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RV Bhangare
Research Scholar,
Department of Plant Physiology,
Banaras Hindu University,
Institute of Agril. Sciences,
Varanasi, Uttar Pradesh, India

VD Salunke
Associate Professor,
Department of Plant Physiology,
VNMKV, College of Agriculture,
Parbhani, Maharashtra, India

DH Sarang
Assistant Professor,
Department of Plant Physiology,
VNMKV, College of Agriculture,
Parbhani, Maharashtra, India

Correspondence
RV Bhangare
Research Scholar,
Department of Plant Physiology,
Banaras Hindu University,
Institute of Agril. Sciences,
Varanasi, Uttar Pradesh, India

Study on morpho-physiological and yield contributing characters response of sweet corn (*Zea mays* L.) to micronutrient application

RV Bhangare, VD Salunke and DH Sarang

Abstract
The experiment was conducted on experimental site of Wheat and Maize Research Unit, VNMKV, Parbhani during *kharif* season 2016-17. The soil was medium black with moderate moisture retention capacity. The land having uniform topography was used to study the responses of micronutrient's (Mg, Zn and B) to crop hybrid (Phule Madhu) under irrigated condition, by using soil and foliar application of (Mg, Zn and B) micronutrients in presence of RDF @ 120:60:50 NPK kg/ha. The experiment was laid out in RBD with three replication and ten treatments. The biometric observations and the yield parameters green cob weight with husk / without husk at harvest (kg/plot), cob length (cm), cob girth (cm), green cob sweetness (brix reading %) and cob yield (qt/ha) at harvest. The maximum cob yield was recorded by treatment T_7 (436.80 q ha^{-1}) with the application of 120:60:50 kg NPK/ha and spraying of Mg+ Zn+ B @ 1% at 30 and 45 DAS) (41.93 kg $plot^{-1}$ and 436.80 q ha^{-1}) which was at par with treatment T_8 (RDF+ Foliar application of Mg @ 1% at 30 & 45 DAS) (36.42 kg $plot^{-1}$ and 379.39 q ha^{-1}) and significantly superior over rest of treatments.

Keywords: Micronutrients, application, cob weight, cob yield, sweet corn (*Zea mays* L.)

Introduction

Sweet corn (*Zea mays* L.) is the world's most widely cultivated food crop providing ample food calories and protein for more than one thousand million human beings in the world. It is a member of family *Gramineae (Poaceae)* sub family *Panicoideae.* Maize is known as 'Queen of cereals' and 'King of fodder'. Maize has been usually considered as poor man's crop and is occupying the place in rich communities due to its multifarious uses as industrial, food and feed crop. Demand for maize in developing countries is projected to surpass wheat and rice by 2020 meaning that maize supplies for these areas must nearly be doubled. Maize (Zea mays L.) is one of the most versatile emerging crop having wide adaptability under varied agro-climatic conditions. It is globally the top ranking cereal high yield potential. Micronutrient play an active role in the plant metabolic process starting from cell development to respiration, photosynthesis, chlorophyll formation, enzyme activity, hormones synthesis, nitrogen fixation etc. The micronutrients are going to play a major protective role in bringing stability and sustainability in food production. The role of macro and micronutrients is crucial in yields. Nitrogen is a primary constituent of proteins and thus all enzymes (Raun and Johnson, 1999) [8]. P is involved in almost all biochemical pathways as a component part of energy carrier compounds, ATP and ADP (Khalil and Jan, 2003). Six micronutrients i.e. Mn, Fe, Cu, Zn, B and Mo are known to be required for all higher plants (Welch, 1995) [10]. These have been well documented to be involved in photosynthesis, N- fixation, respiration and other biochemical pathways (Marschner, 1986, Romheld, 1987 and Warman, 1992).

