fertilizer, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (35 kg ha^{-1}) to soil increased cob weight (Ashoka *et al*, 2008).

Foliar application of zinc (0.2 %) at stem and cob elongation stage significantly increased the cob weight with husk (185.3 g) in maize (Ghazvineh and Yousefi, 2012).

Kumar and Bohra (2014) observed that soil application of $ZnSO_4$ (10 kg ha^{-1}) had increased the cob weight with husk (31.3 g) in baby corn.

El- Azab (2015) noted that maize treated with recommended dose of fertilizers and foliar application of $ZnSO_4$ (2 %) at six leaf stage increased cob weight with husk (363.13 g).

2.6.8 Cob weight without husk

Kumar *et al.* (2008) concluded that combined application of RDF (150 : 75 : 40 kg N, P_2O_5, K_2O ha^{-1}), $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (25 q ha^{-1}) significantly resulted in higher cob weight without husk (17.40 g) in sweet corn.

Significant effects on cob weight without husk (3.69 kg $plant^{-1}$) were seen when zinc- chitosan nanoparticles (0.08 %) were given as foliar application to maize (Choudhary *et al*., 2019).

2.6.9 Total cob yield

Application of RDF (150 : 75 : 40 kg N, P_2O_5, K_2O ha^{-1}), $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (25 q ha^{-1}) resulted in high cob yield (64 q ha^{-1}) in sweet corn (Kumar *et al.*, 2008).

A study conducted by Kumar *et al*. (2010) showed that combination of recommended dose of fertilizers and 4 kg ha^{-1} zinc through pressmud compost recorded the maximum cob yield (7 t ha^{-1}) in maize.

Foliar application of zinc (0.2 %) at stem and cob elongation stage increased the cob yield (10 t ha^{-1}) in maize (Ghazvineh and Yousefi 2012).

Shivay and Prasad (2014) reported that soil application of $ZnSO_4$ (5 kg ha^{-1}) and foliar spray of $ZnSO_4$ (1 kg ha^{-1}) increased the cob yield (5 t ha^{-1}) in maize.

Soil treated with ZnO (10 kg ha^{-1}) increased the cob yield (2 t ha^{-1}) in baby corn (Kumar *et al*., 2015).

According to El-Azab (2015) maize treated with recommended dose of fertilizers and foliar application of $ZnSO_4$ (2 %) at six leaf stage, recorded the highest cob yield (4 t ha^{-1}).

According to Manasa and Devaranavadagi (2015) foliar application of $ZnSO_4$ (1%) during the peak vegetative growth stage of the maize crop resulted in maximum cob yield (90 q ha^{-1}). Similar conclusions were also made by Tahir *et al*. (2016) that three foliar sprays of 0.5 per cent $ZnSO_4$ to maize recorded the maximum cob yield (6 t ha^{-1}).

Highest fresh cob yield (319 q ha^{-1}) was noted when combined application of $ZnSO_4$ and $FeSO_4$ @10 kg ha^{-1} each to soil and foliar application of $ZnSO_4$ and $FeSO_4$ @ one per cent each at 20 and 40 DAS in sweet corn (Arabhanvi and Hulihalli, 2017).

Application of RDF and foliar application of $ZnSO_4$ (0.5 %) and $FeSO_4$ (0.2 %) at booting and silking stage improved the cob yield (5 t ha^{-1}) in sweet corn (Karrimi *et al.*, 2018).

Amutham *et al.* (2019) concluded that combined application of $ZnSO_4$ (37.5 kg ha^{-1}) to soil and foliar application of zinc (0.5 %) at 20 and 40 DAS had recorded the highest green cob yield (8 t ha^{-1}) in baby corn.

2.6.10 Green stover yield

Kumar *et al.* (2008) concluded that combined application of RDF (150 : 75 : 40 kg N, P_2O_5, K_2O ha^{-1}), $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (10 kg ha^{-1}) and vermicompost (25 q ha^{-1}) significantly resulted in higher green stover yield (232 q ha^{-1}) in sweet corn.

A study conducted by Kumar *et al*. (2010) reported that combination of recommended dose of fertilizers and zinc (4 kg ha^{-1}) through pressmud compost had resulted in highest green stover yield (5.6 t ha^{-1}) in maize.

Preetha and Stalin (2014) concluded that giving soil application of $ZnSO_4$ (7.50 kg ha^{-1}) to maize gave the highest stover yield (12 t ha^{-1}).

When ZnO (10 kg ha^{-1}) was given as soil application, green stover yield (31 t ha^{-1}) was maximum in baby corn (Kumar *et al*., 2015).

Highest green stover yield (624 q ha^{-1}) was accumulated when soil application of $ZnSO_4$ and $FeSO_4$ @ 10 kg ha^{-1} each and foliar spray of $ZnSO_4$ and $FeSO_4$ at one per cent each at 20 and 40 DAS in sweet corn (Arabhanvi and Hulihalli, 2017).

Maximum green fodder yield (28 t ha^{-1}) in baby corn was accumulated when soil application of $ZnSO_4$ (25 kg ha^{-1}) and foliar application of $ZnSO_4$ (0.2 %) at 25 and 40 DAS was given to the crop (Chand *et al*., 2017).

Application of RDF and foliar application of $ZnSO_4$ (0.5 %) and $FeSO_4$ (0.2 %) at booting and silking stage increased the green stover yield (20 t ha^{-1}) in sweet corn (Karrimi *et al*., 2018).

Amutham *et al.* (2019) concluded that combined application of $ZnSO_4$ (37.5 kg ha^{-1}) to soil and foliar application of zinc (0.5 %) at 20 and 40 DAS had recorded the highest green stover yield (30 t ha^{-1}) in baby corn.

2.7 EFFECT OF BORON AND ZINC ON SOIL NUTRIENT PARAMETERS

At heavy applications of K and other intensive production practices, higher concentration of boron is needed to optimize corn yield (Woodruff *et al*., 1987).

High nitrogen content in soil reduces the boron availability in crops (Gupta, 1983).

Adiloglu and Adiloglu (2006) suggested that addition of boron @ 7.7 kg ha^{-1} is required to alleviate the boron deficiency in soil.

Application of recommended dose of fertilizers and zinc increased the zinc concentration in soil by 4.94 per cent at the time of harvest in maize (Gayatri and Mathur, 2007).

Boron content in the soil increased from 0.06 to 0.20 mg dm^{-3} when soil application of 2.4 kg per hectare borax was applied (Santos *et al*., 2016).

Application of borax (2 kg ha^{-1}) significantly increased the boron content (1.038 ppm) in soil (Jegadeeswari and Muthumanickam, 2017).

When gypsum (200 kg ha^{-1}) and borax (5 kg ha^{-1}) was given as soil application, the available soil boron content (4.85 ppm) was high (Arunkumar *et al*., 2017).

2.8 EFFECT OF ZINC AND BORON ON PLANT ANALYSIS

2.8.1 Chlorophyll content

The highest chlorophyll content in maize leaf was estimated when combined application of B (0.5 kg ha^{-1}) and Zn (5.0 kg ha^{-1}) was given to soil (Panhwar *et al*., 2011).

According to Chaab *et al.* (2011) the SPAD chlorophyll value (50.9) in maize leaf at 60 DAS was maximum when treated with soil application of $ZnSO_4$ (10 mg kg^{-1}) in a pot culture experiment.

The total chlorophyll content (0.683 mg g^{-1}) in sweet corn leaf increased when $ZnSO_4$ (1 mg L^{-1}) and $MnSO_4$ (0.1 mg L^{-1}) was given as foliar spray (Soltangheisi *et al*., 2014).

Amutham *et al.* (2019) observed that baby corn treated with $ZnSO_4$ (37.5 kg ha^{-1}) and foliar application of zinc (0.5 %) at 20 and 40 DAS recorded high SPAD value (53.56).

2.9 EFFECT OF ZINC AND BORON ON QUALITY PARAMETERS

2.9.1 Ascorbic acid content

In a pot experiment by Chatterjee *et al.* (1987) high ascorbic acid (0.64 mg g^{-1}) content was estimated in maize leaf when Ca (4 m*M*) and B (0.1 µ*M*) was given as foliar spray.

Pandey *et al*. (2002) estimated high ascorbate content (24.2 mmol mg^{-1}) in maize leaf when foliar spray of zinc (0.1 µ*M*) was given.

2.9.2 Moisture content

Soil treated with $ZnSO_4$ (25 kg ha^{-1}) and two foliar sprays of $ZnSO_4$ (2 %) increased the moisture content (74 %) in maize kernel (Debnath, 2014).

Wasaya *et al.* (2017) showed that foliar application of zinc (1 %) and boron (0.01 %) at five leaf and tasseling stage improved the relative leaf water content (38.93 %) in maize.

2.10 EFFECT OF ZINC AND BORON ON PEST AND DISEASE INCIDENCE

Soil application of boron (0.5 kg ha^{-1}), nitrogen (100 kg ha^{-1}) and zinc (1.0 kg ha^{-1}) reduced fungal mycotoxin production in corn ear (Hassegawa *et al.*, 2008).

Boron application reduced the infection of pathogens by improving cell wall and membrane strength and hence, strengthening the plant’s vascular bundles (Liew *et al*., 2012).

Foliar treatment of boron (2.24 kg ha^{-1}) at six leaf stage decreased the severity of grey leaf spot and leaf blight in maize (Kaur and Nelson, 2015).

2.11 EFFECT OF ZINC AND BORON ON ECONOMICS

Tahir *et al*. (2016) noted that three foliar sprays of 0.5 per cent $ZnSO_4$ resulted in high net returns (₹ 71,742 ha^{-1}) in maize.

Singh *et al*. (2017) observed that maize treated with soil application of zinc (10 kg ha^{-1}) and boron (10 kg ha^{-1}) gave highest B:C ratio (2.09).

Highest gross income (₹ 2,37,917 ha^{-1}), net return (₹ 1,39,846 ha^{-1}) and BCR (2.42) was calculated when foliar application of zinc (1 %) and boron (0.5 %) was applied in maize (Anjum *et al.*, 2017).

Latkar *et al.* (2017) concluded that soil test based fertilizer application of NPK, Cu (3 kg ha^{-1}), Zn (6.25 kg ha^{-1}) and B (1.25 kg ha^{-1}) had given the highest B: C ratio (2.31) in sweet corn.

Combined application of $ZnSO_4$ (15 kg ha^{-1}) and foliar application of Borax (0.5 %) at 30 DAS increased gross return (₹ 1,27,956 ha^{-1}), net returns (₹ 71,508 ha^{-1}) and B:C ratio (1.26) in sweet corn (Kumar and Dawson, 2019).

MATERIAL AND METHODS

3. MATERIAL AND METHODS

An experiment entitled "Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality" was carried out at College of Agriculture, Padannakkad and at Regional Agricultural Research Station (RARS), Pilicode from the month September 2019 to January 2020. The objective of the experiment was to evaluate the performance of sweet corn hybrids for yield and quality and study the role of zinc and boron in increasing the productivity. The experimental site, weather conditions, materials used and methods adopted for the experiment is presented in this chapter.

3.1 EXPERIMENTAL SITE

3.1.1 Location

The experimental field was located at Regional Agricultural Research Station (RARS), Pilicode. The geographical coordinates of the field is 12˚ 12'086" N to 12˚ 12'097" N latitude and 75˚ 09'879" E to 75˚ 09'898" E longitude and an altitude of 19 m above mean sea level.

3.1.2 Soil

Soil samples were collected from a depth of 15 cm from the experimental site before the experiment and was analysed for their pH, EC, organic carbon, P, K and B in available form. The standard procedures followed for their analysis are given in Table 1. The soil was moderately acidic with pH (5.30) and organic carbon content was in medium range (0.6 per cent). The available P (145.60 kg ha^{-1}) content in the initial soil sample was found to be high and was medium with regard to available K (245.61 kg ha^{-1}). The boron content (0.1 mg kg^{-1}) of the initial soil sample was found to be low.

Table 1. Analytical procedures for soil analysis and its content

Chemical properties		
Particulars	**Content**	**Method used**
pH	5.3	1:2.5 soil water suspension – pH meter (Jackson, 1958)
EC (dS m^{-1})	0.3	Conductivity meter (Jackson, 1958)
Organic carbon (%)	0.60	Wet digestion method (Walkley and Black, 1934)
Available P (kg ha^{-1})	145.60	Bray extraction and photoelectric colorimetry (Jackson, 1958)
Available K (kg ha^{-1})	245.616	Neutral normal ammonium acetate extractant flame photometry (Jackson, 1958)
Available B (mg kg^{-1})	0.1	Azomethine- H colorimetric method (Bingham, 1983)

3.1.3 Season and weather condition

The experiment was conducted from September 2019 to January 2020. A cool humid tropical climate prevailed over the experimental location. The data on various weather parameters (maximum temperature, minimum temperature, relative humidity, rainfall and sunshine hours) were collected during the entire crop period from the agromet observatory of RARS, Pilicode and is graphically represented in Fig 1. and summarized in Appendix I.

The maximum and minimum temperature varied from 27.47˚C to 32.69˚C and 20.96˚C to 24.26˚C. The relative humidity during the crop period was in the range of 62.71 to 88 per cent. The rainfall received during the field experiment extending from September 2019 to January 2020 was 106 mm.

