

Critical Limits of Potassium in Relation to Growth and Development of French Bean in Acid Soils of Manipur

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Abstract

In a pot culture experiment, the response of French bean (*Phaseolus vulgaris*), cv Contender to K was studied on 25 acidic soils of Manipur. Addition of K in the soils significantly increased the dry matter production and K uptake by the crop. Dry matter yield was positively correlated with IN NH₄OAc ($r = 0.821^{**}$) and K uptake by plant ($r = 0.849^{**}$). The critical levels of K in soils and 40 days old plants below which response of French bean to K fertilization may be expected are 145 ppm of K and 2.2% K, respectively.

Key words : Acidic soils, Dry matter, K uptake, French bean, Critical K concentration.

Of all the beans, French bean is most extensively grown as a green vegetable in India. They are a valuable source of protein, calcium, iron and vitamins. In recent years, the cultivation of French bean, cv Contender has picked up in Manipur. Among several agro-techniques, adequate and balanced nutrition plays an important role increasing yield (1). Correlating nutrients content and their ratio in plant parts during crop growth with yield and yield attributes is prerequisite to find out critical nutrients for optimum yield and quality of crop. Nutrient deficiency of plant can

be replenished well in advance before heavy yield loss. However, there is no such work in Manipur and hence, the present investigation was designed to study the response of French bean to apply K in acidic soils and evaluate the critical limits of K in soils and plant.

Methods

Twenty five soil samples (0–15 cm) representing a wide range were collected from the valley and hill

Table 1. Effect of potassium on dry matter yield, K content and uptake by French bean. CD at 5% for K levels mean = 0.07, CD at 5% for soil mean = 0.21, CD at 5% for K × Soil = 0.36.

Soil no.	IN NH ₄ OAc-K (ppm)	Dry matter yield (g/plot)			mean	Bray's % yield	K content in plants of no K plots (%)	K uptake by plants (mg/plot)			Bay's % K uptake
		0	50	70				0	50	70	
1.	136.0	3.94	4.53	4.46	4.31	87.0	2.72	107.2	147.7	128.0	72.6
2.	131.0	3.15	3.72	3.69	3.52	84.7	2.10	66.2	94.9	84.5	69.7
3.	127.5	3.53	3.92	3.75	3.73	90.1	2.48	87.5	107.8	100.5	81.2
4.	160.0	3.90	4.38	4.16	4.15	89.0	2.61	101.8	125.3	114.4	81.3
5.	115.0	2.90	3.53	3.78	3.40	76.7	1.86	53.9	92.1	104.3	51.7
6.	141.0	3.42	3.92	3.54	3.63	87.2	2.35	80.4	107.0	92.7	75.1
7.	125.0	2.93	3.65	3.82	3.47	76.7	1.76	51.6	84.0	103.1	50.0
8.	123.0	3.10	3.75	3.30	3.38	82.7	2.00	62.0	94.1	72.3	65.9
9.	155.0	4.72	4.91	4.88	4.84	96.1	2.81	132.6	145.3	142.5	91.3
10.	168.0	4.29	4.54	4.37	4.40	94.5	2.59	111.1	128.0	119.7	86.8
11.	135.0	3.22	3.89	3.71	3.61	82.8	2.17	69.9	98.4	91.3	71.0
12.	137.5	3.11	3.65	3.59	3.45	85.2	1.96	48.5	65.3	59.6	76.3
13.	126.0	2.78	3.11	3.47	3.12	80.1	1.92	53.4	67.8	85.7	62.3

Table 1. Continued.

