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Effects of Multi-Micronutrient Mixture on Growth, Yield and Quality of the Summer Pearl Millet (*Pennisetum glaucum* L.)

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A B S T R A C T

A field experiment was conducted on loamy sand soil of Anand (Gujarat) during *summer* season of the year 2017 to study the effects of multi-micronutrient mixture on growth, yield and quality of the pearl millet (*Pennisetum glaucum* L.). The soil used for the experiment was alkaline in reaction with low in available N and high in available P_2O_5 and K_2O. With respect to DTPA-micronutrients, Fe and Mn was deficient, while Zn and Cu were sufficient in status. The higher grain yield was obtained with the 1% foliar spray of multi-micronutrient mixture grade-III (for Fe deficiency) having concentration of Fe-6.0%, Mn-1.0%, Zn-4.0%, Cu-0.3% and B-0.5% at 15, 30 and 45 DAT (Days after Transplanting). While straw and total yield was higher under the soil application of micronutrients of 50 kg $FeSO_4.5H_2O$ ha^{-1} and 40 kg $MnSO_4.3H_2O$ ha^{-1} as per STV (Soil Test Value). Micronutrient supplementation through 1.0% foliar application of the mixture having concentration of Fe-4.0%, Mn-1.0%, Zn-6.0%, Cu-0.5% and B-0.5% (Grade-IV for Zn and Fe deficiency)was also found beneficial in increasing ear head length, grain, straw and total yield of summer pearl millet.

Introduction

Micronutrient deficiencies are becoming increasingly common in agriculture as a result of higher levels of removal by ever-more-productive crops combined with breeding for higher yields, at the expense of micronutrient acquisition efficiency. The, systematic studies for delineation of micronutrients in Gujarat reported 25% Zn and 25% Fe in different soils of Gujarat. The deficiency of Mn was also found to encores in some parts of the state (Anon. 2014-15). Pearl millet (*Pennisetum glaucum* L.) is one of the major coarse grain crops and is considered to be a poor man's food. It is the most drought tolerant crop among cereals and millets.

The diminishing use of micronutrients has lead to the occurrences of widespread deficiency of micronutrients especially of Zn and Fe which warrants the need for research on Zn and Fe on their usage individually and in mixtures as foliar/soil application. Therefore, the experiment was planned to study the effects of multi-micronutrient mixture on growth, yield and quality of the pearl millet.

Materials and Methods

A field experiment was conducted at Main forage Research Station, AAU, Anand during summer season of the year 2017 for studying effects of multi-micronutrients mixture in improving production of summer pearl millet (*Pennisetum glaucum* L.) (GHB-558).The treatment was comprised of T_1-control, foliar spray treatments: T_2-multi-micronutrient mixture grade-I (general), T_3-multi-micronutrient mixture grade-II (for Zn deficiency), T_4-multi-micronutrient mixture grade-III (for Fe deficiency), T_5-multi-micronutrient mixture grade-IV (for Zn & Fe deficiency) and soil application treatments: T_6-multi-micronutrient mixture grade-V and T_7-soil application of micronutrients as per soil test value (STV). The multi-micronutrient mixture grades having concentration shown in table 1 were prepared on the basis of average removal of micronutrients by different crops (grades I and IV) and other grades (II to IV) on the basis of wide spread occurrences of Zn or Fe or Zn and Fe deficiencies in soils of Gujarat. The multi-micronutrients mixture facilitate the application of the wide range of plant nutrients in the proportion and to suit the specific requirements of a crop in different stages of growth, and are more relevant under site specific nutrient management practices. Therefore, there is a need to promote balanced fertilization for which use of appropriate multi-micronutrient mixture grades would play a big role to improve nutrients use efficiency and enhance crops productivity for food and nutritional security.

The rate of application of different grades for foliar spray was kept 1%. The foliar application was made during crop growth period with three sprays at 15, 30 and 45 DAT (Days after Transplanting) of the crop and the soil application of grade-V was 20 kg ha^{-1} as basal. The treatments were tested against the standard recommended application of micronutrients (50 kg $FeSO_4.5H_2O$ ha^{-1} and 40 kg $MnSO_4.3H_2O$ ha^{-1}) on soil test value *i.e.* STV basis and control as well.