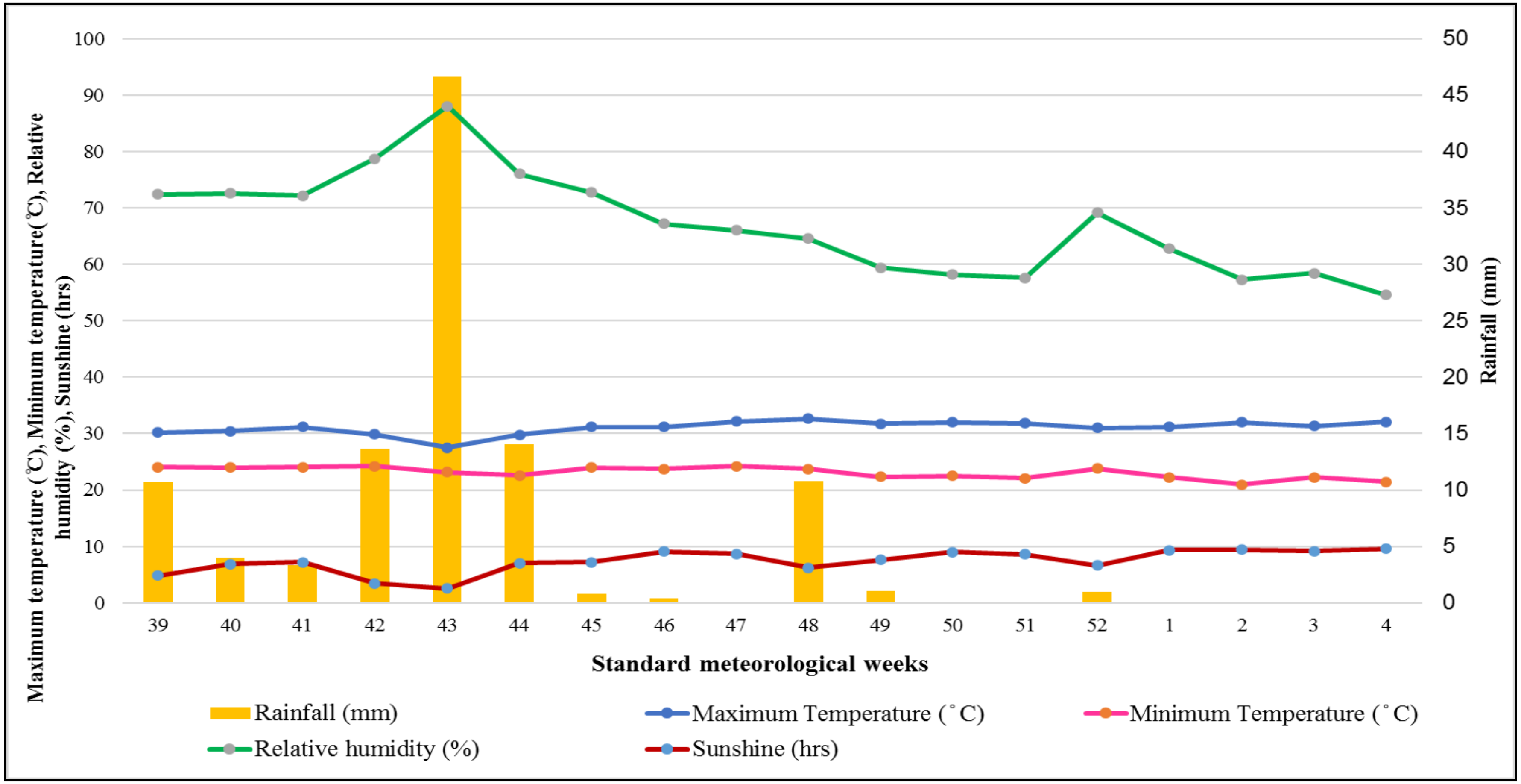


Fig. 1. Weather parameters during the crop season in standard weeks

3.2 CROP AND VARIETY

Sweet corn hybrids Sugar 75, KSCH 333 and Misthi were taken as test crop and their important features are given in Table 2.

Table 2. General characters of hybrids

	Sugar 75	**KSCH 333**	**Misthi**
Maturity	78-85 days	80-90 days	75-80 days
Colour	Yellow	Yellowish white	Creamy yellow
Sugar (%)	15-16	16	16-17
Released by	Syngenta	Kaveri seeds	Nuziveedu seeds

3.3 DETAILS OF THE EXPERIMENT

3.3.1 Design and layout

The experiment was laid out in Factorial randomized block design with 12 treatments replicated thrice. The plot size was 5 m X 3 m. The layout of the experiment is presented in Fig. 2. and details of experiment are given below.

Fig. 2. Layout of the experimental field

N

5 m

3m

R_1	R_2	R_3
H_1M_1	H_3M_2	H_2M_1
H_3M_4	H_1M_3	H_2M_4
H_1M_2	H_2M_2	H_3M_1
H_3M_3	H_1M_4	H_1M_1
H_2M_3	H_1M_2	H_2M_2
H_3M_2	H_2M_4	H_1M_4
H_3M_1	H_1M_1	H_2M_3
H_2M_1	H_3M_4	H_3M_2
H_1M_4	H_3M_3	H_1M_2
H_2M_2	H_2M_3	H_1M_3
H_2M_4	H_3M_1	H_3M_4
H_1M_3	H_2M_1	H_3M_3

3.3.2 Treatments

Factor I- Sweet corn Hybrids - 3

H_1 - Sugar 75

H_2 – KSCH 333 / Candy 333

H_3 – Misthi

Factor II -Micronutrient levels – 4

M_1 - RDN of Maize as per POP + No spray as control

M_2 - RDN of Maize as per POP + Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking

M_3 - RDN of Maize as per POP + Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing

M_4 - RDN of Maize as per POP + Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking + Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing

The nutrient management practices adopted for maize as per the Package of Practices Recommendations 'Crops' (KAU, 2016) *i.e.,* 25 t FYM ha^{-1} + 135:65:15 kg N P_2O_5 K_2O ha^{-1}. Lime was applied based on the soil test results at the time of land preparation to all plots. Boron and zinc were applied as per the treatments.

3.4 CROP HUSBANDARY

3.4.1 Field preparation

The experimental field was cleared from weeds three weeks before sowing. It was followed by ploughing twice using rotovator and the weeds were uprooted and removed. The experimental area was levelled and the field was laid out into experimental plots as per the layout plan (Fig 2.). Ridges and furrows were formed at a spacing of 60 cm between two ridges.

3.4.2 Seeds and sowing

Sweet corn seeds were dibbled as per the treatment @ 2 seeds per hill on the ridges at spacing of 25 cm followed by irrigation. Gap filling was done at 7 DAS to maintain uniform plant population.

3.4.3 Application of organic and inorganic fertilizers

After ten days of lime application @ 346 kg ha^{-1}, well decomposed Farm yard manure was applied and incorporated uniformly to all the plots. Fertilizers like urea, rajphos and muriate of potash were applied to all the plots as per the recommendation for maize given in Package of Practices Recommendations 'Crops' (KAU, 2016). The entire quantity of phosphorus and half the recommended doses of nitrogen and potassium were applied as top dressing at 20 DAS and the remaining quantity of nitrogen and potassium was given at 40 DAS. Foliar application of boron and zinc was given as per the treatment details in the technical programme.

3.4.4 Maintenance of the crop

Hand weeding was done at weekly intervals so as to maintain the plots weed free up to 75 DAS. First irrigation was given immediately after sowing. Subsequent irrigations were given at weekly intervals till cob maturity.

3.4.5 Plant protection measures

The major pest noticed during the crop period was fall army worm. Timely application of flubendiamide was given at 0.01 per cent uniformly to all plots to control the pest.

3.4.6 Harvesting

Mature sweet corn cobs were harvested from each plot at milking stage after 79 DAS. The cobs harvested were weighed and observations on yield parameters were taken. The green stover was harvested after the final harvest of cobs, weighed and was recorded.

Plate 1. Field preparation and layout

Plate 2. General view of field at 20 DAS

Plate 3. General view of field at 45 DAS

Plate 4. Foliar application of zinc

Plate 5. Tassel emergence

Plate 6. Silk emergence

Plate 7. Foliar application of boron

Plate 8. Cob formation

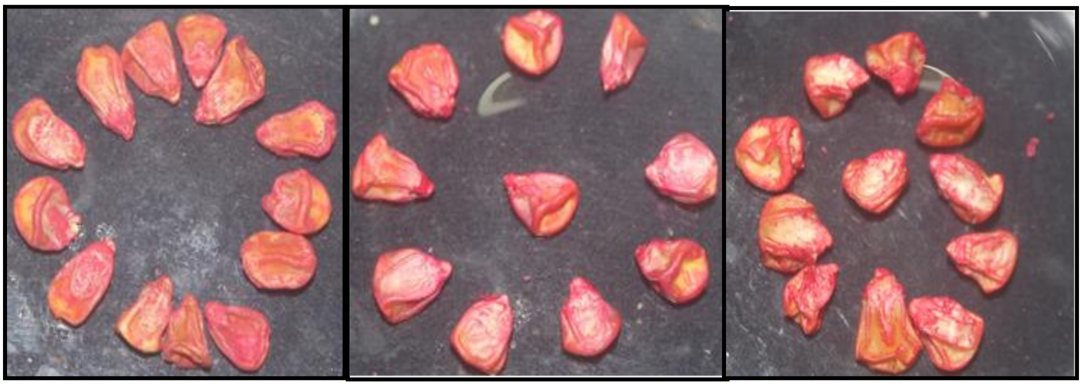
Plate 9. Harvesting of cobs

Plate 10. Harvested cob

Plate 11. General view of field at 70 DAS

Plate 12. Attack of fall armyworm

Plate 13. General view of field at harvest



Sugar 75 **KSCH 333** **Misthi**

Plate 14. Seeds of sweet corn hybrids used in study

Plate 15. Dehusked cobs – Sugar 75

Plate 16. Dehusked cobs- KSCH 333

Plate 17. Dehusked cobs- Misthi

3.5 OBSERVATIONS

3.5.1 Biometric characters

The biometric characters recorded were plant height, number of leaves, leaf area, days to 50 per cent tasseling, days to 50 per cent silking, days to maturity, number of harvests and dry matter production. The observations were taken from six randomly selected plants from each plot which were tagged.

3.5.1.1 Plant height (cm)

The plant height was measured from the base of the stem at ground level to the tip of the longest leaf at 15, 30, 45 and 70 DAS and the mean value was computed and expressed in cm.

3.5.1.2 Number of leaves

The total number of fully opened and photosynthetically active leaves was counted from base to apex at 15, 30, 45 and 70 DAS for tagged plants and the mean number of leaves per plant was computed.

3.5.1.3 Leaf area (m^2)

Leaf area was computed by measuring the maximum length and breadth of the fully opened leaf from the top at 15, 30, 45 and 70 DAS. The leaf area was worked out using the formula below and expressed in m^2 (Balakrishnan *et al*., 1987).

Leaf area = Length X Breadth X 0.75

3.5.1.4 Days to 50 per cent tasseling

Tassels are the male reproductive part in a maize plant. They emerge first. The number of days taken for fifty per cent of the plant population to tassel from the date of sowing in each net plot was recorded as days to fifty per cent tasseling.

3.5.1.5 Days to 50 per cent silking

Female inflorescence in maize is the cob formed on leaf axils. Silk is the thread like clusters formed on top of the cob, which is nothing but style developing from each female flowers. Silking occurs immediately after tasseling. The number of days taken by fifty per cent of the plants in each net plot to reach silking stage was recorded.

3.5.1.6 Days to maturity

Matured cob can be harvested during the milk stage. The number of days taken by the sample plants to reach harvestable maturity was recorded for each plot.

3.5.1.7 Number of harvests

The total number of harvest of cobs from each plot was noted.

3.5.1.8 Dry matter production (kg ha^{-1})

The sample plants from each plot were cut very close to the ground level at the time of harvest and fresh weight was recorded. The plants were shade dried and were then oven dried in hot air oven at 60°C till constant weight was obtained. The weight of the biomass produced was recorded and expressed in kg ha^{-1}.

3.5.2 Yield attributes

3.5.2.1 Number of cobs per plant

The total number of cobs harvested from the sample plants was recorded and their mean was worked out.

3.5.2.2 Cob length (cm)

The length of dehusked cob from the tagged plants was measured from base to tip and the mean cob length was calculated and expressed in centimetres.

3.5.2.3 Cob girth (cm)

The maximum girth of the cobs from the selected cobs was measured and the mean cob girth was calculated and expressed in centimetres.

3.5.2.4 Number of kernel rows per cob

Six cobs were taken from each plot for recording the number of kernel rows per cob. Number of rows in each cob was counted and the average number of rows was recorded.

3.5.2.5 Number of kernels per cob

Total number of kernels per cob was calculated for six cobs from each plot and the mean value was taken and recorded as the number of kernels per cob.

3.5.2.6 Hundred fresh kernel weight (g)

Hundred kernel weight of the selected cobs from each plot were recorded and their mean was expressed in grams.

3.5.2.7 Cob weight with husk (g plant $^{-1}$)

The total cob weight of the unhusked cobs harvested from the labelled plants was recorded for each plot and the mean weight was expressed in gram per plant.

3.5.2.8 Cob weight without husk (g plant $^{-1}$)

The total cob weight of the dehusked cobs harvested from the labelled plants was recorded for each plot and the mean weight was expressed in gram per plant.

3.5.2.9 Total cob yield (kg ha $^{-1}$)

Total cob yield was obtained by addition of yield after harvest from each plot and expressed in kg ha^{-1}.

3.5.2.10 Green stover yield (kg ha^{-1})

After the final harvest of the cobs, the plants of each net plot were cut close to the ground, weighed and the weight was expressed in kg ha^{-1}.

3.5.3 Soil analysis

Soil samples were collected before the experiment and after the harvest of the crop from each plot.

3.5.3.1 Soil analysis before the experiment

Soil samples were taken from different places of field, mixed together, reduced to required quantity and air dried. The air dried soil samples were ground, passed through 2 mm sieve and was analysed for pH, EC, organic carbon, P, K and B in available form.

3.5.3.2 Soil analysis after the experiment

The soil samples were taken from each plot after the experiment. It was then air dried under shade, pounded, sieved and stored for the analysis. Organic carbon and available boron were analysed as per the standard procedures (Table. 1).

3.5.4 Plant analysis

3.5.4.1 Chlorophyll content at 50 per cent tasseling (mg g^{-1})

Total chlorophyll content was estimated from fresh index leaf samples at fifty per cent tasseling by the method given by Hiscox and Israelstam (1979). The chlorophyll content was expressed in mg g^{-1} on fresh weight basis.