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Materials and Methods

The experiment was laid out in Randomized Block Design (RBD) with three replications and ten treatments *viz.*, Control (T1), RDF (120:60:50 kg NPK ha-1) (T2), RDF + 3 Content, through soil (Mg + Zn + B) (20 kg, 20 kg, 5 kg ha-1), respectively (T3), RDF + Mg (20 kg ha-1) soil application at the time of sowing (T4), RDF + Zn (20 kg ha-1) soil application at the time of sowing (T5), RDF + B (5 kg ha-1) soil application at the time of sowing (T6), RDF + foliar application at 30 and 45 DAS of Mg+ Zn + B @ 1% (T7), RDF+ foliar application of Mg at 30 and 45 DAS @ 1% (T8), RDF + foliar application of Zn at 35 and 45 DAS @ 1% (T9) and RDF + foliar application of B at 30 and 45 DAS @ 1% (T10). Plot size of individual treatment was gross 3.60 m x 4.00 m and net 2.40 m x 3.60 m. seed were sown at experimental farm of Wheat and Maize Research Unit, VNMKV, Parbhani following spacing of 60 cm x 20 cm during *Kharif* 2016 after receiving the sufficient rainfall. Only one healthy seedling was maintained. Data on morpho-physiological parameter such as plant height and leaf area were recorded at flowering and harvesting stage. Days to 50% tasselling and 50% silking were recorded from the date of sowing in all treatments similarly chlorophyll content in leaves was recorded at flowering stage. The result obtained were statistically analyzed and appropriately interpreted as per the methods described in "Statistical method for Agricultural Workers" by Panse and Sukhatme (1985) [6]. Appropriate standard error (S.E.) critical differences (C.D.) at 5 percent levels were worked out for interpretation of result.

Results and Discussions

Results pertaining to morpho-physiological traits presented in Table 1 revealed that plant height increased continuously upto the physiological maturity and reached (173.07 cm) at harvesting. The rate of increase in plant height was increasing upto the flowering. The data also indicated that there was constant increase in plant height with the commencement of growth flowering to harvesting. It was also noted that the effect of only NPK was found less as compared to combination of micronutrients along with recommended chemical fertilizer. In present study plant height (cm) at flowering (157.07) and harvesting (173.73) were found non-significant. These results accordance with Kamble and londe (2008) observed that application of zinc and boron resulted in increase in the plant height, (Table No.1). The cob height (cm) at flowering (104.55) and harvesting (119.55) were found non-significant. It is revealed from the data that plants grown under dose of fertilizers level (NPK) supported with micronutrients have showed beneficial effects to earliness in harvesting in maize. Data pertaining to the leaf area were recorded at flowering and harvesting stage. There was increase in leaf area of plant in preceding growth stages. It is apparent from the data that significantly highest leaf area was attained by plants under treatment T7 (RDF+ Mg SO4 + Zn SO4+ B @ 1% spraying 30 and 45 DAS) at both growth stages and at par with treatment T8 (RDF +Mg @ 20 kg ha-1 1% spraying at 30 and 45 DAS) (Table no.1 & Fig.no.1) and significantly superior over rest of the treatments. Similar results were reported by Hussain *et al.* (2005) [3] and Asif *et al.* (2013) [1]. Considering the concentration of NPK and the source of micronutrients application in combination gave highest leaf area than control. It might have accelerated the metabolic and physiological activity of plant and put up more growth by assimilating more amounts of major nutrients and ultimately increased the leaf area plant^{-1} in present investigation. It was predicted that the leaf area was increased with recommended dose of NPK along with micronutrients at both crop growth stages.

Table 1: Influence of different treatments on plant height, cob height and leaf area in sweet corn.

