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Influence of Magnesium Application in Combination with Potassium and lime on the yield of ragi (*Eleusine Coracana* Gaertn.) In Acid soils

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A pot culture study with sixteen treatments (combination of two levels of lime, two levels of K_2O and four levels of magnesium) was conducted with CO 7 ragi (*Eleusine Coracana* Gaertn.) as the test crop. The results indicated that application of magnesium at the rate 50 kg Mg/ha was the optimum in increasing the yield. Ragi yield was increased by 15.14 per cent. However quadratic In both the soils liming depressed the yield Under high calcium content in the soil, lower availability of magnesium and phosphorus was observed.

Potassium did not influence the ragi yield. Top/root ratio indicated that root was affected more intensely by magnesium than the tops Soil variations in their response to application of magnesium, lime and potassium were significant. Titukkal soil was better than Doddabetta soil.

Literature on magnesium deficiency invariably emphasised the need to study this problem in conjunction with calcium and potassium. (Berry and Ulrich. 1970; Hossner and Doll, 1970 and Bolton, 1972). Magnesium deficiency symptoms in the farms of Nilgiri soils were recorded by Mathan *et al.* (1973). The soils of this area were distinctly acidic, the pH values ranging from 3 7 to 6 8. In the present investigation, therefore, Titukkal and Doddabetta soils which were rated as deficient in exchangeable Mg ((less than 2.3 me/100 g soil) were taken up for a pot culture study, to assess whether there is any response to application of magnesium fertilizers.

MATERIAL AND METHODS

Two soils having the exchangeable magnesium content below the critical limit (i.e. 2.3 me/100 g soil) were selected. The soil from Titukkal (2210 MSL) in Ootacamund was clay in texture. The organic matter content was 7.4 per cent. The exchangeable magnesium content was very low (0 99 me/100 g). The second soil collected from Doddabetta peak (26 37 meters MSL) was clay in texture and contained low amounts of exchangeable magnesium (1.11 me/100 g). But it contained higher amount of organic matter (29.5 per cent).

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The following sixteen treatments involving different combinations of lime, potassium and magnesium were tried. The treatments were replicated 5 times and were as follows:

1. L_0 K_0 Mg_0
2. L_0 K_0 Mg_1
3. L_0 K_0 Mg_2
4. L_0 K_0 Mg_3
5. L_0 K_1 Mg_0
6. L_0 K_1 Mg_1
7. L_0 K_1 Mg_2
8. L_0 K_1 Mg_3
9. L_1 K_0 Mg_0
10. L_1 K_0 Mg_1
11. L_1 K_0 Mg_2
12. L_1 K_0 Mg_3
13. L_1 K_1 Mg_0
14. L_1 K_1 Mg_1
15. L_1 K_1 Mg_2
16. L_1 K_1 Mg_3

L_0...No lime
L_1...Liming at 16.8 t/ha
K_0...No potassium
K_1...Potassium applied in the form of potassium sulphate at the rate of 100 kg K_2O/ha

Mg_0...No magnesium
Mg_1...50 Kg Mg/ha as $MgSO_4.7H_2O$
Mg_2...100 kg Mg/ha as $MgSO_4.7H_2O$
Mg_3...150 kg Mg/ha as $MgSO_4.7H_2O$

Constant doses of nitrogen (40 kg N/ha) and phosphorus (20 kg P_2O_5/ha) were applied in the form of ammonium sulphate and diammonium phosphate respectively. The quantity of nitrogen supplied by diammonium phosphate was taken into account while calculating the quantity of N to be applied as ammonium sulphate.

The design of the experiment was split-plot with L and K combination as the main plot treatments. *Ragi* (*Eleusine coracana* Gaertn.) is one of the widely grown cereals in the Nilgiris and therefore selected as the test crop for the pot trial. The crop was harvested at maturity. The yield of grains, straw and roots were recorded on oven dry basis. Post-harvest soil samples were also collected.

Pre-planting and post-harvest soil samples were analysed for exchangeable cations (K, Ca and Mg), available nitrogen, available phosphorus and soil reaction (Jackson 1973). The various parameters were subjected to analysis of variance to find out the effect of various treatments on them as per the procedure suggested by Snedecor and Cochran (1967). Simple correlation, regression equations and second order equations were worked out.

RESULTS AND DISCUSSION

Magnesium fertilization had increased root, shoot and grain yield of ragi significantly in Titukkal soil (Table 1 to 4). In the case of root yield, increase was observed up to Mg_3 level, while in the case of shoot and grain yield, the highest yield was recorded at Mg_1 level (50 kg Mg/ha). In both the cases the relationship between magnesium application and the root yield was quadratic in nature (Fig. 1). Magnesium application to Doddabetta soil increased the root yield up to Mg_3 level (150 kg Mg/ha). Grain yield upto Mg_2 level (100 kg Mg/ha) was found to be significant. The grain yield trend was similar to those in Titukkal soil resulting in a quadratic relationship (Fig.2) Response to applied magnesium in magnesium deficient-acid soils was in consonance with the observations recorded by Sawyer and Dallyn (1966) and Draycott and Durrent (1970).