3.5.5 Quality aspects of kernel

3.5.5.1 Ascorbic acid content (mg $100g^{-1}$)

Estimation of ascorbic acid in sweet corn was determined using 2, 6-dichlorophenol indophenol dye. Sweet corn kernels were extracted by blending with 4 per cent oxalic acid and then made up to 100 ml and centrifuged. After extraction, 10 ml of the supernatant was pipetted into a conical flask and 10 ml of 4 per cent oxalic acid was added to it. Then titration was carried out against the standard dye till a temporary pale pink colour was obtained (Sadasivam and Manickam, 1996). Using the given formula, the vitamin C content of the kernels were calculated and expressed as mg $100g^{-1}$ on fresh weight basis.

$$\text{Ascorbic acid content} = \frac{\text{Titre value X 0.5 X 100 X 100}}{\text{Working standard titre value X 5 X weight of sample}}$$

3.5.5.2 Moisture content (%)

Known weight of fresh kernels was taken and dried in oven at 65°C till constant weight was achieved. Computing the weight of kernels before and after oven drying, moisture percentage in the kernels was calculated and expressed in per cent.

$$\text{Moisture content (\%)} = \frac{\text{(Weight of fresh kernels (g)- weight of oven dry kernels(g)) X 100}}{\text{Weight of fresh kernels (g)}}$$

3.5.6 Economic analysis

3.5.6.1 Net returns

The cost of cultivation was calculated using the price of each input such as seed, fertilizer, labour etc. in rupees at the time of experimentation. The cost of cultivation is estimated for one hectare. Gross returns per hectare was calculated based on the market price of sweet corn. While calculating the gross returns, marketable yield is considered instead of total yield. The net returns were calculated by subtracting cost of cultivation from gross returns.

3.5.6.2 Benefit – cost ratio (BCR)

It is the ratio of gross returns to cost of cultivation. It was calculated using the formula

$$\text{BCR} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3.6 STATISTICAL ANALYSIS

The data from the experiment was statistically analysed by following the techniques of Analysis of Variance (ANOVA) for factorial Randomized Block Design (Panse and Sukhatme, 1995). This was then used for comparison and interpretation of the results obtained.

RESULTS

4. RESULTS

A field experiment was conducted at Regional Agricultural Research Station, Pilicode to find out the best maize hybrid and foliar micronutrient application which is suitable and can be grown under the climatic conditions prevailing in Kerala. Assessment of biometric characters, yield attributes, soil nutrient status, plant analysis and the quality aspects of kernels were made, statistically analysed and their results are presented in this chapter.

4.1 GROWTH CHARACTERS

The growth characters such as plant height, number of leaves and leaf area were recorded at 15, 30, 45 and 70 DAS. Other biometric characters such as days to 50 per cent tasselling, days to 50 per cent silking, days to maturity at their respective growth stages, number of harvests and the dry matter production was recorded at the time of harvest.

4.1.1 Plant height (cm)

The plant height at 15, 30, 45 and 70 DAS as influenced by hybrids and foliar application of micronutrients are presented in Table 3.

The plant height showed significant difference only at 15 DAS and not at any other stage of observation. Highest plant height (35.51 cm) was recorded when no micronutrient spray was given and this treatment was on par with combined foliar application of zinc and boron (32.70 cm). The effect of hybrids and the interaction with micronutrient spray was not significant at all stages of observation.

4.1.2 Number of leaves

Observations on the number of leaves were recorded at 15, 30, 45 and 70 DAS and is represented in Table 4.

No significant effects were observed among hybrids, micronutrient application and their interaction on the number of leaves at all stages of observation.

Table 3. Effect of hybrids and micronutrient levels on plant height at 15, 30, 45 and 70 DAS

Treatments	Plant height (cm)			
Hybrids	**15 DAS**	**30 DAS**	**45 DAS**	**70 DAS**
H_1	31.99	88.60	135.13	174.19
H_2	34.74	87.71	129.70	170.08
H_3	32.63	84.96	135.19	184.38
SE(m)	0.83	4.16	4.08	4.99
CD (0.05)	NS	NS	NS	NS
Micronutrient level				
M_1	35.51	92.34	135.56	180.56
M_2	32.65	85.11	139.45	179.74
M_3	31.42	84.25	126.55	170.80
M_4	32.70	86.65	131.79	173.78
SE(m)	0.96	4.80	4.71	5.76
CD (0.05)	2.86	NS	NS	NS
Interaction				
H_1M_1	35.51	95.44	139.28	181.74
H_1M_2	30.19	85.27	142.83	181.49
H_1M_3	28.61	88.88	122.88	170.77
H_1M_4	33.66	84.83	135.51	162.77
H_2M_1	34.94	93.69	136.17	175.94
H_2M_2	34.55	85.36	137.83	174.30
H_2M_3	35.20	79.44	119.16	157.55
H_2M_4	34.27	92.36	125.66	172.55
H_3M_1	36.66	87.91	131.23	184.00
H_3M_2	33.22	84.72	137.69	183.44
H_3M_3	30.47	84.44	137.61	184.08
H_3M_4	30.16	82.77	134.22	186.02
SE(m)	1.67	8.32	8.17	9.98
CD (0.05)	NS	NS	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 4. Effect of hybrids and micronutrient levels on number of leaves at 15, 30, 45 and 70 DAS

Treatments	Number of leaves			
Hybrids	**15 DAS**	**30 DAS**	**45 DAS**	**70 DAS**
H_1	4.52	5.99	6.94	8.40
H_2	4.63	6.23	6.90	8.41
H_3	4.37	6.33	6.63	8.81
SE(m)	0.07	0.21	0.42	0.27
CD (0.05)	NS	NS	NS	NS
Micronutrient level				
M_1	4.70	6.26	7.15	9.13
M_2	4.48	6.16	7.11	8.51
M_3	4.44	6.21	6.41	8.32
M_4	4.42	6.11	6.62	8.19
SE(m)	0.08	0.24	0.49	0.31
CD (0.05)	NS	NS	NS	NS
Interaction				
H_1M_1	4.77	6.38	7.35	9.19
H_1M_2	4.44	5.80	7.86	8.63
H_1M_3	4.22	6.08	6.85	8.19
H_1M_4	4.66	5.69	6.72	7.58
H_2M_1	4.61	5.80	7.40	9.05
H_2M_2	4.55	6.27	7.16	8.36
H_2M_3	4.83	6.33	6.24	7.83
H_2M_4	4.55	6.52	6.82	8.41
H_3M_1	4.72	6.61	6.70	9.16
H_3M_2	4.44	6.41	6.43	8.55
H_3M_3	4.27	6.22	7.15	8.94
H_3M_4	4.05	6.11	6.33	8.58
SE(m)	0.14	0.24	0.85	0.54
CD (0.05)	NS	NS	NS	NS

Note:

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.1.3 Leaf area (m^2)

The influence of hybrids and micronutrient foliar application on leaf area was observed at 15, 30, 45 and 70 DAS and is given in Table 5.

At 15 DAS, highest leaf area (0.59 m^2) was observed in the control plot. At 45 DAS, highest leaf area (5.04 m^2) was recorded in the control plot and was on par with foliar application of zinc. No significant effects of micronutrients were observed at other stages of observation.

Significant differences on leaf area was not observed at all stages of observation among hybrids and their interaction with the micronutrient levels.

4.1.4 Days to 50 per cent tasseling

The number of days taken for fifty per cent tasseling was recorded for each plot and was statistically analysed and is presented in Table 6.

The number of days to 50 per cent tasseling was significantly influenced in the control plot. The least number of days to 50 per cent tasseling (54.66) was recorded in the control plot.

Hybrids and their interaction with micronutrient levels did not significantly influence the days to 50 per cent tasseling.

4.1.5 Days to 50 per cent silking

Observation on the number of days taken for 50 per cent silking was taken, statistically analysed and is given in Table 6.

The days taken for 50 per cent silking was significantly influenced in the control plot. Least number of days (58.11) taken to reach 50 per cent silking was recorded in the control plot.

Hybrids and their interaction with micronutrient levels did not significantly influence the days to 50 per cent silking.

Table 5. Effect of hybrids and micronutrient levels on leaf area at 15, 30, 45 and 70 DAS

Treatments	Leaf area (m^2)			
Hybrids	**15 DAS**	**30 DAS**	**45 DAS**	**70 DAS**
H_1	0.49	2.83	4.61	4.75
H_2	0.54	2.95	4.75	4.89
H_3	0.49	2.83	4.85	4.90
SE(m)	0.02	0.25	0.10	0.10
CD (0.05)	NS	NS	NS	NS
Micronutrient level				
M_1	0.59	3.02	5.04	5.15
M_2	0.48	2.85	4.52	4.73
M_3	0.46	2.86	4.74	4.76
M_4	0.48	2.75	4.66	4.75
SE(m)	0.03	0.29	0.12	0.12
CD (0.05)	0.09	NS	0.36	NS
Interaction				
H_1M_1	0.60	3.00	5.11	5.19
H_1M_2	0.45	3.00	4.34	4.64
H_1M_3	0.38	3.02	4.53	4.58
H_1M_4	0.52	2.29	4.48	4.58
H_2M_1	0.56	3.24	4.84	5.05
H_2M_2	0.50	2.60	4.75	4.97
H_2M_3	0.57	2.55	4.49	4.54
H_2M_4	0.52	3.42	4.93	5.02
H_3M_1	0.61	2.82	5.16	5.21
H_3M_2	0.48	2.96	4.48	4.57
H_3M_3	0.45	3.02	5.19	5.20
H_3M_4	0.42	2.53	4.59	4.66
SE(m)	0.05	0.51	0.21	0.21
CD (0.05)	NS	NS	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.1.6 Days to maturity

The number of days taken to reach the maturity phase was statistically analysed and recorded in Table 6.

After statistically analysing the data, micronutrient levels varied significantly in the control plots. Least number of days (79.22) taken to reach maturity was recorded when no micronutrients were applied. There were no significant differences among the hybrids and their interaction with micronutrient levels.

4.1.7 Number of harvests

The total number of harvests made was recorded and is presented in Table 7.

The hybrids, micronutrient levels and their interaction did not show significant effects on the number of harvests.

4.1.8 Dry matter production (kg ha^{-1})

The dry matter production by the plant was recorded for each plot, statistically analysed and is presented in Table 7.

The effect of hybrids significantly influenced the dry matter production. Maximum dry matter was accumulated by the hybrid Sugar- 75 (12027 kg ha^{-1}). It was statistically on par with the hybrid Misthi (9962 kg ha^{-1}). However, no significant effects were seen when treated with micronutrients and their interaction with hybrids.

4.2 YIELD CHARACTERS

4.2.1 Number of cobs per plant

The number of cobs per plant for each plot was recorded, statistically analysed and is presented in Table 8.

No significant effect was seen on the number of cobs per plant among hybrids, micronutrient application and their interaction with the hybrids.

Table 6. Effect of hybrids and micronutrient levels on days to 50 per cent tasseling, days to 50 per cent silking and days to maturity

Treatments	Days to 50 per cent tasseling	Days to 50 per cent silking	Days to maturity
Hybrids			
H_1	55.00	58.58	79.58
H_2	55.75	59.33	80.66
H_3	55.66	59.41	79.83
SE(m)	0.34	0.40	0.32
CD (0.05)	NS	NS	NS
Micronutrient level			
M_1	54.66	58.11	79.22
M_2	55.66	58.66	79.66
M_3	56.55	60.55	80.33
M_4	55.00	59.11	80.88
SE(m)	0.39	0.46	0.37
CD (0.05)	1.16	1.37	1.10
Interaction			
H_1M_1	54.66	58.33	79.66
H_1M_2	55.33	58.66	79.33
H_1M_3	55.33	59.33	80.00
H_1M_4	54.66	58.00	79.33
H_2M_1	54.66	58.00	79.00
H_2M_2	56.00	58.66	80.66
H_2M_3	57.66	61.66	81.33
H_2M_4	54.66	59.00	81.66
H_3M_1	54.66	58.00	79.00
H_3M_2	55.66	58.66	79.00
H_3M_3	56.66	60.66	79.66
H_3M_4	55.66	60.33	81.66
SE(m)	0.68	0.80	0.64
CD (0.05)	NS	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 7. Effect of hybrids and micronutrient levels on number of harvests and plant dry matter production

Treatments	Number of harvests	Dry matter production (kg ha^{-1})
Hybrids		
H_1	2.58	12027
H_2	2.58	8180
H_3	2.66	9962
SE(m)	0.14	898
CD (0.05)	NS	2651
Micronutrient level		
M_1	2.66	11055
M_2	2.66	10375
M_3	2.55	8558
M_4	2.55	10237
SE(m)	0.16	1037
CD (0.05)	NS	NS
Interaction		
H_1M_1	2.66	13920
H_1M_2	2.33	12035
H_1M_3	2.66	10311
H_1M_4	2.66	11840
H_2M_1	2.33	9315
H_2M_2	2.66	10275
H_2M_3	2.66	5991
H_2M_4	2.66	7138
H_3M_1	3.00	9929
H_3M_2	3.00	8813
H_3M_3	2.33	9373
H_3M_4	2.33	11733
SE(m)	0.29	1796
CD (0.05)	NS	NS

Note:

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.2.2 Cob length (cm)

After the harvest of the cobs from the tagged plants, it was dehusked and the cob length of each cob was measured, statistically analysed and is given in Table 8.

Micronutrient levels varied significantly in the control plot. The highest cob length (13.12 cm) was recorded when no micronutrients were applied. This treatment was on par with foliar application of boron (12.66 cm) and foliar application of zinc (11.91 cm). The minimum cob length (10.68 cm) was measured when the crop was treated with combined application of zinc and boron.

Significant effect on cob length was not observed among hybrids and their interaction with the micronutrients.

4.2.3 Cob girth (cm)

Cob girth was measured, statistically analysed and is presented in Table 8.

