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NUTRITIONAL STUDIES FOR DRY MATTER YIELD AND MINERAL CONCENTRATION OF CROPS

Part II. Effect of Nutrients on Sorghum *(Sorghum volgare)*

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The sorghum crop when grown in a calcareous sandy-loam soil (pH 8.2), responded well to the application of nitrogen, phosphorus, copper, zinc and manganese. The results were more favourable in case of combined treatments than with single applications. Thus, such combinations like, NPCuZn, NPCu, NPCuMn, NPZn were comparatively more efficient to increase the dry matter yield of the crop. The analysis of the crop for mineral concentration revealed that the addition of any one of the element among nitrogen, phosphorus, copper, zinc and manganese strongly decreased the concentration of other elements in plants. In this respect single treatment, i.e. NCu, NZn, NMn, NPCu, NPZn and NPMn were more effective than full combinations like NCuZnMn and NPCuZnMn, NPCuZn, NPZnMn and NPCuMn in depressing the mineral concentrations.

INTRODUCTION

The necessities for higher yields of crops have increased the utilization of nitrogen and phosphorus fertilizers in Pakistan. Beside, major nutrients (NPK) micronutrients have also been tried for some crops. In this regard, experiments have conducted mostly for rice and wheat [1]. The rice is cultivated in flooded conditions where most of nutrient elements are more soluble and mobile than in upland conditions [2]. The wheat is grown in upland soils but in winter season which is conducive for more availability of minerals [3]. Therefore, it was felt necessary that a representative upland crop, grown in summer season should be tested both for major and minor elements and the best combinations of these elements should be determined. Therefore, sorghum crop which is grown in summer and upland conditions, was selected for such studies. The findings of the present research work will help greatly both to the scientists and farmers for the application of fertilizers and finally to boost the yields of many kharif crops.

EXPERIMENTAL

Five kilogram soil was taken into plastic containers (19 cm dia and 18.5 cm height) and the following treatments were given: (1) Nitrogen at the rate of 168.00 kg/hectare as urea. (2) Phosphorus at the rate of 50.00 kg/hectare as single superphosphate. (3) Copper, zinc and manganese were added at 5.00, 8.00 and 5.50 p.p.m. respectively as their sulphates.

Following combinations and single applications for various treatments were used: (1) Control, (2) N (3) P (4) NP (5) NCu (6) NZn (7) NMn (8) NCuZn (9) NCuMn (10) NZnMn (11) NPCuZn (12) NPCuMn (13) NPZnMn (14) NCuZnMn and (15) NPCuZnMn.

Nitrogen was given in split doses, one at the time of sowing and other after 20 days. However, phosphorus, copper, zinc and manganese were added in single doses at the time of sowing the seeds. The treatments were replicated thrice and completely randomized design was employed.

Eight seeds, variety V-263, were sown in each pot. Irrigation was done with deionized water at 7–15 days interval, according to the need. Five plants per pot were maintained and the crop was harvested at preflowering stage.

Soil Analysis. The soil used was characterized with the determinations of (1) Texture by hydrometer method [4]. (2) Electrical conductivity of saturated paste extract and pH of saturated paste by the techniques described by US salinity staff [5]. (3) Total nitrogen, lime and organic

Table 1. Effect of nitrogen and phosphorus application on the dry matter yield and mineral concentration in sorghum at preflowering stage.

Treatments	Dry matter yield (g/pot)	Mineral concn.			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
Control	10.782 b	0.097 b	4.65 a	20.46 a	84.13 a
N	24.479 a	0.097 b	4.67 a	18.75 c	82.56 a
P	14.023 b	0.112 a	2.38 c	14.59 d	67.73 b
NP	25.269 a	0.122 a	3.38 b	19.09 b	54.83 c
S.E.	1.30	0.004	0.046	0.064	1.890

Table 2. Effect of nitrogen, copper, zinc and manganese application in various combinations on the dry matter yield and mineral concentration of sorghum at preflowering stage.

Treatments	Dry matter yield (g/pot)	Mineral concn.			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
N	24.479 e	0.095 b	4.67 e	18.75 e	82.56 c
NCu	25.834 cd	0.083 c	5.89 ab	13.40 h	75.20 cd
NZn	24.748 de	0.083 c	3.72 f	23.70 d	67.94 de
NMn	24.399 e	0.084 c	4.81 d	13.82 g	128.87 a
NCuZn	36.244 ab	0.093 b	5.81 b	25.54 b	63.10 e
NCuMn	27.594 c	0.080 c	5.99 a	15.29 f	97.72 b
NZnMn	35.628 b	0.110 a	2.41 g	37.38 a	103.54 b
NCuZnMn	38.322 a	0.114 a	5.68 c	25.02 c	104.70 b
S.E.	0.787	0.001	0.035	0.090	3.620

matter percentage by standard methods [6]. (4) Available phosphorus was determined colorimetrically with stannus chloride [7]. (5) Available copper, zince and manganese were measured by atomic absorption spectrophotometerically using DTPA as extractant [8].