The treatments were replicated four times in a randomized block design. The soil of the experimental field was *Typic Ustochrepts*, loamy sand in texture and had $pH_{1:2.5}$-7.96, $EC_{1:2.5}$-0.44 dS m^{-1}, organic carbon-3.65 g kg^{-1}, available N- 188 kg ha^{-1}, available P_2O_5-80.70 kg ha^{-1}, available K_2O-301.6 kg ha^{-1}, available S-9.24 mg kg^{-1}, Fe-4.20 mg kg^{-1}, Mn-4.39 mg kg^{-1}, Zn-1.20 mg kg^{-1}, Cu-0.59 mg kg^{-1} and B-0.37 mg kg^{-1}. Before field preparation the pearl millet nursery was raised at Model laboratory, Micronutrient Research Project (ICAR) during February, 2017. The soil was collected from the experimental site and filled in micro plot and then pearl millet seed were broadcasted and nursery was prepared as per recommendation. After fertilization, pre-transplanting irrigation was given to the experimental plot. The uniform healthy seedlings of pearl millet cv. GHB–558 having an age of twenty days were uprooted after applying the irrigation to the nursery and one seedling per hill was transplanted at 45 cm x 10 cm spacing.

The field observation on plant height, ear head length, no. of effective tillers, test weight, grain and straw yield were recorded. Plant height was recorded at 30, 45 DAT and at harvest for five randomly selected tagged plants in each net plot and average was calculated and recorded separately. The ear head length from the some randomly tagged five plants was used for studying this character. Length of five ear heads was measured in centimetre from the cut end of the ear head to the tip of the ear head and mean was worked out and recorded plot wise. Number of effective tillers per meter row length was recorded from net plot area at harvesting of crop. From the composite samples of grain of each net plot, 1000 seeds were counted and the weight was recorded in g for all the experimental plots. The produce of each net plot was threshed separately, cleaned and the grain yield was recorded in kg per net plot and then converted into kg ha^{-1}. Straw yield was obtained by subtracting the grain yield of each net plot from their respective total dry matter (Above ground) yield and computed in terms of kg ha^{-1} and converted it on hectare basis. The percentage protein of grains was worked out by Lowry's method (Lowry's *et al.,* 1951). The soil samples drawn from the experimental field at harvest were analysed for available micronutrients by extracting with 0.005 M DTPA (Lindsay and Norvell, 1978) and the contents were determined on atomic absorption spectrophotometer. Boron content in soil was determined by spectrophotometer using azomethine-H by hot water method (Datta *et al.,* 2002). The plant samples were taken for determination of contents of micronutrients. Then samples were dried in paper bags at 70ºC in hot air oven till constant weight and ground in stainless steel grinder and were digested in di-acid mixture of HNO_3:$HClO_4$ (4:1) as per procedure outlined by Lindsay and Norvell (1978). Boron content in grain and straw samples was analysed by dry ashing method (Page *et al.,* 1982).

Results and Discussion

Growth

The effect of multi-micronutrient mixture on plant height of pearl millet at 30, 45 DAT and at harvest are presented in table 2. The little improvement in plant height of pearl millet was noticed at 30, 45 DAT and at harvest due to different treatments of multi-micronutrients mixture, but did not reach the level of significance.

The data on ear head length, no. of effective tillers, test weight of grain and harvest index of pearl millet for different treatments are presented in table 3. An appraisal of data revealed that the three foliar spray of 1% multi-micronutrient mixture Grade-IV (grade for Zn & Fe deficiency) at 15, 30 and 45 DAT recorded significantly the higher ear head length (23.40 cm) of pearl millet, over control. However, the T_5 was at par with soil application (T_6) of 20 kg ha^{-1} multi-micronutrient mixture (Grade-V) and STV (Soil Test Value) 50 kg $FeSO_4.5H_2O$ ha^{-1} and 40 kg $MnSO_4.3H_2O$ ha^{-1} which was also resulted in increase of ear head length. The increase in head length with the application of multi-micronutrient mixture Grade-IV might be due to Grade-IV is deficient in Zn and Fe and the soil was low in available Fe status, their supplementation in balanced form along with other micronutrients might have played an important role to mitigate the hidden hunger of the crop for micronutrients. Although the micronutrients are required in a small quantity, there supplementation during the crop growth help in better utilization of all other nutrients which in turn result in increase of crop growth of maize (Patel *et al.,* 2009). Further, the results revealed that there were no significant effect of multi-micronutrient mixture on No. of effective tillers, test weight and harvest index of pearl millet.