Micronutrient levels had significant influence in the control plot. Among the treatments, highest cob girth (3.99 cm) was measured when no micronutrients were applied. This treatment was statistically on par with foliar application of zinc (3.83 cm). Least cob girth (3.47 cm) was recorded when foliar application of zinc and boron was given in combination. However, hybrids and their interaction with micronutrients did not have any significant effects on the cob girth.

4.2.4 Number of kernel rows per cob

The total number of kernel rows per cob was recorded, statistically analysed and is presented in Table 8.

Hybrids, micronutrient levels and their interaction did not have any significant effects on the number of kernel rows per cob.

Table 8. Effect of hybrids and micronutrient levels on number of cobs per plant, cob length, cob girth and number of kernel rows per cob

Treatments	Number of cobs/ plants	Cob length (cm)	Cob girth (cm)	Number of kernel rows/cob
Hybrids				
H_1	1.00	11.89	3.72	11.82
H_2	1.00	12.03	3.68	11.59
H_3	1.07	12.36	3.82	11.84
SE(m)	0.39	0.39	0.08	0.17
CD (0.05)	NS	NS	NS	NS
Micronutrient level				
M_1	1.00	13.12	3.99	11.68
M_2	1.00	12.66	3.67	11.59
M_3	1.01	11.91	3.83	11.85
M_4	1.10	10.68	3.47	11.88
SE(m)	0.04	0.45	0.09	0.20
CD (0.05)	NS	1.33	0.27	NS
Interaction				
H_1M_1	1.00	12.94	3.73	11.98
H_1M_2	1.00	12.45	3.86	11.88
H_1M_3	1.00	11.15	3.91	11.72
H_1M_4	1.03	11.02	3.41	11.73
H_2M_1	1.00	13.58	3.99	11.58
H_2M_2	1.00	11.75	3.50	11.45
H_2M_3	1.00	12.21	3.71	11.60
H_2M_4	1.00	10.58	3.54	11.73
H_3M_1	1.00	12.85	4.26	11.49
H_3M_2	1.00	13.78	3.66	11.45
H_3M_3	1.03	12.36	3.87	12.23
H_3M_4	1.26	10.46	3.48	12.20
SE(m)	0.07	0.78	0.16	0.35
CD (0.05)	NS	NS	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.2.5 Number of kernels per cob

The total number of kernels per cob was recorded, statistically analysed and is presented in Table 9.

Hybrids, micronutrient levels and their interaction did not have any significant effects on the number of kernels per cob.

4.2.6 Hundred fresh kernel weight (g)

The weight of hundred fresh kernels was taken, statistically analysed and is presented in Table 9.

Hybrids, micronutrient levels and their interaction did not have any significant effects on the hundred fresh kernel weight.

4.2.7 Cob weight with husk (g plant^{-1})

The cob weight with husk was recorded for the selected plants, statistically analysed and is presented in Table 9.

Hybrids, micronutrient levels and their interaction did not have any significant effects on the cob weight with husk.

4.2.8 Cob weight without husk (g plant $^{-1}$)

The cob weight without husk as influenced by hybrids and micronutrient levels are presented in Table 9.

The cob weight without husk (68.90 g plant $^{-1}$) was maximum when no micronutrient was applied and was statistically on par with foliar application of boron (63.73 g plant^{-1}). Least cob weight without husk (51.76 g plant $^{-1}$) was observed when combined treatment of zinc and boron was given. No significance was observed among the hybrids and also with their interaction with micronutrient levels.

Table 9. Effect of hybrids and micronutrient levels on number of kernels per cob, hundred fresh kernel weight, cob weight with husk and cob weight without husk

Treatments	Number of kernels/cob	Hundred fresh kernel weight (g)	Cob weight with husk (g plant $^{-1}$)	Cob weight without husk (g plant^{-1})
Hybrids				
H_1	280.44	17.43	103.30	55.41
H_2	266.19	20.14	118.05	62.58
H_3	288.38	17.43	116.44	60.49
SE(m)	8.96	1.01	5.86	3.87
CD (0.05)	NS	NS	NS	NS
Micronutrient level				
M_1	296.64	19.96	125.36	68.90
M_2	275.86	18.24	117.68	63.73
M_3	285.30	18.90	108.33	53.59
M_4	255.54	16.24	99.03	51.76
SE(m)	10.35	1.16	6.77	4.47
CD (0.05)	NS	NS	NS	13.20
Interaction				
H_1M_1	332.85	17.02	115.55	62.50
H_1M_2	284.38	20.35	110.55	54.99
H_1M_3	264.90	16.02	83.33	51.50
H_1M_4	239.65	16.35	103.77	52.68
H_2M_1	271.05	22.52	138.33	78.33
H_2M_2	257.45	16.68	112.77	64.88
H_2M_3	269.77	24.68	121.66	53.27
H_2M_4	266.50	16.68	99.44	53.83
H_3M_1	286.03	20.35	122.19	65.88
H_3M_2	285.76	17.68	129.72	71.33
H_3M_3	321.25	16.02	119.99	56.00
H_3M_4	260.49	15.68	93.88	48.77
SE(m)	17.93	2.02	11.72	7.75
CD (0.05)	NS	NS	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.2.9 Total cob yield (kg ha^{-1})

The total cob yield from each plot was recorded, statistically analysed and is presented in Table 10.

The effect of hybrids on the total cob yield was found to be significant. Among the hybrids, Sugar 75 recorded the maximum cob yield (11102 kg ha^{-1}) and the minimum cob yield was recorded for Misthi (7791 kg ha^{-1}).

The effect of micronutrients and their interaction with hybrids significantly influenced the total cob yield. Maximum cob yield (11640 kg ha^{-1}) was recorded when recommended dose of nutrients alone were given. The total cob yield (8067 kg ha^{-1}) was minimum with recommended dose of nutrients and foliar application of zinc.

Highest cob yield (13813 kg ha^{-1}) was recorded when Sugar-75 was treated with recommended dose of nutrients alone and was on par with KSCH 333 and recommended dose of nutrients alone (13247 kg ha^{-1}).

4.2.10 Green stover yield (kg ha^{-1})

After harvest, the green stover yield was recorded and is given in Table 10.

The green stover yield of sweet corn was significantly influenced by the hybrids. Maximum green stover yield was produced by the hybrid Sugar 75 (20667 kg ha^{-1}) and this was statistically on par with the hybrid Misthi (19111 kg ha^{-1}). The hybrid KSCH 333 (14889 kg ha^{-1}) recorded the lowest green stover yield.

The effect of micronutrient levels and their interaction with hybrids did not differ significantly.

Table 10. Effect of hybrids and micronutrient levels on total cob yield and green stover yield

Treatments	Total cob yield (kg ha^{-1})	Green stover yield (kg ha^{-1})
Hybrids		
H_1	11102	20667
H_2	9376	14889
H_3	7791	19111
SE(m)	258	1443
CD (0.05)	762	4260
Micronutrient level		
M_1	11640	20148
M_2	9422	20138
M_3	8067	14815
M_4	8563	17778
SE(m)	298	1666
CD (0.05)	880	NS
Interaction		
H_1M_1	13813	23111
H_1M_2	12155	22222
H_1M_3	9627	17778
H_1M_4	8813	19555
H_2M_1	13247	17778
H_2M_2	8327	15999
H_2M_3	7382	10667
H_2M_4	8550	15111
H_3M_1	7860	19555
H_3M_2	7784	22222
H_3M_3	7193	15999
H_3M_4	8327	18667
SE(m)	516	2886
CD (0.05)	1524	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

4.3 SOIL NUTRIENT STATUS AFTER THE EXPERIMENT

Organic carbon and available boron content of the soil was recorded after the harvest of the crop and is presented in Table 11.

Organic carbon and available form of boron in soil did not significantly differ among hybrids, micronutrient levels and their interaction.

4.4 PLANT ANALYSIS

4.4.1 Chlorophyll content at 50 per cent tasseling (mg g^{-1})

The chlorophyll content of the index leaf was estimated at 50 per cent tasseling from each plot, statistically analysed and is presented in Table 12.

Significant interaction effects between hybrids and micronutrient levels on chlorophyll content was observed. Highest chlorophyll content (2.44 mg g^{-1}) was recorded when the hybrid KSCH 333 was treated with recommended dose of nutrients alone and was on par with all the interaction effects except for the treatment when KSCH 333 was treated separately with foliar application of zinc and boron. Minimum chlorophyll content (1.30 mg g^{-1}) was observed when the KSCH 333 was treated with foliar application of boron.

Effects among different hybrids and micronutrient levels was not found to be significant.

4.5 QUALITY ASPECTS OF GRAIN

4.5.1 Ascorbic acid content (mg 100g $^{-1}$)

After the harvest of cob, kernels were estimated for their ascorbic acid content. Their values were recorded, statistically analysed and is presented in Table 13.

No major influence of hybrids, micronutrient level and their interaction were observed in ascorbic acid content of grains.

4.5.2 Moisture content (%)

The moisture content of grains immediately after harvest was recorded and is presented in Table 13.

No significant effects on moisture content were seen by the hybrids, micronutrient levels and their interaction.

4.6 PEST AND DISEASE INCIDENCE

The major pest in the experimental area noticed during the crop period was fall army worm. The attack was noticed from 20 DAS to 60 DAS. The mean per cent damage caused by fall army worm (*Spodoptera frugiperda*) on the leaves per plant was recorded and thereafter control measures were taken effectively. The data obtained was statistically analysed and is presented in Table 14.

The mean per cent of damage caused by *Spodoptera frugiperda* had significant influence on hybrids. It was observed that the lowest percent damage was on hybrid Mishti.

Micronutrient levels and their interaction with hybrids did not significantly influence the pest incidence.

4.7 ECONOMIC ANALYSIS

Net returns (₹ ha^{-1}) and BCR as influenced by hybrids and micronutrient levels are presented in Table 15.

Significant effect on hybrids was recorded for net returns and BCR. The highest net returns (₹ 225710 ha^{-1}) and BCR (2.03) was recorded for Sugar 75. The lowest net returns (₹ 97345 ha^{-1}) and BCR (1.45) was recorded for Misthi.

Net returns and BCR varied significantly with micronutrient levels and their interaction with hybrids.

Highest net returns (₹ 252341 ha^{-1}) and BCR (2.17) was recorded when recommended dose of nutrients alone were given. The lowest net returns (₹ 104657 ha^{-1}) and BCR (1.47) was noticed when foliar application of zinc with RDN was given.

Highest net returns (₹ 337789 ha^{-1}) and BCR (2.57) was registered when Sugar-75 was treated with recommended dose of nutrients alone and was on par when KSCH 333 with recommended dose of nutrients alone. Minimum net returns (₹ 72289 ha^{-1}) and BCR (1.33) was recorded when Misthi was treated with foliar application of zinc. This is in conformity with total cob yield.

Table 11. Effect of hybrids and micronutrient levels on soil organic carbon and available boron after the harvest

Treatments	Organic carbon (%)	Available B (ppm)
Hybrids		
H_1	1.03	0.07
H_2	1.13	0.08
H_3	1.20	0.09
SE(m)	0.10	0.008
CD (0.05)	NS	NS
Micronutrient level		
M_1	1.02	0.08
M_2	1.03	0.07
M_3	1.20	0.08
M_4	1.22	0.10
SE(m)	0.12	0.010
CD (0.05)	NS	NS
Interaction		
H_1M_1	1.12	0.07
H_1M_2	1.12	0.07
H_1M_3	0.96	0.06
H_1M_4	0.93	0.09
H_2M_1	0.95	0.07
H_2M_2	0.90	0.06
H_2M_3	1.63	0.08
H_2M_4	1.03	0.12
H_3M_1	1.00	0.09
H_3M_2	1.07	0.08
H_3M_3	1.03	0.11
H_3M_4	1.69	0.08
SE(m)	0.21	0.01
CD (0.05)	NS	NS

Note:

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 12. Effect of hybrids and micronutrient levels on chlorophyll content at 50 per cent tasseling

Treatments	Chlorophyll content (mg g^{-1})
Hybrids	
H_1	2.03
H_2	1.86
H_3	2.19
SE(m)	0.13
CD (0.05)	NS
Micronutrient level	
M_1	2.06
M_2	2.22
M_3	1.95
M_4	1.89
SE(m)	0.15
CD (0.05)	NS
Interaction	
H_1M_1	1.72
H_1M_2	2.38
H_1M_3	2.29
H_1M_4	1.76
H_2M_1	2.44
H_2M_2	1.30
H_2M_3	1.47
H_2M_4	2.25
H_3M_1	2.02
H_3M_2	2.22
H_3M_3	1.95
H_3M_4	1.89
SE(m)	0.26
CD (0.05)	0.77

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 13. Effect of hybrids and micronutrient levels on ascorbic acid content and moisture content in kernels

Treatments	Ascorbic acid content (mg 100g $^{-1}$)	Moisture content (%)
Hybrids		
H_1	5.88	37.10
H_2	6.14	43.37
H_3	6.89	38.83
SE(m)	0.34	1.86
CD (0.05)	NS	NS
Micronutrient level		
M_1	5.97	40.81
M_2	6.59	41.61
M_3	5.79	38.14
M_4	6.86	38.51
SE(m)	0.39	2.12
CD (0.05)	NS	NS
Interaction		
H_1M_1	6.32	39.16
H_1M_2	5.98	39.14
H_1M_3	5.57	33.31
H_1M_4	5.64	36.80
H_2M_1	5.11	46.32
H_2M_2	6.17	42.93
H_2M_3	5.59	45.43
H_2M_4	7.68	38.80
H_3M_1	6.48	36.94
H_3M_2	7.61	42.75
H_3M_3	6.21	35.68
H_3M_4	7.25	39.94
SE(m)	0.68	3.67
CD (0.05)	NS	NS

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 14. Effect of hybrids and micronutrient levels on pest and disease incidence

Treatments	Mean per cent of damage on leaf *(Spodoptera frugiperda)*
Hybrids	
H_1	79.11 (63.92)
H_2	84.31 (67.14)
H_3	68.03 (56.14)
SE(m)	2.11
CD (0.05)	6.23
Micronutrient level	
M_1	78.55 (63.25)
M_2	72.71 (59.56)
M_3	75.75 (61.42)
M_4	81.60 (65.37)
SE(m)	2.44
CD (0.05)	NS
Interaction	
H_1M_1	73.26 (60.09)
H_1M_2	74.40 (59.98)
H_1M_3	77.20 (62.14)
H_1M_4	91.60 (73.46)
H_2M_1	83.33 (65.92)
H_2M_2	85.46 (68.82)
H_2M_3	85.20 (67.94)
H_2M_4	83.26 (65.89)
H_3M_1	79.06 (63.75)
H_3M_2	58.26 (49.89)
H_3M_3	64.86 (54.19)
H_3M_4	69.93 (56.74)
SE(m)	4.22
CD (0.05)	NS

Figures in parenthesis denotes $\sin^{-1}\sqrt{x/100}$ transformed values.

