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Direct effect of magnesium, potassium and calcium on yield, protein content and Mg uptake by fingermillet (*Eleusine coracana*) in acid soil

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ABSTRACT

A pot-culture experiment was conducted during 1992–93 to study the effect of Mg, K and Ca on the Mg uptake, protein content and yield of fingermillet [*Eleusine coracana* (L.) Geartn.]. Magnesium application at 50 kg/ha and Ca @ 16.8 tonnes/ha gave significantly higher grain and straw yields. Magnesium uptake was significantly increased by 30.3, 13.0, 30.5 and 13.0% over the control in grain, straw, roots and dry matter respectively, and protein content by 15.9% in the grains. There was a significant reduction of total dry matter, root and straw by potasssium application. The Mg x K interaction was significant, indicating the antagonistic effect.

Magnesium uptake is controlled by the ratio of many ions present in the soil, especially of ions like Ca^{2+} and K^+. Soluble magnesium compounds in acid soils are transformed into a more sparingly soluble form on liming, while the effect of excessive application of calcium could be removed by magnesium and vice versa (Bolton, 1972). Mathan *et al.* (1973) reported Mg deficiency in about 67.5% of the cultivable soils of the acid soils of Nilgiris. An experiment was conducted to explore the possibility of improving the yield and protein content in grains of fingermillet [*Eleurine coracana* (L.) Gaertn.] by application of potassic fertilizers and liming materials along with magnesium fertilizers.

MATERIALS AND METHODS

A pot-culture experiment was conducted on acid soil of the Nilgiris during 1992–93. The soil (0–0.15 m) was loam in texture having pH_w (1 : 2) 3.8, electrical conductivety 0.2 dS/m, organic carbon 6.3 g/kg, $KMnO_4$-N 113 kg/ha, Bray-II P 11 kg/ha, 1 N NH_4OAc-K 130 kg/ha and 1 N NH_4OAc-Mg 0.99 meq/100 g. The NH_4OAc-extractable Mg was less than 2.3 me, being the critical level suggested for the acid soils of Nilgiris (Mathan, 1979).

Each pot of 30 cm diameter and 30 cm height was filled with 5 kg soil. There were 2 levels of calcium (0 and 16.8 tonnes/ha), potassium (0 and 100 kg K_2O/ha; K_0 and K_1 respectively) and 4 levels of Mg (0,50,100 and 150 kg/ha; Mg_0, Mg_1, Mg_2 and Mg_3). 'Calcium was added as $CaCO_3$, K as muriate of potash and Mg as $MgSO_4$. A basal dose of 40 kg N/ha and 25 kg P/ha in the form of ammonium sulphate and diammonium phosphate (DAP) respectively was incorporated into each soil. The quantity of N supplied through the diammonium phosphate was taken into account while calculating N. Five seedlings at age of 25 of 'Co. 9' fingermillet were transplanted in each pot. At harvest grain, straw and root yields were recorded separately. Protein content in root, shoot and grain samples was determined by multiplying the total N (determined by Kjeldahl's method) by 6.25 (AOAC, 1965). Total Mg in the above samples was estimated as per the method described by Metson (1956), and uptake was worked out.

RESULTS AND DISCUSSION

Yield

Grain, straw and root yields increased significantly up to 50 kg Mg/ha (Mg_1); however, there was a significant reduction beyond 50 kg Mg/ha (Table 1). The significant response of fingermillet to Mg addition was due to its low status in the experimental soil. The reduction in yield beyond Mg_3 level is probably due to availability of more than optimum level of Mg in soil at Mg_2 level, or beyond Mg_1 level the Mg balance with K and Ca becomes upset.

The interaction effect of Mg x K was significant (Table 2). At K_0 level, magnesium-applied crop recorded significantly higher grain yield, while at K_1 level the response to Mg application was not significant. Though there was a tendency for reduction in yield due to K application at all levels of Mg, it was not significant.

The interaction effect of Mg x lime was also significant. At L_0, magnesium-applied crops yielded significantly higher grain while they were at par among themselves. At L_1 level response to Mg application was recorded at Mg_1 level, beyond which there was significant reduction. But at any Mg

Table 1. Influence on Mg, lime and K on yield, Mg uptake and protein content of fingermillet

Treatment	Yield (mg/pot)			Magnesium uptake (mg/pot)			Protein content (%)
	Grain	Straw	Root	Grain	Straw	Root	
Mg level							
Mg_0	4.83	13.62	3.60	2.28	7.56	1.97	5.41
Mg_1	6.12	15.84	4.69	2.98	8.54	2.57	6.27
Mg_2	5.52	14.65	4.56	2.91	8.08	2.53	6.29
Mg_3	5.32	14.00	4.46	3.12	7.73	2.42	6.49
CD (P = 0.05)	0.27	0.95	0.12	0.18	0.63	0.04	0.78
Lime level							
L_0	4.41	12.46	3.75	2.57	6.84	2.06	5.82
L_1	6.44	14.80	4.94	3.08	8.11	2.69	5.81
CD (P = 0.05)	0.26	1.34	0.17	0.31	0.25	0.31	NS
K level							
K_0	5.55	14.46	4.55	2.97	8.97	2.49	5.89
K_1	5.76	12.81	4.14	2.68	6.99	2.26	5.75
CD (P = 0.05)	NS	1.11	0.17	0.25	0.52	0.13	NS