The various physical and chemical values of the soil were: texture sandy loam saturation 28%,electrical conductivity of saturation extract (EC $\times 10^3$) 8.81,pH of the saturated soil paste 8.2,potassium of saturation extract (me/l) 1.60, sodium of the saturation extract (me/l) 97.82, chloride of the saturation extract (me/l) 25.04%, lime 9.50%, organic matter 0.74%, cation exchange capacity (me/100g) 8.92%, available phosphorus (ppm) 10.50%, available copper (ppm) 0.90%, available zinc (ppm) 2.15%, available manganese 7.39%, and total nitrogen 0.026%.

Plant Analysis. The harvested plant material was first washed with deionized water and later with distilled water. The plant samples now obtained were dried in the air and finally placed into the oven at 60^o for complete dryness. Then the samples were weighed for dry matter yield. In the end for total plant analysis the plants were cut into small pieces and then ground in a mill fitted with stainless-steel blades. Following determinations were made: (1) Total phosphorus in case of major nutrients. (2) Total copper zinc and manganese among micronutrients.

To analyse total copper, zinc and manganese, the plant samples were digested in nitric acid (concd) and perchloric acid. Then from the digested material phosphorus was determined by yellow colour method [5], whereas, copper zinc and manganese by atomic absorption spectrophotometrically [9]. The results obtained for various characteristics were subjected to anlaysis of variance and means were compared with each other by Duncan Multiple Range Test.

RESULTS AND DISCUSSION

The Effect of Treatment on Dry Matter Yield. The data regarding the yield are furnished in Tables 1–3. It is evident that application of nitrogen either alone (N) or in combination with phosphorus (NP) significantly increased the dry matter yield. However, the effect of phosphorus

Table 3. Effect of NP, copper, zinc and manganese application in various combinations on the dry matter yield and mineral concentration of the sorghum at preflowering stage

Treatments	Dry matter yield (g/pot)	Mineral concn..			
		P (%)	Cu (p.p.m.)	Zn (p.p.m.)	Mn (p.p.m.)
Np	25.269 d	0.122 a	3.38 d	19.09 d	54.83 d
NPCu	34.638 b	0.082 d	5.59 a	14.62 e	65.30 c
NPZn	34.013 b	0.083 d	2.91 e	25.38 b	62.88 c
NPMn	29.077 c	0.087 d	2.92 e	19.01 d	97.72 a
NPCuZn	38.163 a	0.095 c	4.70 b	24.36 c	67.49 c
NPCuMn	35.608 b	0.109 b	4.85 b	14.65 e	89.00 b
NPZnMn	37.238 ab	0.097 c	2.61 f	27.23 a	84.12 b
NPCuZnMn	35.861 b	0.097 c	3.77 c	24.38 c	83.64 b
S.E.	1.214	0.004	0.083	0.153	2.180

alone (P) in this regard was insignificant as compared to control. The response of nitrogen could be explained that the soil used contained a little quantity of organic matter (Table 1), which was unable to provide sufficient amount of nitrogen to plants [10].

Application of copper, zinc and manganese, in various combinations markedly raised the dry matter yield of the crop. Highest increase was noticed in case of NCuZnMn treatment, where there was 56.5% increase over nitrogen alone treatment kept as control (Table 2). Treatment NCuZnMn was followed by NCuZn, NZnMn, NCuMn, NCu and NZn, towards the increase in dry matter yield. However, NMn treatment decreased the yield but nonsignificantly.

In the presence of NP as control (Table 3) the crop responded well to the addition of copper, zinc and manganese when applied in various combinations. In this respect NPCuZn treatment proved best and the increase was 51.00% over control. Other treatments like NPZnMn, NPCuZnMn, NPCuMn, NPCu, NPZn, and NPMn were in descending order respectively in promoting the dry matter yield.

The effect of trace elements with respect to the increase in dry matter yield of the crop could be regarded to the formation of auxins which otherwise would had been destroyed by the high light intensity of the summer season [11]. Adequate supply of copper, zinc and manganese therefore, produced the sufficient amount of these growth hormones which consequently increased the dry matter yield. The results are in accordance with the previous work [9].

The Effect of Treatment on Mineral Concentrations. The addition of nitrogen alone (N) did not effect mineral concentration in sorghum plants except zinc which was significantly decreased (Table 1). On the other hand, the use of phosphorus, either alone or in combination with nitrogen considerably reduced the concentration of copper, zinc and manganese in sorghum straw and the behaviour might be due to the precipitation or inactivation of the trace elements as phosphates [12].

The reaction of micronutrients, towards the concentration of phosphorus, copper, zinc and manganese was mainly antagonistic. The results presented in Tables 2 and 3, showed that the addition of copper, zinc and manganese in various combinations alongwith N and NP as check, depressed the concentration of phosphorus in the crop. A similar negative tendency among copper, zinc and manganese was also observed. In this respect combinations like NCu, NZn, NMn, NPCu, NPZn, and NPMn were comparatively more effective than other combinations. These findings were in resemblence with previous investigations on the similar lines [13].

CONCLUSIONS

The sorghum crop responded well to the application of nitrogen, phosphorus, copper, zinc and manganese, when added to the soil in various combinations. Thus, such treatments like NPCuZn, NPZnMn, NPCuZnMn, NPCuMn, NCuZnMn, NCuZn were comparatively better than rest of the combinations. The response of the crop to copper, zinc and manganese invites attention of researchers working on soil fertility and plant nutritions that beside nitrogen and phosphorus, micronutrients like copper, zinc and manganese may necessarily be tried for crops grown in upland conditions and summer season.

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