Note:

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

Table 15. Effect of hybrids and micronutrient levels on economics of sweet corn

Treatments	Net Returns (₹ ha^{-1})	B:C ratio
Hybrids		
H_1	225710	2.03
H_2	157052	1.72
H_3	97345	1.45
SE(m)	10324	0.04
CD (0.05)	30477	0.14
Micronutrient level		
M_1	252341	2.17
M_2	161140	1.74
M_3	104657	1.47
M_4	122006	1.55
SE(m)	11922	0.05
CD (0.05)	35192	0.16
Interaction		
H_1M_1	337789	2.57
H_1M_2	268990	2.23
H_1M_3	165542	1.75
H_1M_4	130521	1.58
H_2M_1	315497	2.47
H_2M_2	116209	1.53
H_2M_3	76139	1.34
H_2M_4	120363	1.54
H_3M_1	103736	1.49
H_3M_2	98221	1.46
H_3M_3	72289	1.33
H_3M_4	115134	1.52
SE(m)	20649	0.09
CD (0.05)	60954	0.28

Note :

H_1- Sugar 75

H_2- KSCH 333

H_3- Misthi

M_1- KAU POP Recommendation

M_2- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking

M_3- M_1+ Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

M_4- M_1+ Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS

DISCUSSION

5. DISCUSSION

An investigation was taken up at College of Agriculture, Padannakkad to study the performance of sweet corn hybrids under Kerala agro ecosystem. This study was also intended to assess the role of zinc and boron on increasing the growth, productivity, profitability and quality of the crop.

The results obtained on the experiment “Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality” presented in the previous chapter are discussed and justified below based on available literature.

5.1 GROWTH CHARACTERS

5.1.1 Plant height

Plant height is an important character which helps in the determination of growth attained during the growing period. Results on the plant height revealed significant influence of micronutrients at 15 DAS. Application of recommended dose of nutrients alone recorded the highest plant height and was on par with combined foliar application of zinc and boron. However, no micronutrient sprays were given at 15 days after sowing. Hence, the difference in the treatments can be attributed to plant nutrients absorbed from soil by the plants. Optimum application of fertilizers may have caused cell division and elongation. Sarwargaonkar *et al*. (2008) reported that significant increase in plant height of kharif maize was recorded with 100 per cent recommended fertilizer dose. Similar effects were also reported by Jat (2006), Sobhana *et al.* (2012) and Bisht *et al.* (2012). Boron and zinc mediated increment in plant height can be attributed to the role of zinc and boron in photosynthesis.

However significant influence on plant height was not recorded at any other stages of observation. The effect of hybrids and their interaction with foliar application of zinc and boron was not significant at all stages of observation. Supporting results was obtained by DMR (2009) concluding that the plant height did not significantly vary among maize cultivars and Hanmant (2014) concluded that interaction of sweet corn hybrids and fertilizer levels was not significant for plant height.

5.1.2 Number of leaves

Total number of photosynthetically active leaves enhances growth, yield and quality parameters of a crop. Number of leaves did not significantly differ with treatments at any stage of observation. This could be attributed to the fact that the number of leaves is influenced by environmental conditions and not a genetic character. Hesketh *et al.* (1969) studied the effect of varying temperatures and concluded that higher atmospheric temperature increased the number of leaves in a maize hybrid and also reported that changes in the nutrient level did not alter the leaf number. Hanmant (2014) reported that interaction effect between sweet corn hybrids and fertilizer levels did not influence the number of leaves. Alimuddin *et al*. (2020) reported that maize varieties and their interaction with boron fertilization did not significantly influence the number of leaves.

5.1.3 Leaf area

Leaf area is a key factor that influence the interception and utilization of solar radiation in crop canopies. Significant effects on leaf area was observed only at 15 and 45 DAS. Maximum leaf area at 15 DAS was recorded in the control plot. Kannan *et al.* (2013) and Choudhari and Channappagouda (2015) concluded that combined application of recommended dose of nutrients and organic manures had resulted in highest leaf area. At 45 DAS, highest leaf area was observed when treated with recommended dose of nutrients alone and was on par with foliar application of zinc. Zinc regulates the production of endogenous auxin and gibberllins in maize (Sekimoto *et al*., 1997). Gibberellic acid stimulates cell division and cell elongation hence, increase leaf area in maize (Al-Shaheen and Soh, 2018). However, combined foliar application of zinc and boron did not increase the leaf area. This might be due to an antagonistic interaction between zinc and boron in the plant. Presence of boron prevents the increase of zinc concentration in the leaf (Aref, 2011). Manasa and Devaranavadagi (2015), El-Azab (2015), Amanulla *et al*. (2016) and Wailare and

Kesarwani (2017) concluded that foliar application of zinc increased the leaf area in maize. Effect of zinc and boron was not recorded at any other stage of observation. Effects between hybrids and their interaction with foliar application of zinc and boron was non- significant at all stages of observation. Afzal *et al*. (2013) concluded that maize hybrids and their interaction with zinc application did not significantly influence the leaf area.

5.1.4 Days to 50 per cent tasseling and silking

Foliar application of micronutrients did not influence days to fifty per cent tasseling and silking. Application of recommended dose of fertilizers alone recorded the least number of days taken for 50 per cent tasseling and silking. Anderson (1959) cited by Cross and Zuber (1973) stated that plant height influences the days to 50 per cent tasselling and silking and taller plants reduce the days taken for tasseling and silking. Gul *et al*. (2015) contributed that application of recommended dose of fertilizers had reduced the days to tasselling and silking in rainfed maize as increased dose of fertilizer lengthens the vegetative phase of the crop. The results are in contrast with Debnath (2014) and (Choudhary *et al*., 2019) which reported that foliar application of zinc had reduced the days taken for 50 per cent tasselling and silking.

Hybrids and their interaction with micronutrient application did not significantly influence the days to 50 per cent tasseling and silking. Similar observations were recorded for plant height and leaf area. Hanmant (2014) and Bhadu (2016) concluded that interaction effect between sweet corn varieties and fertilizer application was non-significant for days to 50 per cent tasseling and silking.

5.1.5 Days to maturity

An accurate determination of the sweet corn maturity for harvest can ensure the best crop yield and quality (Ruan *et al*., 1999). At maturity, the kernels are plump, sweet, milky, tender, and nearly of maximum sizes (Szymanek, 2009). Foliar application of zinc and boron did not influence the days to maturity. Least number of days taken to reach maturity was observed when treated with recommended dose of nutrients alone. This could be attributed to similar results in days to 50 per cent tasseling and silking. It could also be indicated that the days taken to reach maturity is dependent on the nutrient schedule and not an inherent genetic crop character. Asghar *et al*. (2010) and Kumar and Bohra (2014) concluded that increase in application of fertilizers had resulted in increasing the number of days taken to maturity. Effect of hybrids and their interaction with foliar application of zinc and boron was not significant. Asghar *et al*. (2010) concluded that maize hybrids did not differ for days to maturity.

5.1.6 Number of harvests

The total number of harvests made is a factor which influences the total cob yield. Significant influence of treatments on number of harvests was not observed. Mavarkar (2016) reported that nutrient application levels did not significantly affect the number of harvests in baby corn. Irrespective of the treatments, an average of two harvests could be obtained.

5.1.7 Dry matter production

Dry matter production of a crop is an important parameter for higher yields as it signifies photosynthetic ability of the crop. Sweet corn hybrids had significant influence on the dry matter production. Sugar 75 had assimilated the maximum dry matter and was on par with Misthi. Similar results in cob yield and green stover yield were recorded and could have contributed to high dry matter production. The results are in conformity with Suthar *et al.* (2012), Dhaka (2014), Bhatt (2012) and Keerthi *et al.* (2017) also found that sweet corn hybrid Sugar 75 had recorded the maximum dry matter production. Foliar application of zinc, boron and their interaction with hybrids did not show significant variations in dry matter production. Bhadu (2016) and Pandu (2019) also concluded that interaction effect between maize hybrids and fertilizer application did not significantly influence dry matter production.

5.2 YIELD CHARACTERS

5.2.1 Number of cobs per plant

The number of cobs per plant is an important yield parameter. Hybrids, foliar application of micronutrients and their interaction did not significantly influence the number of cobs per plant. Similar observation was recorded by DMR (2009) that sweet corn varieties did not significantly influence the number of cobs per hectare. Tahir *et al.* (2009) reported that the number of cobs per plant was not influenced by zinc chelates in maize hybrid Monsanto-6525. Mavarkar (2016) concluded that application of recommended dose of fertilizers did not influence the number of cobs per plant. Kumar and Dawson (2019) concluded that sweet corn varieties treated with zinc and boron did not significantly influence the number of cobs per plant. A mean of one cob per plant was noted for all the treatments.

5.2.2 Cob length

Highest cob length was recorded when treated with recommended dose of fertilizers alone and was on par with foliar application of zinc and boron. Boron and zinc enhance the assimilate partitioning to the cob as they are cofactors for enzymatic activation (Anjum *et al*., 2017). An increase in cob length was observed due to the role of zinc in initiation of reproductive parts and partitioning of photosynthates towards them. This is in line with studies conducted by Tahir *et al.* (2009), Mohsin *et al*. (2014), Pande *et al.* (2015), Shabbir *et al*. (2017), Chand *et al*. (2017) and Kumar and Dawson (2019) concluded that foliar application of zinc increased the cob length significantly. Boron is required for cell division and cob formation which influence the cob length. Similar results were reported by Tahir *et al.* (2012) and Salimi *et al*. (2013) that foliar application of boron significantly influences the cob length. Hybrids and their interaction with zinc and boron did not significantly influence cob length.

5.2.3 Cob girth

Maximum cob girth was recorded when treated with recommended dose of fertilizers alone and was on par with foliar application of zinc. The increase in cob girth due to application of zinc might have been caused by high photosynthetic activity and synthesis of growth-regulating hormones. The results are in conformity with Meena *et al*. (2013), Shivay and Prasad (2014), Kumar and Bohra (2014), Pande *et al.* (2015), Manasa and Devaranavadagi (2015), and Chand *et al.* (2017) recorded significant influence of zinc on cob girth.

Hybrids and their interaction with foliar application of micronutrients were not significant. Azam *et al.* (2007), Hanmant (2014), Archana (2016) and Aprillianti *et al.* (2016) also observed similar results.

5.2.4 Number of kernel rows per cob

Treatments did not significantly influence the number of kernel rows per cob. Potarzycki and Grzebisz (2009) and Tahir *et al*. (2012) reported that application of micronutrients did not significantly influence number of kernel rows per cob. Khan *et al.* (2012) concluded that maize hybrids did not influence the number of kernel rows per cob. Potarzycki *et al.* (2015) reported that interaction effect between maize cultivars and zinc fertilization was not significant for number of kernel rows per cob. An average of 11 kernel rows per cob was observed across treatments.

5.2.5 Number of kernels per cob

Number of kernels per cob is considered as a critical yield-component for final grain yield simulation (Ritchie and Alagarswamy, 2003). Treatments did not significantly influence the number of kernels per cob. Nasim *et al.* (2012) and Kandil (2013) reported that the interaction effect between maize hybrids and fertilizer levels did not influence the number of kernels per cob.

Boron influences the yield parameters in sweet corn as it is a nutrient necessary for stimulation of root and shoot development, tassel and silk formation, movement of sugars from leaves to ears, pollen germination, pollen tube growth and seed formation. Irregular distribution of kernels and a general reduction in growth are the first signs of boron deficiency. Severe boron deficiency results in short bent cobs of corn with under-developed tips and very poor kernel development. This is observed in the experiment irrespective of the hybrids, foliar application and their interaction in Plate 18. In boron deficient maize, poor grain-setting can result in barren cobs, and this was attributed by Vaughan (1977) to the silks being non-receptive. Tahir *et al.* (2012) observed that the improvement in grain and biological yield of maize is mainly attributed to complementary role of boron in the reproduction and vegetative stage of plants.

This can also be attributed to the deficient range of available boron (0.1 mg kg^{-1}) in the soil where field experiment was undertaken. This indicates that the amount of nutrient required by the crop for normal metabolic activities could not be met from foliar application of boron @ 0.15 per cent once at tasseling and silking which was envisaged in the experiment. When the soil is deficient in any of the nutrients, foliar application becomes more effective but, only nearly 10 per cent of the requirement can be met through foliage. Among the nutrients, nitrogen is absorbed effectively and fast (Rajakumar, 2015). The inherent deficient available boron status and high available phosphorus which limit absorption of boron from the soil of the experimental field by the plant might have provided additive effect (Table 1).

According to Humtsoe *et al.* (2018) nitrogen application @ 150 kg ha^{-1} along with Zinc @ 25 kg ha^{-1} as basal and foliar application of Boron at 0.3 per cent recorded a greater number of kernels per cob. Keerthi (2012) and Hanmant (2014) concluded that the number of kernels per cob in Sugar 75 and Misthi was 493.5 and 480 respectively. In this experiment, number of kernels per cob recorded was 280 on an average irrespective of the treatments. It can be attributed to deficiency of boron in the cob.