Potassium fertilization did not increase the yield of shoot, grain and total dry matter yield in both the soils. But there was a significant L×K interaction in Titukkal soil, indicating that potassium fertilization in the absence of lime increased the yield of roots. Similar results were recorded by Fine and Shannon (1976). However York, *et al*. (1954) stated that application of potassium to the unlimed soil proved futile and in some cases even yields reduced slightly. There was a significant Mg×K interaction in increasing the yield in Doddabetta soil $Mg_2 \times K_1$ combination registered the highest yield. Similar results were obtained by Page and Bingham. (1965) and McIntosh *et. al*. (1973) to mention a few. In the present study exchangeable Mg correlated positively with available K of the soil (r=0 350**, n=16.)

Ca

In both the soils liming decreased the yield of grains substantially Depression in yield was observed by several earlier workers also In the present study exchangeable Ca content of the post-harvest soil sample was observed to be negatively correlated with cxchangeable Mg (r=-0 670**) n=16). Chucka (1934) observed similar results due to antagonistic effect on available magnesium.

Further, exchangeable Ca was found to be negatively correlated with available P content of soil (r=-0 422**;n=32). Lanyon *et al*. (1977) suggested that depressed yield due to liming in excess might be due to its adverse effect on P availability. As indicated earlier potassium effect on yield was significant only in the presence of lime or magnet sium. (Dorofaeff and McNaught 1962 and Lee and MacDonald 1977). It was evident from the above observations that excessive release of exchangeable Ca into solution retarded the availability of P and Mg and reduced the uptake of P, Mg and K. This might be the probable reason for the depressed yield and the results of Hossner and Doll (1970) and Bolton (1977) are in agreement with the present findings)

Pooled analysis of the total dry matter yield from the two soil types (Table-5) revealed that liming to neutral or near neutral pH as per lime requirement determination resulted in depressed yield. Christenson *et al*. (1973) reported that liming did not influenec oats yields. It is imperative, therefore, that whiel liming the exchangeble Ca status of the soil, the pH rise desired, magnesium status of the soil should also be taken into account. Pooled analysis further revealed that magnesium fertilization increased the total dry matter yield in a quadratic fashion, the highest yield being obtained from magnesium fertilization at the rate of 50 kg Mg/ha.

Although the growth of both roots and tops were influenced by magnesium fertilization, roots were affected more intensively than the tops. This was supported by decrease in top/root ratio (Table 6) from 3.27 to 2.30 in Titukkal soil and from 4.62 to 3.16 in Doddabetta soil. This was in line with the results of Clark (1975).

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Table 1 Effect of Treatments on the Mean Dry Matter Yield of Ragi Crop *(Eleucine Coracana Gaertn.)* - Pot Culture (g/pot - mean of five replications)

Treatments			Titukkal soil				Doddabetta soil			
			Root	Shoot	Grain	Total dry matter	Root	Shoot	Grain	Total dry matter
L_0	K_0	Mg_0	12.2	32.3	11.5	56.0	5.7	28.5	9.4	43.6
L_0	K_0	Mg_1	12.4	39.9	16.0	68.3	10.0	28.1	10.0	48.1
L_0	K_0	Mg_2	12.3	36.9	14.4	63.6	8.3	24.5	8.6	41.4
L_0	K_0	Mg_3	17.8	34.4	13.5	67.7	10.5	26.3	8.2	45.6
L_0	K_1	Mg_0	17.1	27.1	10.5	54.7	8.3	29.0	8.6	45.9
L_0	K_1	Mg_1	17.4	35.6	14.2	67.2	9.6	33.8	6.8	50.2
L_0	K_1	Mg_2	15.2	36.2	13.2	64.6	10.4	30.5	10.2	51.1
L_0	K_1	Mg_3	22.4	37.1	9.7	69.2	13.0	24.6	6.7	44.3
L_1	K_0	Mg_0	14.5	32.1	9.6	46.2	8.0	25.3	6.5	39.8
L_1	K_0	Mg_1	16.1	38.2	10.3	64.6	8.5	26.3	6.4	44.2
L_1	K_0	Mg_2	16.5	34.6	11.1	62.2	6.8	27.4	7.6	41.8
L_1	K_0	Mg_3	17.5	33.8	8.9	60.2	10.6	26.9	5.7	43.1
L_1	K_1	Mg_0	17.2	29.3	11.6	58.1	10.1	27.2	6.1	43.4
L_1	K_1	Mg_1	15.0	36.3	12.7	64.0	6.4	26.2	6.5	39.1
L_1	K_1	Mg_2	14.9	27.5	11.9	54.3	10.0	28.1	6.4	44.5
L_1	K_1	Mg_3	15.9	27.4	9.1	52.4	10.0	31.9	4.5	46.4
Mean			15.9	33.7	11.8	61.4	9.2	28.1	7.5	44.8