Yield

Foliar application of 1% multi-micronutrient mixture Grade-III (grade for Fe deficiency) at 15, 30 and 45 DAT recorded significantly higher grain yield of pearl millet (2291 kg ha^{-1}), wherein an overall increase of 299 kg ha^{-1} was observed over control (1992 kg ha^{-1}). It was remained at par with three foliar spray of 1% multi-micronutrient mixture Grade-II (grade for Zn deficiency) and Grade-IV (for Zn & Fe deficiency) and soil application of Grade-V (T_6) and Soil Test Value (STV) treatment. The increase in grain yield of pearl millet could be attributed to greater response of applied Grade-III (Fe deficiency) may be due to experimental soil was deficient in available Fe. The effect of Fe on grain yield can also be explained on the basis of relatively higher doses of Fe tended to produce more vegetative growth resulting from efficient utilization of nutrients, water, radiation and increased metabolic activities followed by increased translocation toward yield contributing characters, which might have led to significant increase in grain yield. Further, the addition of the micronutrients also helps in better utilization of the major nutrients to produce higher yield of crops. Earlier workers, Chandrakumar *et al.,* (2004), Singh and Ram (2005) and Esfahani *et al.*, (2014) have also reported similar increase in yield of wheat and rice due to Fe and/or Zn application under different agro-climatic conditions. Patel and Singh (2010) also found the beneficial effect of multi-micronutrients could be the balanced nutrition of the crops and thereby improved crop growth as well as yield.

The application of micronutrients of 50 kg $FeSO_4.5H_2O$ ha^{-1} and 40 kg $MnSO_4.3H_2O$ ha^{-1} as per STV (Soil Test Value) increased straw (4906 kg ha^{-1}) and total (7138 kg ha^{-1}) yield of pearl millet was significantly higher over control. The maximum increase of 702 kg ha^{-1} and 942 kg ha^{-1}was observed respectively, over control. However, in case of straw yield it was at par with T_3 (Grade-II), T_4 (Grade-III) and soil application (Grade-V), while total yield was at par with T_3 (Grade-II), T_4 (Grade-III), T_5 (Grade-IV) and T_6 (Grade-V) (Table 4). It's might be due to the favourable effect of applied Fe on these growth parameters may be ascribed to synergetic effect of Fe on most of the photosynthesis, physiological and metabolic processes of the plant followed by increased translocation toward yield contributing characters, which might have led to significant increase in straw yields of rice (Ali *et al.,* 2014, Abid *et al.,* 2002 and Keram *et al.,* 2012).

Since, site of experiment was categorized as low with regard to soil available Mn, its supplementation through soil application might have increase that Mn-containing enzymes *viz.* alcohol dehydrogenase, carbonic anhydrase, alkaline phosphatase, phospholipase, carboxypeptidase, and RNA polymerase which improve the photosynthetic activity and translocation.

Good responses to Mn fertilization in terms of attaining high crop yield on Mn-deficient soils have been reported by (Nayyer *et. al*., 1985; Soni 1996; Sharma and Bapat 2000; Bansal and Khurana 2002; Varshney *et al.*, 2008; Dhaliwal *et al.,* 2009).

Khan *et al.*, (2008) also reported improvements in wheat yield with soil application of Mn. They indicated that the apparent mechanism for improvements in wheat yield due to application of Mn might be due to the increase in leaf area index, providing an improved resource generating base for the crop *i.e.* an improved carbohydrate source. The consequence of this improved source is the improvement in overall biomass and consequently improvements in yield components of the crop.