5.2.6 Hundred fresh kernel weight

Hybrids, foliar micronutrient application and their interaction did not significantly influence the hundred fresh kernel weight. Similar results were recorded by Khaliq *et al*. (2009) and Kandil (2013) that interaction effect between maize hybrids and nutrient levels did not significantly influence the hundred fresh kernel weight. Potarzycki *et al.* (2015) concluded that interaction effect between maize cultivars and zinc fertilization was not significant for thousand fresh kernel weight. Three foliar sprays of 0.5 per cent borax yielded maximum thousand grain weight (333.00 g) in maize compared to the control (Sarwar *et al.,* 2018). In an experiment conducted by Sujatha (2005), significant effects in hundred seed weight (23.5 g) was observed when combined soil application of boron (2 kg ha^{-1}) and recommended dose of fertilizers was treated in maize.

Mean value of hundred fresh kernel weight noticed in this experiment is 20 g. This was in contrast to the report by Keerthi (2012) in which the hundred fresh kernel weight of Sugar -75 and Misthi was 28.5 g and 31.9 g respectively. It could be related to boron deficiency as boron is a nutrient which is essential for translocation of sugars from source to sink.

5.2.7 Cob weight with husk

Cob weight with husk did not record significant effects among treatments. Results are in contrast with Ghazvineh and Yousefi, (2012) and El- Azab (2015) which concluded that foliar application of boron significantly increased the cob weight with husk in maize. Keerthi (2012) and Hanmant (2014) conducted an experiment in sweet corn hybrids and concluded that cob weight with husk recorded for Sugar- 75 was 280 g $plant^{-1}$ and for Misthi was 261 g $plant^{-1}$. The weight of cob recorded in this study was lower (130 g $plant^{-1}$). It could be attributed to reduced number of kernels per cob and hundred fresh kernel weight. Boron deficiency which was observed, resulted in decrease in cob weight. As reported by Meena *et al.* (2012) significant effects on cob weight with husk (238 g $plant^{-1}$) was recorded when boron (5 kg ha^{-1}) as soil application was given along with 90: 20:25 kg N: P_2O_5: K_2O ha^{-1} in maize. It can be concluded that foliar application of boron @ 0.15 per cent once at tasseling and silking is not enough to meet the nutrient requirement of the crop in a boron deficient soil.

5.2.8 Cob weight without husk

Highest weight was recorded when treated with recommended doses of fertilizers alone and was on par with foliar application of boron. Boron nutrition increases the cob length and hence, the cob weight. This is in line with the findings of Thavaprakash *et al*. (2005) and Jaliya *et al*. (2008) who concluded that application of boron significantly improved the cob weight without husk. Hybrids and their interaction with micronutrients did not significantly differ with cob weight without husk.

5.2.9 Total cob yield

Grain yield is a function of integrated effects of genetic makeup and yield components of a crop. Sweet corn hybrids significantly influenced the total cob yield. Highest cob yield was recorded for hybrid Sugar 75 (11102 kg ha^{-1}). Higher dry matter content and green stover yield might have resulted in higher cob yield in Sugar 75. This is in conformity with the findings of Bhatt (2012), Suthar (2012), Ananda (2013), Hanmant (2014) and Keerthi *et al.* (2017) wherein reported that Sugar- 75 had recorded the maximum cob yield.

Foliar application of micronutrients and their interaction with hybrids was significant. Total cob yield is a function of yield attributes of sweet corn *viz.*, number of plants per ha, number of cobs per plant and cob weight with husk which in turn is decided by number of kernels per cob and 100 fresh kernel weight. Maximum cob yield (11640 kg ha^{-1}) was recorded when recommended dose of nutrients alone were given. Cob yield (13813 kg ha^{-1}) was the highest when Sugar-75 was supplied with recommended dose of nutrients alone and was on par when KSCH 333 with recommended dose of nutrients alone (13247 kg ha^{-1}). Similar results are reported by Sahoo and Mahapatra (2007), Thakur *et al.* (2009), Sunitha and Reddy (2012), Ravi *et al.* (2012) and Rathod (2014) that application of recommended dose of nutrients had increased the cob yield in sweet corn.

Hanmant (2014), Keerthi *et al*. (2017) and Kumar and Chawla (2018) conducted an experiment in sweet corn hybrids and concluded that the total cob yield recorded for Sugar- 75, Misthi and KSCH 333 was 16500 kg ha^{-1}, 15000 kg ha^{-1} and 14160 kg ha^{-1} respectively. Lower cob yield was recorded in this study for the sweet corn hybrids and can be attributed to low content of boron available for metabolic activities which reflected in yield contributing factors and in turn total cob yield of sweet corn.

Foliar application of boron alone cannot meet the requirements of the crop. Plant response to foliar application is often only temporary. Foliar fertilization cannot substitute for soil application. It is only a nutrient corrective technique in crops during growth cycle when soil application is ineffective due to immobilization of soil applied nutrients (Fageria *et al.*, 2009).

Corn removes significant amounts of boron from the soil each year. In high yield situations, boron fertilization becomes critically important. Boron application at 2.24 kg ha^{-1} was the best option for boron fertilization in corn on fine-textured soils with low soil test boron (Kaur and Nelson, 2015). Most researches recommend boron at planting, in side dressing, or fertigated for irrigated corn. An in-row application of boron has showed higher plant uptake compared to foliar application while both of these application methods were more effective than a broadcast soil application (Peterson and Mac Gregor, 1966). Band application of boron to soil will ensure large quantity of available nutrient as it is concentrated in the immediate root zone (Gupta, 2007). Hence future research should be reorganised in this direction in boron deficient soils to ensure high yield in sweet corn.

5.2.10 Green stover yield

Significant influence of hybrids on green stover yield was observed. Sweet corn hybrid Sugar 75 (20667 kg ha^{-1}) had recorded the highest green stover yield and was on par with Misthi (19111 kg ha^{-1}). Similar observations were also contributed by Suthar (2012), Kandil (2013), Dhaka (2014) and Archana (2016) concluded that maize varieties have significant influence on green stover yield. Foliar application of micronutrients and their interaction with hybrids did not significantly influence the green stover yield. It can be attributed to the conclusions by Hanmant (2014), Keerthi *et al.* (2017) and Kumar and Chawla (2018) which green fodder yield in Sugar 75, Misthi and KSCH 333 was 21553 kg ha^{-1}, 20924 kg ha^{-1} and 16030 kg ha^{-1} respectively. However green stover yield recorded was comparable for the hybrids in in the present study as well as previous experimental results unlike yield attributes. Boron limitation negatively alters the reproductive performance of plants by causing abrupt changes in flowering and fruiting modes. This often results in empty and shrivelled anthers, pollen tubes bursting, pollen viability loss, abscission of flower buds, failure of fruit setting, and premature fruit drop because of failure of photosynthate transport resulting in yield loss (Dell and Huang, 1997; Marschner, 2012). These findings suggest that boron predominantly affects reproductive growth compared with vegetative growth in plants (Shireen *et al.,* 2018). Bhatt (2012) and Suthar (2012) concluded that Sugar-75 had recorded the maximum green stover yield.

5.3 SOIL NUTRIENT STATUS AFTER THE EXPERIMENT

Treatments did not have any significant effect on organic carbon and available boron content in soil after harvest. However, an increase in the organic carbon content of soil after harvest was noted which may be due to the addition of farm yard manure and decomposition of the older leaves. The results are in accordance with Rasool *et al.* (2008) and Kaur *et al*. (2008) who reported that application of farm yard manure and decomposed plant matter increased the organic carbon content in soil.

The available boron content in soil had decreased after harvest. This could be attributed to the absorption of boron from the soil by the plant. However high available phosphorus in the soil before experiment might have limited the absorption of boron by sweet corn due to antagonistic nutrient interactions between boron and phosphorus in the soil. The fact emphasizes that boron is a critical nutrient required for high yield and quality of sweet corn. It has been proven from this experiment that under such circumstances foliar application can only add benefit if the soil nutrient level is in sufficient range provided few factors are limiting its uptake at critical growth stage of the crop.

5.4 PLANT ANALYSIS

5.4.1 Chlorophyll content

Significant interaction effect between hybrids and micronutrient application was observed in chlorophyll content. Maximum chlorophyll content was recorded when KSCH 333 was treated with recommended dose of fertilizers alone and was on par with all the treatments except when KSCH 333 was treated with foliar application of zinc and boron. Follet *et al*. (1981) reported that the chlorophyll content largely depends on the amount of nutrients assimilated in the plant. Chaab *et al.* (2011), Panhwar *et al*. (2011), Soltangheisi *et al*. (2014) and Amutham *et al.* (2019) observed that foliar application of micronutrients had increased the chlorophyll content in maize hybrids. Hybrids and micronutrient application did not significantly influence chlorophyll content. Similar findings were reported by Abubakar *et al.* (2019) in maize hybrids.

5.5 QUALITY ASPECTS OF KERNELS

5.5.1 Ascorbic acid content

Ascorbic acid content in kernels did not significantly differ among the treatments. An average of 6 mg $100g^{-1}$ ascorbic acid content was recorded. Kumar and Bohra (2014) concluded that application of recommended dose of nutrients and zinc did not significantly influence the ascorbic acid content in maize kernels.

5.5.2 Moisture content

The moisture content in the kernels can determine shelf life and processing. Hybrids, micronutrient application and their interaction did not significantly influence the moisture content in the kernels. Farnham (2001) reported that maize hybrids did not significantly influence moisture content. Results are in contrast with Debnath (2014) and Wasaya *et al.* (2017) who concluded that moisture content increases with the application of zinc and boron.

5.6 PEST AND DISEASE INCIDENCE

The fall army worm (*Spodoptera frugiperda)* is the primary insect pest attacking sweet corn (Foster, 1989). They attack all stages of crop growth and above ground plant structures (Buntin 1986). Hybrids had significant influence on the mean per cent of damage caused by fall army worm. The lowest per cent damage was recorded in hybrid Misthi. Pest resistance is an inherent character of a crop. Kumar and Mihm (2002) concluded that the infestation of fall army worm was influenced by maize hybrids. Foliar application of micronutrients and their interaction with hybrids did not significantly influence the pest incidence.

5.7 ECONOMIC ANALYSIS

Hybrids showed significant effect on net returns and BCR. The highest net returns (₹ 225710 ha^{-1}) and BCR (2.03) was recorded for Sugar 75. Similar trend was observed with respect to total cob yield in sweet corn. These results are in conformity with Suthar (2012), Hanmant (2014), Dhaka (2014) and Keerthi *et al.* (2017) wherein sweet corn hybrid Sugar- 75 had reported the highest net returns and BCR.

However, application of micronutrients as well as its interaction with hybrids differ significantly with respect to total cob yield and in turn net returns and BCR. Net returns (₹ 252341 ha^{-1}) and BCR (2.17) was recorded maximum when no micronutrients were given. Highest net returns (₹ 337789 ha^{-1}) and BCR (2.57) was recorded when Sugar-75 was treated with recommended dose of nutrients alone and was on par with KSCH 333 and recommended dose of nutrients alone. The results are in conformity with Bharud (2010), Ravi *et al*. (2012), Sunitha and Reddy (2012) and Rathod (2014). They reported that application of recommended dose of nutrients to sweet corn had given higher net returns and BCR.

To conclude a BCR more than three is easily attainable if boron wouldn't have limited the productivity of sweet corn which was visualized through characteristic deficiency symptoms in the cob.

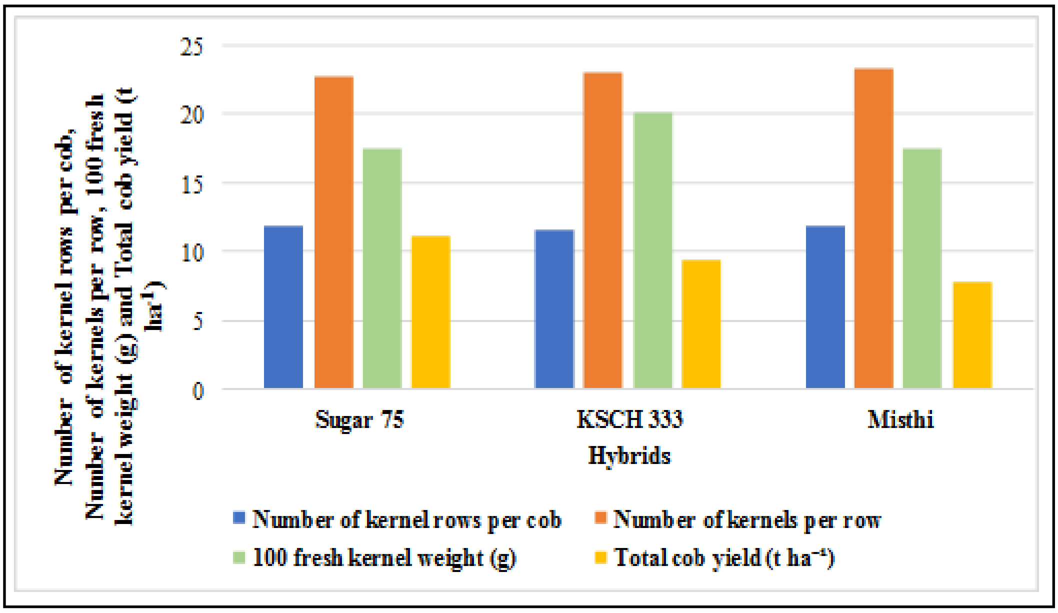


Fig. 3. Effect of hybrids on number of kernel rows per cob, number of kernels per row, 100 fresh kernel weight and total cob yield