Table 2

RAGI ROOT YIELD (g/pot)

(a) TITUKKAL SOIL

i. *Lime x potash interactions*	*Root yield*
$L_0 K_0$	13.67
$L_0 K_1$	18.04
$L_1 K_0$	16.16
$L_1 K_1$	15.84
S. E.	1.19
C. D. (P=0.05)	3.66

ii. *Mg levels*	*Root yield*
Mg_0	16.27
Mg_1	15.33
Mg_2	14.73
Mg_3	18.38
S. E.	0.87
C. D. (P=0.05)	2.46

(b) DODDABETTA SOIL

i. *Mg. levels*	*Root yield*
Mg_0	8.02
Mg_1	8.89
Mg_2	8.79
Mg_3	11.06
S. E.	0.56
C.D. (P=0.05)	1.69

ii. *Mg. × K interactions*	*Root yield* K_0	K_1
Mg_0	6.84	9.20
Mg_1	9.72	8.00
Mg_2	7.72	10.04
Mg_3	10.59	11.51
S.E. (Mg at K)	0.78	
C. D (P=0.05)	2.26	
S. E. (K at Mg)	0.80	
C. D. (P=0.05)	2.32	

TABLE 3
RAGI SHOOT YIELD (g/pot)

a. TITUKKAL SOIL

Mg levels	*Shoot yield*
Mg_0	30.20
Mg_1	37.50
Mg_2	33.77
Mg_3	33.77
S. E.	1.53
C. D. (P=0.05)	4.36

b. DODDABETTA SOIL

K leves	*Shoot yield*
K_0	26.95
K_1	29.18
S. E.	0.58
C. D. (P=0.05)	1.79

Table 4 RAGI GRAIN YIELD (g/Pot)

(a) TITUKKAL SOIL

Lime levels	*Grain yield*	*Mg levels*	*Grain yield*
L_0	12.90	Mg_0	10.83
L_1	10.64	Mg_1	13.30
S. E.	0.71	Mg_2	12.65
C. D. (P=0.05)	2.18	Mg_3	10.30
		S. E.	0.46
		C. D. (P=0.05)	1.31

(b) DODDABETTA SOIL

Lime levels	*Grain yield*	*Mg levels*	*Grain yield*
L_0	8.58	Mg_0	7.66
L_1	6.49	Mg_1	7.93
S. E.	0.22	Mg_2	8.24
C. D. (P=0.05)	0.68	Mg_3	6.31
		S. E.	0.45
		C. D. (P=0.05)	1.29

K levels	
K_0	9.06
K_1	5.99
S. E.	0.22
C. D. (P=0.05)	0.68

Table 6 DRY MATTER YIELD OF RAGI CROP (g/pot)

a. *Lime Levels*	*Pooled Analysis*	*Titukka soil*	*Doddabetta soil*
L_0	55.12	63.96	46.28
L_1	50.11	57.39	42.83
S. E.	1.06	2.03	0.77
C. D. (P=0.05)	3.16	6.25	2.38

b. *Mg. levels*		
Mg_0	48.43	53.80
Mg_1	55.83	66.13
Mg_2	55.03	61.41
Mg_3	53.11	61.35
S. E.	1.16	1.90
C. D. (P=0.05)	3-25	5.43

c. *Soils*	
Titukkai	60.67
Doddabetta	44.56
S. E.	1.08
C. D. (P=0.05)	3.16

d. *Soil × Mg*

Interactions	*Titukkai*	*Doddabetta*
Mg_0	53.80	43.19
Mg_1	66.13	45.53
Mg_2	61.41	44.65
Mg_3	61.35	44.87
S. E. (Mat at Soil)	1.63	
C. D. (P=0,05)	4.86	
S. E. (Soil at Mg)	1.79	
C. D. (P=0.05)	5.13	

Table 6 Top / Root Ratio of Rahi Crop *(Eleucine Coracana Gaerth.)* Pot Experiment