Treatments	Plant height (cm)		Cob height (cm)		Leaf area (dm^2)	
	At flowering	At harvesting	At flowering	At harvesting	At flowering	At harvesting
T_1: Control	144.03	169.36	93.18	112.95	50.56	48.37
T_2: RDF (120:60:50 kg NPK ha^{-1})	144.48	171.14	93.50	113.17	51.33	49.68
T_3: RDF + 3 Content, through soil (Mg + Zn +B) (20 kg, 20kg, 5kg ha^{-1}) respectively.	155.58	172.92	96.02	115.95	54.69	52.98
T_4: RDF + Mg (20kg ha^{-1}) soil application at the time of sowing	151.21	172.25	95.36	115.36	53.93	51.84
T_5: RDF + Zn (20kg ha^{-1}) soil application at the time of sowing	149.76	171.43	95.20	114.20	53.22	51.12
T_6: RDF + B (5kg ha^{-1}) soil application at the time of sowing	149.66	170.87	94.30	113.63	52.49	50.98
T_7: RDF + foliar application at 30 & 45 DAS of Mg + Zn + B @ 1%	157.07	174.73	104.55	119.55	57.17	56.45
T_8: RDF+ foliar application of Mg at 30 & 45 DAS @ 1%	156.93	174.43	99.95	118.62	56.86	55.36
T_9: RDF + foliar application of Zn at 30 & 45 DAS @ 1%	156.57	172.24	98.00	117.92	55.85	54.55
T_{10}: RDF + foliar application of B at 30 & 45 DAS @ 1%	156.54	170.87	97.08	116.75	55.32	53.54
S.E.$\pm$	3.827	2.165	4.136	1.110	0.323	0.340
C.D. 5%	NS	NS	NS	NS	0.998	1.010
C.V %	4.356	2.185	7.40	6.14	1.035	1.124
GM.	152.18	171.60	96.71	115.81	54.14	52.48

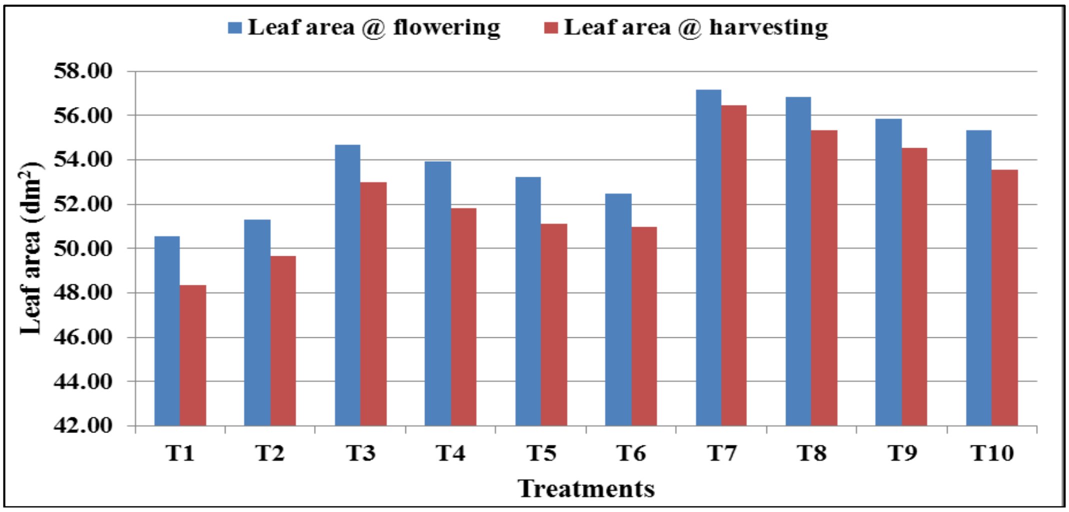

Fig 1: Influence of different treatments on mean leaf area at flowering and harvesting (dm^2)