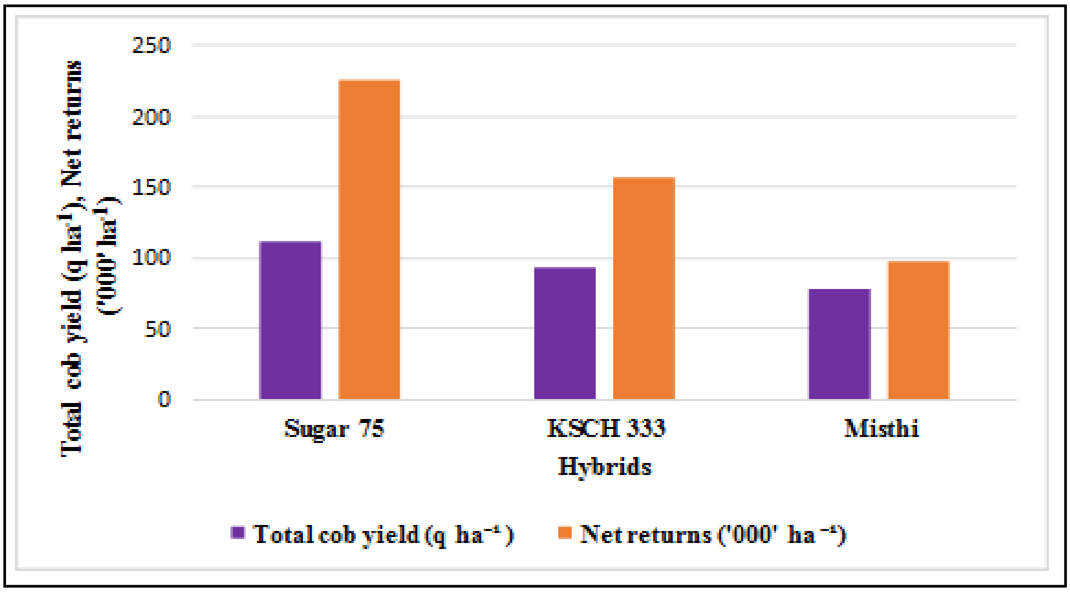


Fig. 4. Relationship between total cob yield and net returns

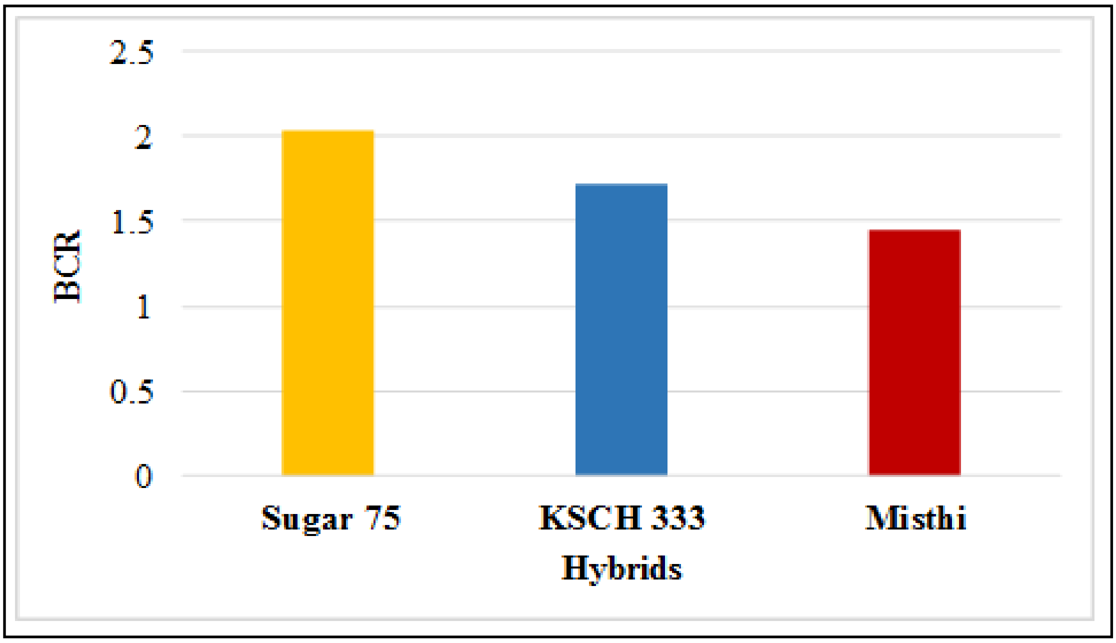


Fig. 5. Effect of sweet corn hybrids on Benefit- cost ratio (BCR)

Plate 18. Symptoms of boron deficiency in harvested cob

SUMMARY

6. SUMMARY

An investigation entitled "Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality" was undertaken during 2019-2020 at College of Agriculture, Padannakkad and Regional Agricultural Research Station, Pilicode. The experiment was aimed to evaluate the performance of sweet corn hybrids suitable under agro- climatic conditions of Kerala and to study the role of zinc and boron in increasing the productivity, quality and profitability of the crop.

The field experiment was carried out in factorial randomized block design with 12 treatments and three replications. Studies were carried out with three sweet corn hybrids *viz.,* Sugar 75, KSCH 333, Misthi and four levels of micronutrient application *viz.,* No spray (control) , Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking, , Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing and Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking + Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing along with RDN of Maize as per KAU POP. The results of the experiment are summarized below:

1) Highest plant height was recorded in control plot at 15 DAS. The effect of hybrids and their interaction with zinc and boron was not significant at all stages of observation. Number of leaves did not show significant effects with treatments at all stages of observation.

2) The leaf area of the crop recorded significant effects at 15 and 45 DAS. Highest leaf area was recorded in the control plot at 15 DAS and 45 DAS. The treatment was on par with foliar application of zinc at 45 DAS. Hybrids and their interaction with micronutrient application did not have significant effects on leaf area at all stages of observation.

3) Significant effect on days to 50 per cent tasseling, silking and maturity was observed. The least number of days to 50 per cent tasseling, silking and maturity was noted in the control plot. Effects of hybrids and their interaction with micronutrient

application was not significant on these parameters. Number of harvests was not varying significantly with treatments.

4) Maximum dry matter was accumulated in Sugar-75 (12027 kg ha^{-1}) and was statistically on par with Misthi (9962 kg ha^{-1}). However, micronutrient levels and their interaction with hybrids were not significant.

5) Maximum cob length (13.12 cm) was recorded in control plot and the treatment was on par with foliar application of boron and zinc. Highest cob girth (3.99 cm) was measured when treated with recommended dose of nutrients alone and was statistically on par with foliar application of zinc. Maximum cob weight without husk (68.90 g plant^{-1}) was recorded in the control plot and the treatment was on par with foliar application of boron. Hybrids and their interaction with micronutrient application did not significantly influence cob length, cob girth and cob weight without husk.

6) Number of cobs per plant, number of kernels per cob, cob weight with husk, number of kernel rows per cob and hundred fresh kernel weight did not differ significantly with treatments.

7) Among the different hybrids tested, Sugar 75 was superior recording a cob yield of 11102 kg ha^{-1}. Maximum cob yield (11640 kg ha^{-1}) was recorded in the control plot and among interaction effects, the highest cob yield (13813 kg ha^{-1}) was recorded when Sugar-75 was provided with recommended dose of nutrients alone and was on par with KSCH 333 and recommended dose of nutrients alone (13247 kg ha^{-1}).

8) Maximum green stover yield was recorded in Sugar 75 (20667 kg ha^{-1}) and was statistically on par with Misthi (19111 kg ha^{-1}). Green stover yield did not vary significantly with micronutrient application and their interaction with hybrids.

9) Organic carbon and available boron content in soil after harvest did not differ significantly with treatments. The soil organic carbon content increased after harvest and the soil available boron content was deficient in range.

10) Significant interaction effects between hybrids and micronutrient application on chlorophyll content was noted. Highest chlorophyll content (2.44 mg g^{-1}) was recorded when KSCH 333 was treated with recommended dose of nutrients alone and was on par with all the interaction effects except when KSCH 333 was treated with foliar application of zinc and boron. Hybrids and micronutrient application did not significantly influence the chlorophyll content in leaves.

11) The ascorbic acid content and the moisture content in kernels did not vary significantly with treatments.

12) The mean per cent of damage caused by fall army worm had significant influence on hybrids and the lowest percent damage was observed in Misthi. Micronutrient application and their interaction with hybrids did not significantly influence the pest incidence.

13) The highest net returns (₹ 225710 ha^{-1}) and BCR (2.03) was obtained in Sugar 75. Maximum net returns (₹ 252341 ha^{-1}) and BCR (2.17) was recorded when RDN alone was given. Among interaction effects, highest net returns (₹ 337789 ha^{-1}) and BCR (2.57) was noticed when Sugar-75 was supplied with recommended dose of nutrients alone and was on par with KSCH 333 and recommended dose of nutrients alone.

Perusal of results revealed that **Sugar 75** is the best sweet corn hybrid that can be recommended for cultivation in Kerala. Application of recommended dose of nutrients with or without foliar spray of either Zn or B or both performed on par in most of the observations irrespective of the hybrids tested. However, we could observe visual symptoms of boron deficiency in cobs and the results revealed that boron is a critical nutrient that influences the yield and yield attributes in sweet corn. Foliar application of boron @ 0.15 per cent once at tasseling and silking did not meet the requirements of the crop when grown in boron deficient soil. Hence, foliar application of a nutrient alone cannot alleviate the nutrient deficiency in the crop when grown under limited soil nutrient supply.

Future line of work

i. Experiments on role of boron under low, medium and high soil boron conditions in sweet corn can be investigated.
ii. Standardisation of 4 R’s for increasing productivity and profitability can be explored with respect to B in sweet corn.
iii. Possibility of organic farming/GAP in sweet corn can be looked into.

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APPENDICES

Appendix I. Weather parameters during the crop season in standard weeks

Standard weeks	Temperature (˚C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hrs)
	Maximum	Minimum			
39 (Sep 24 - Sep 30)	30.23	24.06	72.43	10.69	4.80
40 (Oct 1- Oct 7)	30.46	23.97	72.57	4.00	6.91
41 (Oct 8 - Oct 14)	31.20	24.07	72.14	3.33	7.17
42 (Oct 15 - Oct 21)	29.89	24.26	78.71	13.69	3.46
43 (Oct 22 - Oct 28)	27.47	23.20	88.00	46.63	2.53
44 (Oct 29 - Nov 4)	29.80	22.60	76.00	14.07	7.06
45 (Nov 5 - Nov 11)	31.21	24.01	72.71	0.83	7.17
46 (Nov 12 - Nov 18)	31.16	23.73	67.14	0.43	9.06
47 (Nov 19 - Nov 25)	32.17	24.20	66.00	0.00	8.67
48 (Nov 26 - Dec 2)	32.69	23.71	64.57	10.81	6.21
49 (Dec 3 - Dec 9)	31.74	22.37	59.43	1.04	7.63
50 (Dec 10 - Dec 16)	32.00	22.53	58.14	0.00	8.97
51 (Dec 17 - Dec 23)	31.83	22.10	57.57	0.00	8.57
52 (Dec 24 - Dec 31)	31.04	23.79	69.13	1.00	6.68
1 (Jan 1- Jan 7)	31.19	22.26	62.71	0.00	9.37
2 (Jan 8- Jan 14)	31.97	20.96	57.29	0.00	9.40
3 (Jan 15 - Jan 21)	31.36	22.23	58.43	0.00	9.17
4 (Jan 22 - Jan 28)	32.04	21.47	54.57	0.00	9.59

Appendix II

Effect of hybrids and micronutrient levels on cost of cultivation

Treatments	Cost of cultivation (₹ ha^{-1})							Total cost (₹ lakh ha^{-1})
	Seeds	Lime	Farm yard manure	Fertilizers (N+P+ K)	Micronutrients	Plant protection chemicals	Labour	
Sugar 75+ KAU POP Recommendation	18000	4375	90000	8580	NA	6039	87750	2.14
Sugar 75 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	18000	4375	90000	8580	238	6039	90000	2.17
Sugar 75 + KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	18000	4375	90000	8580	280	6039	92250	2.19
Sugar 75 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	18000	4375	90000	8580	518	6039	94500	2.22
KSCH 333+ KAU POP Recommendation	17625	4375	90000	8580	NA	6039	87750	2.14
KSCH 333 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	17625	4375	90000	8580	238	6039	90000	2.16

KSCH 333+ KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	17625	4375	90000	8580	280	6039	92250	2.19
KSCH 333+ KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	17625	4375	90000	8580	518	6039	94500	2.21
Misthi+ KAU POP Recommendation	13920	4375	90000	8580	NA	6039	87750	2.10
Misthi + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	13920	4375	90000	8580	238	6039	90000	2.13
Misthi+ KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	13920	4375	90000	8580	280	6039	92250	2.15
Misthi+ KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	13920	4375	90000	8580	518	6039	94500	2.17

Appendix III

Effect of hybrids and micronutrient levels on marketable yield and gross returns

Treatments	Marketable yield (t ha^{-1})	Gross Returns (₹ lakh ha^{-1})
Sugar 75+ KAU POP Recommendation	13.81	5.52
Sugar 75 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	12.15	4.86
Sugar 75 + KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	9.62	3.85
Sugar 75 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	8.81	3.52
KSCH 333+ KAU POP Recommendation	13.24	5.29
KSCH 333 + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	8.32	3.33
KSCH 333+ KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	7.38	2.95
KSCH 333+ KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	8.55	3.42
Misthi+ KAU POP Recommendation	7.86	3.14
Misthi + KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking	7.78	3.11
Misthi+ KAU POP Recommendation + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	7.19	2.87
Misthi+ KAU POP Recommendation + Spray of boron as solubor @ 0.15 % once at tasseling and silking + Spray of zinc as $ZnSO_4$ @ 1.0 % at 20 and 40 DAS	8.32	3.33

MICRONUTRIENT MANAGEMENT OF SWEET CORN (*Zea mays* var. *saccharata*) HYBRIDS FOR YIELD AND QUALITY

by

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ABSTRACT OF THE THESIS

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ABSTRACT

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An investigation entitled "Micronutrient management of sweet corn (*Zea mays* var. *saccharata*) hybrids for yield and quality" was undertaken with the objectives to evaluate the performance of sweet corn hybrids for yield and quality and to study the role of zinc and boron in increasing the productivity, quality and profitability of the crop. The study was carried out at College of Agriculture, Padannakkad and Regional Agricultural Research Station, Pilicode during 2019-2020. The experiment was laid out in factorial randomized block design with 12 treatments replicated thrice. The treatment combinations included three hybrids *viz*., H_1- Sugar 75, H_2- KSCH 333, H_3- Misthi and four levels of micronutrient application *viz.*, M_1- RDN of Maize as per KAU POP (control), M_2- RDN of Maize as per KAU POP + Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking, M_3- RDN of Maize as per KAU POP + Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing and M_4- RDN of Maize as per KAU POP + Spray of Boron as Solubor @ 0.15 per cent once at tasseling and silking + Spray of Zinc as $ZnSO_4$ @ 1.0 per cent at 20 and 40 days after sowing.

