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Potassium Response and its Critical Limit for Pearl Millet in Calcareous Soils

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ABSTRACT

A pot expriment was conducted to study the response and critical limit of potassium in soil and plant for pearl millet by collecting 20 medium black calcareous soils (Vertic Ustochrepts) varying in physico-chemical properties and K status. Addition of potassium significantly increased grain, straw yield, concentration of K and uptake by pearl millet. Per cent grain yield response ranged between -34.2 to 48.7 and -20.4 to 38.1 at 50 and 100 kg K_2O ha^{-1} level, respectively. Exchangeable K showed significant positive correlation with available K and 1 N HNO_3 K. Bray's percentage yield was significantly correlated with exchangeable K, available K and 1N HNO_3 soluble K. Critical limits 1N NH_4OAC K in soil and concentration of K in pearl millet were found to be 160 kg K_2O ha^{-1} and 2.4 per cent, respectively.

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INTRODUCTION

Pearl millet is an important food grain cereal, grown in large dry farming areas of Saurashtra. Addition of potassium significantly increased yield of crops (Patel *et al.* 1985). The optimum amount of potassium required for good yields can be determined from its content in soil as well as plant K concentration. The present study was undertaken in medium black calcareous soils (Vertic Ustochrept) to know the froms of K in soils and determine critical limits of K in pearl millet and soils.

MATERIALS AND METHODS

Twenty bulk surface samples representing medium black calcareous (Vertic Ustochrept) soils were collected for pot experiment to determine the critical limits of potassium. The soil samples were air dried processed and passed through 2 mm sieve and analysed for different physico-chemical characteristics (Jackson, 1967) and soils were also analysed for different forms of potassium i.e. water soluble, 1 N NH_4OAC (pH 7.0) extractable (Hanway and Heidel, 1952) and boiling 1N HNO_3 soluble K (Wood and De Turk, 1940) and for total potassium it was disested with HF-$HClO_4$ miture (Pratt, 1965). Sixty kilogram processed soil was placed in each iron pot measuring 37.5 x 60 x 25 cm. Potassium was applied at the rate of 0, 50 and 100 kg K_2O ha^{-1} through pure KCl. The uniform application of 80 kg N ha^{-1} and 40 kg P_2O_5 ha^{-1} through urea and DAP was done in all the pots and the

treatments were replicated twice in Completely Randomized Design. Phosphate and potash were applied as basal while N was applied in two equal splits at the time of sowing and one month after sowing. The seeds of pearl millet variety 'GHB 181' were sown in each pot and after germination, nine healthy plants were maintained. The crop was raised upto maturity. Grain and plant samples were ovendried (65°C) to record grain and dry matter yield. Plant samples were digested in diacid mixture of HNO_3 and $HClO_4$ (3:1) and analysed for K by flamephotometer.

The critical limit of K in pearl millet crop and soil were determined by plotting Bray's percentage yield against available soil K and plant K concentration, respectively (Cate and Nelson, 1965). Bray's per cent yield was calculated as :

$$\text{Bray's per cent yield} = \frac{\text{Yield without K}}{\text{Yield at optimum K level}} \times 100$$

RESULTS AND DISCUSSION

The soils used in the present investigation varied widely in physico-chemical characteristics (Table 1). The concentration of water soluble, ammonium acetate extractable and 1N HNO_3 soluble K in soils ranged from 9.4 to 28.3 (16.2), 128.2 to 498.3 (233.0) and 546 to 1584 (807.9) kg K ha^{-1}, respectively.

TABLE 1

Range values of soil chemical properties.

Characteristics	*Range*
SOIL	
Textural class	Sandy clay loam to clay
pH 1:2.5	7.0 to 8.0
EC 1:2.5 (dSm^{-1})	0.35 to 0.80
$CaCO_3$%	1.5 to 42.5
Organic carbon (%)	0.39 to 0.78
Avail. N (kg ha^{-1})	165 to 243
Avail. P_2O_5 (kg ha^{-1})	18.0 to 92.1
Water solube K (kg ha^{-1})	9.4 to 28.3
1 N NH_4OAC-K (kg ha^{-1})	128.2 to 498.3
1 N HNO_3-K (kg ha^{-1})	546 to 1584
Total-K (ppm)	3803 to 7803

TABLE 2

Effect of applied K on grain yield and response of pearl millet.