Soils	Treatments	Mg_0	Mg_1	Mg_2	Mg_3
Titukkal Soil	L_0 K_0	3.59	4.51	4.17	2.70
	L_0 K_1	2.20	2.87	3.25	2.09
	L_1 K_0	2.88	3.02	2.27	2.44
	L_1 K_1	2.38	3.27	2.65	2.30
	Mean	2.51	3.42	3.21	2.38
Doddabetta soil	L_0 O_0	6.65	3.81	4.12	3.53
	L_0 K_1	4.53	4.23	3.92	2.41
	L_1 K_0	3.98	3.68	6.15	3.07
	L_1 K_1	3.30	5.43	3.05	3.64
	Mean	4.62	4.28	4.14	3.16

Mg_0 ... No magnesium

Mg_1 ... 50 kg Mg/ha as $MgSO_4 . 7H_2O$

Mg_2 ... 100 kg Mg/ha as $MgSO_4 . 7H_2O$

Mg_3 ... 150 kg Mg/ha as $MgSO_4 . 7H_2O$

L_0 ... No lime

L_1 ... Lime at 16.8 tonnes/ha for Titukkal soil

19.9 tonnes/ha for Doddabetta soil

K_0 ... No potassium

K_1 ... 100 kg K_2O/ha as K_2SO_4

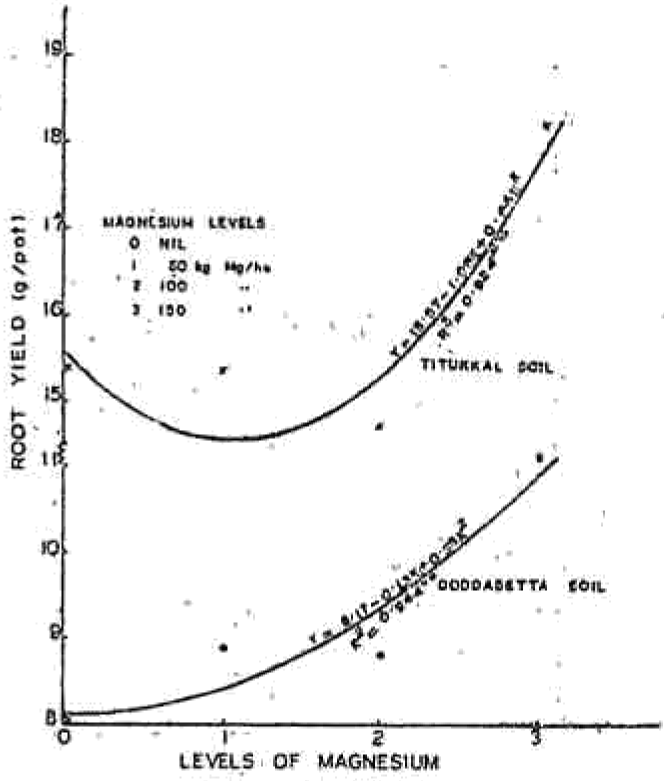

FIG. 1. QUADRATIC REGRESSION OF ROOT YIELD ON LEVELS OF MAGNESIUM

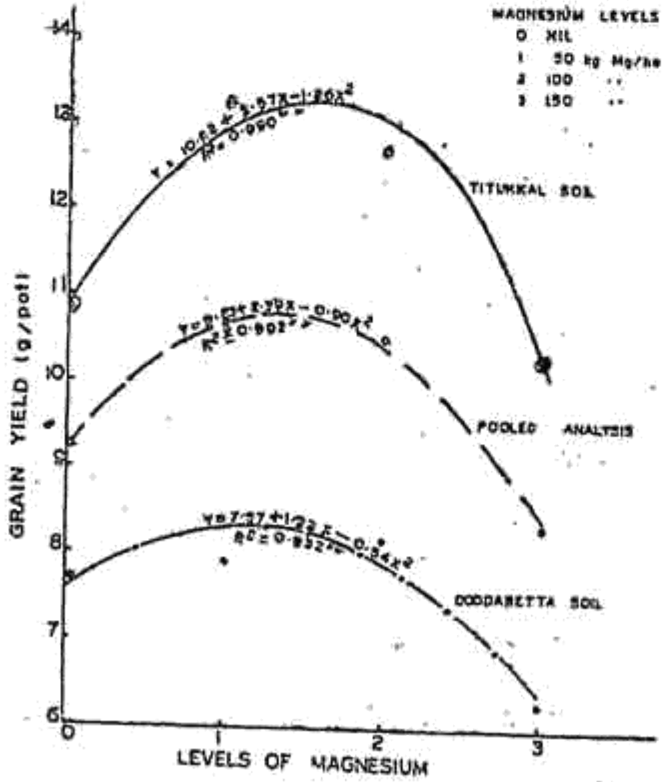

FIG.2 - QUADRATIC REGRESSION OF GRAIN YIELD ON LEVELS OF MAGNESIUM