Perusal of the results on growth attributes revealed that sweet corn hybrids did not significantly influence plant height, number of leaves, leaf area, days to 50 per cent tasseling and silking, days to maturity and number of harvests. However, significant effects of hybrids were recorded in dry matter production. Highest dry matter accumulation was noticed in Sugar 75 (12027 kg ha^{-1}) and was statistically on par with Misthi (9962 kg ha^{-1}). Recommended dose of nutrients alone had resulted in highest plant height at 15 DAS and was on par with combined foliar application of zinc and boron. Leaf area was recorded maximum at 15 and 45 DAS in control plot and at 45 DAS, the treatment was on par with foliar application of zinc. Number of days taken for 50 per cent tasseling, silking and maturity was least in the control plot. Number of harvests did not differ significantly with micronutrient application. However, growth attributes did not show any significant variation between hybrids and their interaction with zinc and boron.

Hybrids did not differ in any of the yield attributes recorded. However, total cob yield and green stover yield varied significantly with hybrids. Among the different hybrids tested, Sugar 75 was superior recording a cob yield of 11102 kg ha^{-1}. Green stover yield was the highest in Sugar 75 (20667 kg ha^{-1}) and was on par with Misthi (19111 kg ha^{-1}). Among the yield attributes, the highest cob length was noticed in the control plot and was on par with foliar application of zinc and boron. Maximum cob girth was recorded in the control plot and was statistically on par with foliar application of zinc. Cob weight without husk was maximum when treated with recommended dose of fertilizers alone and was on par with foliar application of boron. Foliar nutrition with either zinc, boron or both had no influence on number of cobs per plant, number of kernel rows per cob, number of kernels per cob, hundred fresh kernel weight, cob weight with husk, total cob and stover yield. Visual symptoms of boron deficiency were observed in cobs irrespective of the treatments. The hybrids and their interaction with foliar application of micronutrients did not show significant influence on yield attributes. However, maximum cob yield (11640 kg ha^{-1}) was recorded when recommended dose of nutrients alone were given and among interaction effects, the highest cob yield (13813 kg ha^{-1}) was recorded when Sugar-75 was provided with recommended dose of nutrients alone and was on par with KSCH 333 and recommended dose of nutrients alone (13247 kg ha^{-1}).

Organic carbon and available boron content in the soil was not significantly influenced by hybrids, micronutrient application and their interaction. However, after harvest, there was an increase in the organic carbon content in the soil. Available boron content in the soil was in deficient range before and after the experiment.

Chlorophyll content did not vary significantly with hybrids and micronutrient application. Highest chlorophyll content (2.44 mg g^{-1}) was recorded when KSCH 333 was treated with recommended dose of fertilizers alone and was on par with all the interaction effects except when KSCH 333 was treated with foliar application of zinc and boron. Ascorbic acid content and moisture content was not significant among treatments.

Among the hybrids, mean per cent damage by fall army worm was recorded the lowest in Misthi. Micronutrient application and their interaction with hybrids did not significantly influence the pest incidence.

Highest net profit of ₹ 225710 ha^{-1} and BCR of 2.03 was realized with Sugar 75.

Therefore, it can be concluded from the study that ***growing sweet corn hybrid Sugar 75 is beneficial for getting higher yield per unit area and maximum economic returns. Visual symptoms of boron deficiency were evident, reflected as unfilled kernel rows within the cobs of sweet corn. The study also reveals that boron is a critical nutrient that influences the yield and yield attributes in sweet corn. Foliar application of boron @ 0.15 per cent once at tasseling and silking did not meet the requirements of the crop when grown in boron deficient soil. Hence, foliar application of a nutrient alone cannot alleviate the nutrient deficiency in the crop when grown under limited soil nutrient supply.***

സംക്ഷിപ്തം

മധുര ചോള (*Zea mays* var. *saccharata*) സങ്കരയിനങ്ങളിൽ വിളവും ഗുണനിലവാരവും വർദ്ധിപ്പിക്കുന്നതിനായുള്ള സൂക്ഷ്മ മൂലക പരിപാലനം എന്ന വിഷയത്തിൽ 2019 - 2020 കാർഷിക കോളേജ് പടന്നക്കാടിലും പീലിക്കോട് പ്രാദേശിക കാർഷിക ഗവേഷണകേന്ദ്രത്തിലും പഠനം നടത്തുകയുണ്ടായി. ഫാക്ടോറിയൽ റാൻഡമൈസ്ഡ് ബ്ലോക്ക് ഡിസൈനിൽ 12 പരിചരണമുറകൾ 3 തവണ ആവർത്തനത്തോടു കൂടിയാണ് പരീക്ഷണം കൃഷിയിടത്തിൽ ആവിഷ്കരിച്ചത്. മധുര ചോളത്തിന്റെ 3 സങ്കരയിനങ്ങളായ ഷുഗർ 75, KSCH 333, മിസ്തി എന്നിവയും നാല് വിധത്തിലുള്ള സൂക്ഷ്മ മൂലക പരിപാലന മുറകളും സംയോജിപ്പിച്ചാണ് പരീക്ഷണം നടത്തിയത്. M_1 - കേരള കാർഷിക സർവകലാശാല പാക്കേജ് ഓഫ് പ്രാക്ടീസസ് അനുസരിച്ച് ചോളത്തിന് ശുപാർശ ചെയ്യുന്ന മൂലകങ്ങൾ മാത്രം, M_2 - M_1 + ബോറോൺ സൊലുബോർ രൂപത്തിൽ 0.15 % വീര്യത്തിൽ ആൺ പെൺ പൂങ്കുലോൽപ്പത്തി സമയത്ത് തളിക്കുക, M_3 - M_1+ നാകം സിങ്ക് സൾഫേറ്റ് രൂപത്തിൽ 1% വീര്യത്തിൽ വിത്ത് നട്ടു 20 ദിവസത്തിനു ശേഷവും 40 ദിവസത്തിനു ശേഷവും തളിക്കുക, M_4 - M_1 + ബോറോൺ സൊലുബോർ രൂപത്തിൽ 0.15 % വീര്യത്തിൽ ആൺ പെൺ പൂങ്കുലോൽപ്പത്തി സമയത്ത് തളിക്കുക + നാകം സിങ്ക് സൾഫേറ്റ് രൂപത്തിൽ 1% വീര്യത്തിൽ വിത്ത് നട്ടു 20 ദിവസത്തിനു ശേഷവും 40 ദിവസത്തിനു ശേഷവും തളിക്കുക.

പരീക്ഷണഫലങ്ങൾ പരിശോധിക്കുമ്പോൾ മേൽപ്പറഞ്ഞ പരിചരണമുറകൾ വളർച്ചാ ലക്ഷണങ്ങളായ ചെടിയുടെ ഉയരം, ഇലകളുടെ എണ്ണം, വിസ്തൃതി, പൂങ്കുലയുണ്ടാകുന്നതിനും, മൂപ്പ് എത്തുന്നതിനും, വിളവെടുപ്പിനും ഉള്ള ദിനങ്ങൾ എന്നിവയെ കാര്യമായി സ്വാധീനിക്കുന്നില്ല എന്ന് കാണാം. എന്നാൽ സങ്കരയിനങ്ങൾ അനുസരിച്ച് ശുഷ്ക പദാർത്ഥത്തിന്

വ്യത്യാസമുണ്ട്. ഷുഗർ 75 എന്ന ഇനത്തിന് പരമാവധി ശുഷ്ക്ക പദാർത്ഥം (12027 കി.ഗ്രാം / ഹെക്ടർ) രേഖപ്പെടുത്തി.

വിളവിന്റെ ലക്ഷണങ്ങളായി കരുതുന്ന കതിർക്കുലയുടെ നീളം, വ്യാസം, തൂക്കം, ഒരു ചെടിയിൽ ഉണ്ടാകുന്ന കതിർക്കുലയുടെ എണ്ണം, ഓരോ കതിർക്കുലയിലെയും വിത്ത് പരിപ്പിന്റെ നിരകൾ, എണ്ണം, തൂക്കം എന്നിവയിൽ വലിയ വ്യത്യാസങ്ങൾ തിട്ടപ്പെടുത്തിയിട്ടില്ല. എന്നാൽ മൊത്തം വിളവുകളിൽ സങ്കരയിനങ്ങൾ അനുസരിച്ച് വ്യത്യാസം രേഖപ്പെടുത്തിയിട്ടുണ്ട്. ഷുഗർ 75 എന്ന ഇനം ഹെക്ടറൊന്നിന് പരമാവധി വിളവ് ഉത്പാദിപ്പിച്ചു (11102 കി.ഗ്രാം / ഹെക്ടർ). ധ്യാനക്കറ്റ കൂടുതൽ രേഖപ്പെടുത്തിയതും ഇതേ ഇനത്തിനാണ് (20667 കി.ഗ്രാം / ഹെക്ടർ) മിസ്തിയും താരതമ്യേന ഉയർന്ന വിളവ് രേഖപ്പെടുത്തി (19111 കി.ഗ്രാം / ഹെക്ടർ). പരിചരണമുറകൾ പരിഗണിക്കാതെ എല്ലാ ചെടികളിൽ നിന്നും ലഭിച്ച കതിർക്കുലയിൽ ബോറോൺ അഭാവ ലക്ഷണങ്ങൾ കാണുകയുണ്ടായി.

സങ്കരയിനങ്ങളും സൂക്ഷ്മ മൂലക പ്രയോഗവും മണ്ണിൽ ലഭ്യമായ ജൈവ കാർബണിനെയും, ബോറോണിനേയും സ്വാധീനിച്ചിട്ടില്ല. വിളവെടുപ്പിനുശേഷം മണ്ണിലെ ജൈവകാർബണിന്റെ അളവ് വർദ്ധിച്ചതായി കണ്ടു. പരീക്ഷണത്തിനു മുൻപും ശേഷവും മണ്ണിൽ ലഭ്യ രൂപത്തിലുള്ള ബോറോണിന്റെ അളവ് കുറവായിരുന്നു .

ഹരിതകം, അസ്കോർബിക്, അമ്ലം, ഈർപ്പം മുതലായവ സങ്കരയിനമനുസരിച്ചോ സൂക്ഷ്മ മൂലക പ്രയോഗമനുസരിച്ചോ മാറ്റങ്ങൾ രേഖപ്പെടുത്തിയിട്ടില്ല.

മിസ്റ്റി എന്ന സങ്കരയിനത്തിൽ പുഴുവിന്റെ ആക്രമണം കുറവുള്ളതായി പരീക്ഷണങ്ങളിൽ കണ്ടു.

ഏറ്റവും ഉയർന്ന അറ്റാദായവും (₹ 225710/ഹെക്ടർ) വരവ് ചെലവ് അനുപാതവും (2.03) ഷുഗർ 75 എന്ന സങ്കര ഇനത്തിൽ രേഖപ്പെടുത്തുകയുണ്ടായി.

ചുരുക്കത്തിൽ ഈ പഠനത്തിൽ നിന്നും ഉരുത്തിരിഞ്ഞ വസ്തുതകൾ :

- ഷുഗർ 75 എന്ന മധുര ചോളത്തിന്റെ സങ്കരയിനം വളർത്തുന്ന യൂണിറ്റ് സ്ഥലത്തുനിന്നും പരമാവധി വിളവും സാമ്പത്തിക വരുമാനവും ലഭിക്കാൻ ഉതകുന്നതാണ്.
- പരീക്ഷണ പ്ലോട്ടുകളിൽ ബോറോൺ എന്ന മൂലകത്തിന്റെ അഭാവലക്ഷണങ്ങൾ കാണപ്പെട്ടു. കതിർ കുലകളിലെ വിത്ത് പരിപ്പ് വരികൾ പൂർണ്ണമായി നിരക്കാതെ പ്രകടമായി.
- പഠനത്തിൽ നിന്നും മധുര ചോളത്തിന്റെ വിളവിനെ സ്വാധീനിക്കുന്ന നിർണ്ണായക മൂലകമാണ് ബോറോൺ എന്ന് വെളിവാക്കപ്പെട്ടു. കൂടാതെ, ബോറോൺ കുറവുള്ള മണ്ണിൽ മധുര ചോളം വളർത്തുമ്പോൾ 0.15 ശതമാനം എന്ന തോതിൽ സോലുബോർ പത്രപോഷണം പൂങ്കുലോൽപ്പത്തി സമയത്ത് മാത്രം പ്രയോഗിക്കുന്നത് വിളയുടെ ആവശ്യകത പൂർത്തീകരിക്കുന്നില്ല എന്ന് കാണാം. അതിനാൽ, ഒരു വിള പരിമിതമായ മൂലക ലഭ്യതയുള്ള മണ്ണിൽ വളർത്തുമ്പോൾ ആ മൂലകത്തിന്റെ പത്ര പോഷണം കൊണ്ടുമാത്രം മൂലകത്തിന്റെ ചെടിയിലെ കുറവ് പരിഹരിക്കാനാവില്ല എന്ന് ഉറപ്പിക്കാം.