Flowering of maize indicated by extrusion of anthers from the spikelet's on tassel and emergence of silk (stigma) from the husk. The days to tasseling and silking on present investigation were recorded when 50% of plants in plot emerged tassels and silks in maize grown under nutrients (NPK) along with micronutrients (Mg, Zn & B). The chlorophyll content in leaves was progressively increased with advancement in growth period and the maximum was attained at flowering stage and also the chlorophyll content was recorded the highest in treatment T_7 (RDF + Mg + Zn + B @ 1% spraying at 30 and 45 DAS) (64.87 SPAD) followed by T_8 (RDF +Mg @ 20 kg ha^{-1} 1% spraying at 30 and 45 DAS) (64.19 SPAD), T_9 (RDF+ Zn @ 20 kg ha^{-1} 1% spraying at 30 and 45 DAS) (63.36 SPAD) and T_{10} (RDF + foliar application of B at 30 & 45 DAS @ 1%) (63.09 SPAD) and significantly superior over rest of the treatments (Table no.2 & fig.no.2) Similar findings for chlorophyll index were recorded by Chaab *et al.* (2010) [2] and Panwar *et al.* (2011) [7].

Table 2: Influence of different treatments on Chlorophyll content, Days to 50% pollen shedding and Days to siliking in sweet corn.

Treatments	Chlorophyll content (SPAD) At flowering	Days to 50% pollen shedding	Days to silking
T_1: Control	54.68	49.67	59.67
T_2: RDF (120:60:50 kg NPK ha^{-1})	61.65	50.00	62.33
T_3: RDF + 3 Content, through soil (Mg + Zn + B) (20 kg, 20kg, 5kg ha^{-1}) respectively.	62.88	51.33	62.33
T_4: RDF + Mg (20kg ha^{-1}) soil application at the time of sowing	62.32	52.01	61.33
T_5: RDF + Zn (20kg ha^{-1}) soil application at the time of sowing	62.18	50.00	60.33
T_6: RDF + B (5kg ha^{-1}) soil application at the time of sowing	61.95	52.67	63.33
T_7: RDF + foliar application at 30 & 45 DAS of Mg + Zn + B @ 1%	64.87	51.01	65.01
T_8: RDF+ foliar application of Mg at 30 & 45 DAS @ 1%	64.19	51.00	62.02
T_9: RDF + foliar application of Zn at 30 & 45 DAS @ 1%	63.36	50.67	63.00
T_{10}: RDF + foliar application of B at 30 & 45 DAS @ 1%	63.09	51.32	60.33
S.E.±	0.727	0.985	1.006
C.D. 5%	2.159	NS	NS
C.V %	2.029	3.356	2.953
GM.	62.11	50.86	59.03

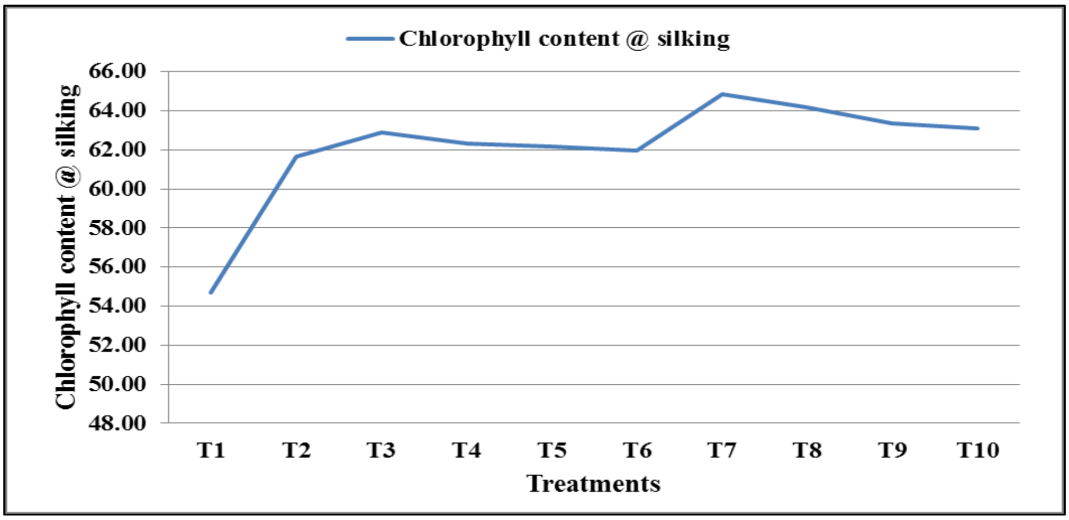

Fig 2: Influence of different treatments on mean chlorophyll content at silking (SPAD)