Sr. No.	1 N NH_4 OAC K (kg ha^{-1})	Grain yield g pot^{-1} K level kg K_2O ha^{-1}			Bray's % yield	Response (%) K level kg K_2O ha^{-1}	
		0	50	100		50	100
1	139.1	38.6	45.2	36.5	85.40	17.10	—5.44
2.	147.8	41.0	50.5	53.1	81.19	23.17	29.51
3.	141.1	35.9	49.4	36.0	72.67	37.60	0.28
4.	128.3	35.7	38.8	49.3	92.01	8.68	38.10
5.	128.3	30.4	39.9	37.9	76.19	31.25	24.67
6.	149.1	31.9	36.1	38.6	88.37	13.17	21.00
7.	182.2	46.0	48.4	47.1	95.04	5.21	2.39
8.	186.7	34.3	37.0	36.7	92.70	7.87	7.00
9.	170.3	38.9	50.5	43.1	77.03	29.82	10.80
10.	237.9	39.4	50.8	46.5	77.56	28.93	18.02
11.	169.5	38.6	45.8	36.9	84.28	18.65	—4.40
12.	165.7	34.9	51.9	35.6	67.25	48.71	2.01
13.	253.2	43.0	51.4	46.3	83.66	19.53	7.67
14.	273.2	37.6	38.9	48.4	96.66	3.46	28.72
15.	198.7	54.0	39.8	51.0	135.68	—26.30	—5.56
16.	231.6	32.6	33.4	36.4	97.60	2.45	11.66
17.	290.0	44.6	40.3	46.0	110.42	—9.44	3.37
18.	585.7	47.7	31.4	38.7	151.91	—34.17	—18.88
19.	472.7	50.0	43.0	39.8	116.28	—14.00	—20.40
20.	408.2	57.0	51.3	50.7	111.11	—10.00	—11.05
Means		40.6	43.7	42.6	9465	7.64	4.93

CD. 5 % 2.48, Soil : 6.39, K X S : 11.07

of applied K on concentration (%) and uptake (g pot^{-1}) by pearl millet.

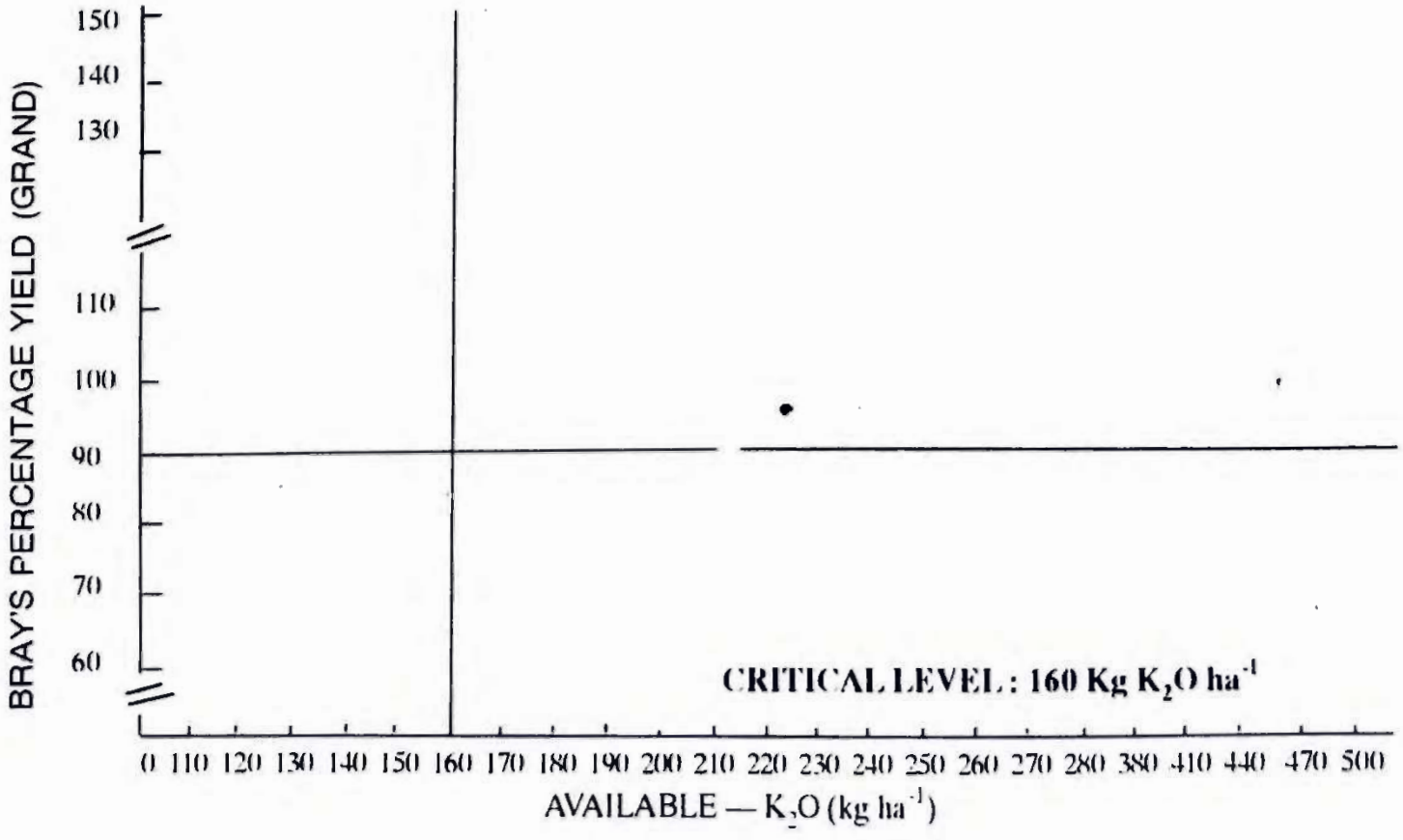
Sr. No.	K conc. at 60 days			K conc. at harvest			Total K uptake (g pot^{-1})		
	K level kg K_2O ha^{-1}						K level kg K_2O ha^{-1}		
	0	50	100	0	50	100	0	50	100
1.	2.53	3.10	3.64	2.45	2.64	2.97	2.598	3.027	3.192
2.	2.55	2.80	2.88	2.28	2.50	3.11	2.355	2.973	3.297
3.	2.86	3.04	2.83	2.53	2.86	3.00	2.708	3.212	3.280
4.	2.08	2.97	3.75	1.65	2.17	3.14	1.734	2.377	3.355
5.	2.33	3.60	2.55	1.83	2.39	2.56	1.874	2.855	3.156
6.	1.82	3.14	3.03	2.56	2.81	3.04	2.875	3.097	3.320
7.	2.16	2.88	3.21	2.17	2.85	3.14	2.526	3.717	3.735
8.	2.19	3.07	3.14	1.93	2.56	3.11	2.182	3.059	3.539
9.	2.86	2.80	2.88	2.86	2.67	3.07	3.158	3.112	3.667
10.	2.19	2.41	2.72	1.85	2.69	2.83	2.271	3.370	3.773
11.	1.87	2.55	3.04	1.53	2.59	3.08	1.692	2.922	3.363
12.	2.05	2.88	3.03	2.25	2.89	3.11	2.711	3.804	3.752
13.	3.03	2.64	3.00	2.70	2.92	3.22	3.419	4.149	4.223
14.	2.69	3.46	3.75	2.89	3.02	2.97	2.929	3.409	3.390
15.	2.36	2.83	2.79	2.81	2.92	2.96	2.927	3.424	3.431
16.	2.47	2.44	3.86	2.73	2.78	2.97	2.580	2.966	2.942
17.	2.83	2.94	2.94	2.25	2.89	2.95	2.724	3.210	3.595
18.	3.10	2.86	2.53	1.93	2.67	2.70	2.338	2.679	2.948
19.	3.25	2.88	3.00	2.42	2.94	2.31	2.809	3.473	2.605
20.	3.03	3.17	2.86	2.47	3.15	2.59	4.056	4.148	5.114
Mean	2.51	2.92	3.12	2.30	2.75	2.94	2.619	3.251	3.386
CD 5%	K = 0.044	S = 0.11	KxS = 0.196	K = 0.079	S = 0.0200	KxS = 0.347	K = 0.134	S = 0.348	KxS = 0.600