Crude protein

The mean data regarding protein content in pearl millet grain as influenced by multi-micronutrient mixture application are presented in table 5.

The result revealed that there was no significant effect of application of multi-micronutrient mixture on protein content of pearl millet.

Table.1 Composition of different grades

Sr. No.	Grade	Content (%)				
		Fe	Mn	Zn	Cu	B
1.	LF Grade I (General)	2	0.5	4.0	0.3	0.5
2.	LF Grade II (For Zn deficiency)	2	0.5	8.0	0.5	0.5
3.	LF Grade III (For Fe deficiency)	6	1.0	4.0	0.3	0.5
4.	LF Grade IV (For Zn & Fe deficiency)	4	1.0	6.0	0.5	0.5
5.	LF Grade V (Soil application)	2	0.5	5.0	0.2	0.5

Table.2 Effect of multi micronutrient mixture on plant height (cm) of pearl millet

Treatments	Period		
	30 DAT	45 DAT	At Harvest
T_1: Control	73.3	117	121.80
T_2: Grade-I (FS)	73.1	118	125.10
T_3: Grade-II (FS)	73.9	119	125.85
T_4: Grade-III (FS)	73.3	119	125.33
T_5: Grade-IV (FS)	72.8	118	126.30
T_6: Grade-V (SA)	73.9	123	126.30
T_7: STV	77.2	122	126.05
SEm ±	1.3	1.8	1.78
CD at 5%	NS	NS	NS
CV (%)	3.5	3.0	2.85

Table.3 Effect of multi micronutrient mixture on growth of pearl millet

Treatments	Ear head length (cm)	No. of tillers per meter row length	Test weight (g)	Harvest index (%)
T_1: Control	20.98	24.63	7.78	32.13
T_2: Grade-I (FS)	22.18	25.42	7.90	31.72
T_3: Grade-II (FS)	22.45	25.26	8.18	32.35
T_4: Grade-III (FS)	22.18	25.24	8.05	33.07
T_5: Grade-IV (FS)	23.40	28.00	8.14	32.97
T_6: Grade-V (SA)	23.15	25.70	8.13	32.04
T_7: STV	22.50	24.09	8.15	31.27
SEm ±	0.34	1.07	0.13	1.03
CD at 5%	1.00	NS	NS	NS
CV (%)	3.01	8.36	3.29	6.41

Table.4 Effect of multi micronutrient mixture on yield (kg ha^{-1}) of pearl millet

Treatments	Grain	Straw	Total
T_1: Control	1992	4204	6196
T_2: Grade-I (FS)	2014	4345	6359
T_3: Grade-II (FS)	2214	4650	6863
T_4: Grade-III (FS)	2291	4654	6945
T_5: Grade-IV (FS)	2268	4615	6883
T_6: Grade-V (SA)	2260	4792	7052
T_7: STV	2232	4906	7138
SEm ±	63	140	141
CD at 5%	187	417	419
CV (%)	5.8	6.1	4.1

Table.5 Effect of multi micronutrient mixture on protein content of pearl millet

Treatments	Protein content (%)
T_1: Control	1.97
T_2: Grade-I (FS)	1.90
T_3: Grade-II (FS)	2.00
T_4: Grade-III (FS)	1.91
T_5: Grade-IV (FS)	1.81
T_6: Grade-V (SA)	1.94
T_7: STV	1.98
SEm ±	0.06
CD at 5%	NS
CV (%)	6.17

In conclusion, the results of the present study indicated that from yield point of view, soil application as per STV (Soil Test Value) or application of multi-micronutrient mixture (except Grade-I) were found significantly superior over control. Foliar application and soil application of multi-micronutrient mixture grades found comparable with STV indicated that chemical load can reduce without affecting the yield of pearl millet.

Thus, the finding of the present study suggested that agronomic approach for yield and micronutrients concentration enhancement could be better accomplished by its supplementation through soil (basal) or foliar application at 15, 30 and 45 DAT (Days after Transplanting) of summer pearl millet.

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