Similar results were reported by Hussain *et al.* (2005) [3] and Asif *et al.* (2013) [1]. As regards to higher yield (Table no.4 and Fig. 2) treatment T7 (RDF+ Mg SO4 + Zn SO4 + B spraying @1% at 30 and 45 DAS) (41.93 kg plot^{-1} and 436.80 q ha^{-1}) recorded significantly higher yield and was at par with T8 (RDF +Mg @ 20 kg ha-1 1% spraying at 30 and 45 DAS) (36.42 kg plot^{-1} and 379.39 q ha^{-1} cob yield), T9 (RDF+ Zn @ 20 kg ha-1 1% spraying at 30 and 45 DAS) (33.48 kg plot^{-1} and 348.71 q ha^{-1} cob yield) and T10 (RDF + Foliar application of B at 30 and 45 DAS @ 1%)(32.36 kg plot^{-1} and 337.12 q ha^{-1} cob yield) and T3 (RDF + 3 content, through soil) (Mg + Zn + B) (31.72 kg plot^{-1} and 330.39 q ha^{-1} cob yield) and significantly superior over rest of the treatment. Similar findings for chlorophyll index were recorded by Chaab *et al.* (2010) [2] and Panwar *et al.* (2011) [7].

Table 3: Influence of different treatments on cob length, girth, no. of rows/cobs, no. of kernels/row and no of cobs /plot in sweet corn.

Treatments details	Cob length (cm)	Cob girth (cm)	No. of rows/ cob	No. of kernels/ row	No. of cobs/ plot
T1: Control	23.83	16.90	13.06	30.00	74.33
T2: RDF (120:60:50 kg NPK ha-1)	24.50	17.70	13.63	32.53	75.33
T3: RDF +3 Content, through soil (Mg + Zn + B) (20 kg, 20kg, 5kg ha-1) respectively.	25.97	19.69	15.00	34.13	75.33
T4: RDF + Mg (20kg ha-1) soil application at the time of sowing	25.57	18.85	14.60	33.53	76.01
T5: RDF + Zn (20kg ha-1) soil application at the time of sowing	25.06	18.70	13.97	33.31	76.00
T6: RDF + B (5kg ha-1) soil application at the time of sowing	24.89	17.95	13.69	33.10	75.66
T7: RDF + foliar application at 30 & 45 DAS of Mg + Zn + B @ 1%	28.00	22.45	17.20	36.13	77.01
T8: RDF+ foliar application of Mg at 30 & 45 DAS @ 1%	27.56	21.81	16.72	35.77	75.67
T9: RDF + foliar application of Zn at 30 & 45 DAS @ 1%	26.46	20.57	15.46	34.67	76.00
T10: RDF + foliar application of B at 30 & 45 DAS @ 1%	26.15	19.79	15.22	34.53	75.33
S.E.+	0.331	0.243	0.276	0.594	0.601
C.D. 5%	0.984	0.723	0.820	1.764	1.784
C.V %	2.228	2.171	3.224	3.051	1.376
G M.	25.79	19.44	14.85	33.77	75.66

Table 4: Influence of different treatments on cob wt. with husk & without husk, cob yield/plot & cob yield qt/ha in sweet corn.