Yield

Potassium application significantly increased the grain in low and medium K soils but in high K status soils it decreased (Table 2). The grain yield (g pot^{-1}) of bajra in various soils ranged from 30.4 to 57.0 (mean 40.6), 31.4 to 51.9 (mean 43.7) and 35.6 to 51.0 (mean 42.6) under 0, 50 and 100 kg K_2O ha^{-1}, respectively. On the whole treatments of 50 kg K_2O ha^{-1} and 100 kg K_2O ha^{-1} increased bajra grain yield, it ranged from -34.2 to 48.4 (mean 7.6) and -20.4 to 38.1 (mean 4.93) percentage response, respectively over the control treatment (K_0). Similar trend was observed with straw yield. The trend of results was in conformity with Roy *et al.* (1989), Mehta *et al.* (1991) and Brar and Brar (1992). The effects of soil variation, potash application and interaction (S x K) on yield were significant in both grain and straw. Brar's per cent yield at optimum K level showed wide variation 72.7 to 151.9 with mean values 94.7 in grain yield. Out of 20 samples, Bray's per cent yield was less than 100 in 15 and above 100 in samples indicating response and non responsiveness of the soils for grain yield.

K concentration and uptake

The concentration of K significantly increased in grain by K application, but soils and their interactions did not differ significantly. In case of straw, K levels, soils and its interaction significantly increased the K concentration. The uptake of K was significantly increased by levels of K, soils and K x S (Table 3). The different levels of K influenced the content of K in bajra at different stages. At 35 days, concentration of K was quite higher than at 60 days and at harvest. The concentration of K decreased with advancement of growth of bajra. Solanki (1985) and Kumar *et al.* (1991) also reported that the application of K increased the content and uptake in wheat plant.



Simple correlations (r) were worked out among the various forms of potassium and Bray's percentage yield. Bray's per cent yield was significantly correlated with exchageable K (r = 0.723**) and 1N HNO_3 soluble K (r = 0.654**). Keeping in view these values, critical limit were established by plotting the values of Bray's percentage yield and ammonium acetate K in soil using Cate and Nelson procedure. Accordingly, the critical limit of available K_2O (NH_4OAC-K) for bajra in calcareous soils could be fixed as 160 kg K_2O ha^{-1} (Fig. 1). Roy *et al.* (1989) reported 108 kg K ha^{-1} as critical limit for Puto series and Mehta *et al.* (1991) also reported 155 kg K ha^{-1} as critical limit for pearl millet in Lukhi soil series. The critical K concentration in pearl millet plant at 35 days and maturity has been found to be 3.0 and 2.4 per cent, respectively.

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