Details of treatments are given in text

Table 2. Interaction effect of magnesium, lime and potassium on yield, Mg uptake and protein content of fingermillet

Treatment	Yield (g/pot)				Mg uptake (mg/pot)			
	L_0		L_1		L_0		L_1	
	K_0	K_1	K_0	K_1	K_0	K_1	K_0	K_1
Grain								
Mg_0	3.94	3.62	5.68	6.06	1.88	1.72	2.68	2.85
Mg_1	5.00	4.96	6.98	7.52	3.22	2.35	3.17	3.18
Mg_2	9.22	3.68	6.64	6.92	2.94	2.50	3.11	3.05
Mg_3	4.00	5.14	6.92	5.22	2.93	3.38	4.17	2.41
CD (P = 0.05)								
Mg x K	0.40				0.44			
Mg x L	0.37				0.44			
Mg x K x L	NS				NS			
Straw								
Mg_0	14.32	11.34	16.50	12.30	8.06	6.22	9.15	6.79
Mg_1	16.32	14.54	18.10	14.40	8.70	8.03	10.03	7.39
Mg_2	19.62	11.08	14.18	13.70	10.84	6.10	7.83	7.56
Mg_3	14.38	12.44	16.56	12.62	7.92	6.85	9.20	6.94
CD (P = 0.05)								
Mg x K	NS				0.95			
Mg x L	NS	NS						
Mg x K x L								
Root								
Mg_0	3.72	2.82	3.92	3.94	2.01	1.56	2.17	2.12
Mg_1	3.66	4.30	6.16	4.62	2.01	2.36	3.40	2.52
Mg_2	3.88	4.56	5.68	4.36	2.08	2.53	3.14	2.36
Mg_3	2.90	4.12	6.46	1.60	2.28	3.48	2.30	
CD (P = 0.05)								
Mg x K	0.35				NS			
Mg x L	0.35				0.37			
Mg x K x L	NS				NS			

Treatment details are given in text

level lime application significantly increased the grain yield, the percentage increase over L_0 was 55.3, 50.4, 47.9 and 32.8 at Mg_0, Mg_1, Mg_2 and Mg_3 levels respectively. Thus at higher levels of magnesium availability the crop showed decreased response to lime application.

Magnesium uptake

The magnesium uptake by grain, straw and root portion ranged from 1.72 mg/pot (Mg_2 K_0 L_0) to 4.17 mg/pot (Mg_3 K_0 L_1), from 6.10 mg/pot (Mg_2 K_1 L_0) to 10.84 mg/pot (Mg_2 K_0 L_0) and from 1.56 mg/pot (Mg_0 K_1 L_0) to 3.48 mg/pot (Mg_3 K_0 L_1)

respeuuvely. Application of Mg at 50 kg/ha (Mg_1) significantly increased Mg uptake by grain, straw, root and by the total dry matter, the increase being 30.3, 13.0, 30.5 and 13.0% over the respective controls. At Mg_2 level uptake of Mg in grain and total dry matter significantly decreased. The significant decrease of Mg uptake in root and straw was observed only at Mg_2 level. Liming the soil increased the uptake significantly, the percentage increase being 18.9, 18.6, 30.6 and 21.1 by grain, straw, root and total dry matter respectively. This might be due to acidic nature of the soil and magnesium is an alternate source in improving acid soils (Mathan, 1979). There was a significant reduction in Mg uptake by K application, being 10.8, 28.3, 10.2 19.9% in grain, straw, root and total dry matter respectively. This might be due to higher available K status of the experimental soil that exhibited its antagonistic effect with Mg. Salmon (1963) reported similar antagonistic effect between K and Mg.

Interaction of Mg x K was significant by Mg uptake up grain and straw (Table 2). At K_0 level, the highest uptake was registered in Mg_1 level, which was significantly higher than others. At K_1 level though Mg-applied plots registered significantly higher Mg uptake than Mg_0, they were at par between them. Thus at higher K level, the response to Mg was negligible. At Mg_0 level, there was no significant response to K, but in Mg-applied plots there was significant reduction in Mg uptake, being 16.8, 17.4 and 19.6% under Mg_1, Mg_2 and Mg_3 levels respectively. This phenomenon is due to the antagonistic reaction between Mg x K. Similar effect was reported by Bolton (1972). Response of straw and total dry matter to K application on Mg uptake was similar to that of grains.

Similarly, there was significant Mg x lime interaction. At L_0 level, Mg application could increase Mg uptake significantly, while different levels were at par. Similar results were obtained at L_1 level. Liming at Mg_0 level caused significant Mg uptake, but at increasing Mg levels the response was non-significant. Similar trend was observed for root and total dry matter; but there was no significant interaction effect of straw.

Grain protein

Liming and potassium application did not influence the grain protein. Application of Mg increased significantly the protein content, the increase over the control being 15.9, 16.3 and 20.0% under Mg_1, Mg_2 and Mg_3 levels respectively. Functions of Mg in the living process of plants are many, of which its role on chlorophyll formation and protein synthesis is well-documented (Salman, 1863).

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