Treatments details	Cob wt. with husk (kg/cob)	Cob wt. without husk (kg/cob)	Cob yield (kg.plot^{-1})	Cob yield (qt.ha^{-1})
T1: Control	0.321	0.230	17.38	181.02
T2: RDF (120:60:50 kg NPK ha-1)	0.346	0.244	18.75	195.27
T3: RDF +3 Content, through soil (Mg + Zn + B) (20 kg, 20kg, 5kg ha-1) respectively.	0.504	0.414	31.72	330.39
T4: RDF + Mg (20kg ha-1) soil application at the time of sowing	0.470	0.366	28.32	295.03
T5: RDF + Zn (20kg ha-1) soil application at the time of sowing	0.442	0.342	26.49	275.92
T6: RDF + B (5kg ha-1) soil application at the time of sowing	0.378	0.288	22.24	231.67
T7: RDF + foliar application at 30 & 45 DAS of Mg + Zn + B @ 1%	0.623	0.533	41.93	436.80
T8: RDF+ foliar application of Mg at 30 & 45 DAS @ 1%	0.566	0.473	36.42	379.39
T9: RDF + foliar application of Zn at 30 & 45 DAS @ 1%	0.536	0.433	33.48	348.71
T10: RDF + foliar application of B at 30 & 45 DAS @ 1%	0.519	0.422	32.36	337.12
S.E.+	0.027	0.029	2.274	23.70
C.D. 5%	0.081	0.086	6.747	70.31
C.V %	9.951	13.49	13.63	13.63
G M.	0.470	0.374	28.90	301.13

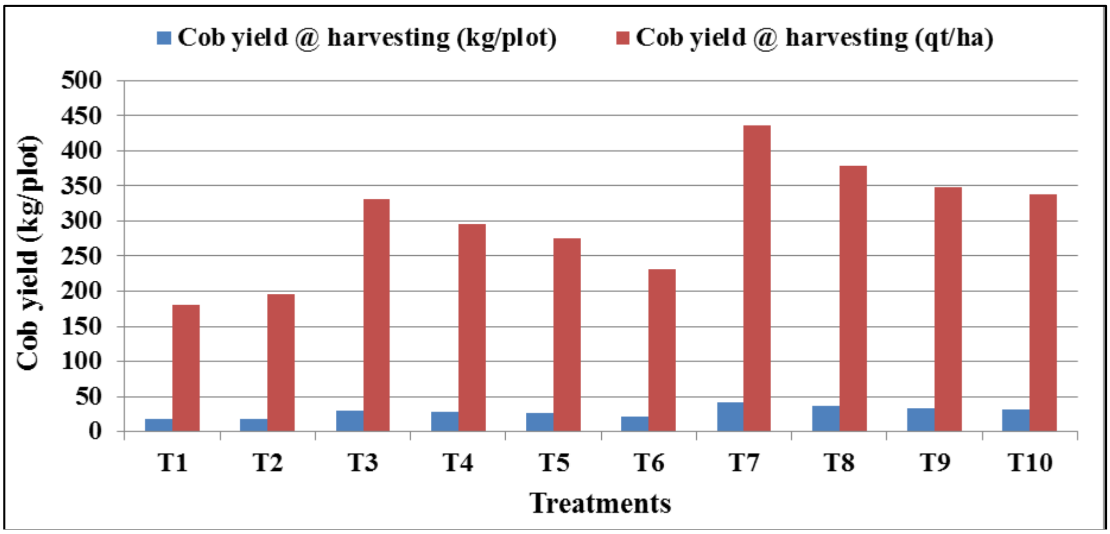

Fig 3: Influences of different treatments on mean cob yield (kg plot^{-1}) and (q ha^{-1}) at harvesting

Conclusion

Based on the findings of the present investigation following conclusion were drawn. Among all the treatment T_7 (RDF + $MgSO_4$ + $ZnSO_4$ + B spraying @ 1% at 30 and 45 DAS) showed higher in yield which was at par with treatment T_8 (RDF +Mg @ 1% spraying at 30 and 45 DAS) and significantly superior over rest of treatments. Among all the treatment T_7 (RDF + $MgSO_4$ + $ZnSO_4$ + B spraying @ 1% at 30 and 45 DAS) showed higher cob yield (41.93 kg $plot^{-1}$) and yield attributing character over the rest of the treatments. Application of micronutrients through foliar sprays gave significant results as compared to soil application under irrigated condition.

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