Soil no.	IN NH ₄ OAc-K (ppm)	Dry matter yield (g/plot) K ₂ O level (kg/ha)				mean	Bray's % yield	K content in plants of no K plots (%)	K uptake by plants (mg/plot) K ₂ O levels (kg/ha)			Bray's % K uptake
		0	50	70	0				50	70		
14.	145.0	3.45	4.06	3.89	3.80	85.0	2.20	75.9	101.9	91.8	74.5	
15.	144.2	3.78	4.32	3.91	4.00	87.5	2.50	94.5	123.1	106.4	76.8	
16.	134.0	3.97	4.65	4.23	4.28	85.4	2.75	109.2	144.6	127.7	75.5	
17.	159.0	4.02	4.38	4.30	4.23	91.8	2.86	115.0	138.0	129.9	83.3	
18.	195.0	5.26	5.42	5.29	5.32	97.1	3.12	164.1	174.0	166.1	94.3	
19.	157.0	3.52	3.96	3.79	3.76	88.9	2.48	87.3	109.3	101.2	79.9	
20.	119.0	3.05	3.37	3.75	3.39	81.3	1.93	58.9	71.4	90.4	65.1	
21.	143.0	3.16	3.94	3.62	3.57	80.2	2.00	63.2	105.2	91.6	60.1	
22.	117.0	2.88	3.41	3.63	3.31	79.3	1.82	52.4	75.4	89.3	58.7	
23.	90.0	2.45	2.96	3.47	2.96	70.6	1.66	40.7	56.8	78.8	51.6	
24.	123.0	2.92	3.79	3.62	3.44	77.0	1.92	56.1	102.7	87.6	54.6	
25.	129.0	2.79	3.38	3.57	3.24	78.2	1.74	48.5	70.0	84.3	78.3	
Mean	137.4	3.45	3.97	3.90		84.6	2.25	80.2	106.1	102.4	71.5	

regions of Manipur. These soils are sandy loam to clay in texture having pH varying from 4.94 to 6.11 (mean 5.41), EC from 0.08 to 0.95 dS/M, organic carbon from 9.0 to 21.9 g/kg, CEC from 9.0 to 39.4 [cmol (p⁺)/kg], available N from 192.0 to 542.2 kg/ha, available P from 3.4 to 14.4 kg/ha.

Two and half kg of each soil was filled in the earthen pots and treated with MOP solution at 0, 50 and 70 kg K₂O/ha. The treatments were replicated thrice in a complete randomized design. A basal dose of 60 kg N/ha (urea) and 40 kg P₂O₅/ha (SSP) was applied in each pot. Two seeds were sown in each pot and thinned to one after two weeks. Plants were irrigated with distilled water as and when required.

The crops were harvested at 40 days and plants

were washed in water. The samples were dried in an oven at 65C for 48 hours, weighed and ground in a stainless steel blender and digested in tri-acid mixture (HNO₃ : HClO₄ : H₂SO₄). The K in plants was determined in these digests by flame photometric method. Coefficients of correlation were worked out. The critical soil and plant were determined by technique of Cate and Nelson (2).

Parameters on Bray's per cent yield and Bray's per cent uptake were computed as follows :

$$\text{Bray's per cent yield} = \frac{\text{Yield without K fertilizer}}{\text{Maximum yield in K treated pots}} \times 100$$

Table 2. Methods used for determination of soil potassium.

	Extractant	Soil : Solution ratio	Time of shaking (min)	Reference
1.	1N NH ₄ OAc	1 : 5	30	Woodruff & McIntosh (5)
2.	0.01M CaCl ₂	1 : 2	30	Woodruff & McIntosh (5)
3.	0.13M HCl	1 : 5	1	Woodruff & McIntosh (5)
4.	0.75 M HCl	1 : 3	5	Jaworskin & Barber (6)
5.	1N HNO ₃	1 : 10	10 boiling	Haylock (7)
6.	6M H ₂ SO ₄	1 : 10	30	Hunter & Pratt (8)
7.	Morgan's reagent	1 : 2	1	Morgan (9)
8.	Olsen's reagent	1 : 20	30	Olsen et al. (10)
9.	Modified Olsen's reagent (0.5M NaHCO ₃ + 0.01M Na-EDTA)	1 : 20	30	Olsen et al. (10)
10.	Distilled water	1 : 10	30	McLean (11)
11.	0.5M HOAc	1 : 20	Kept overnight	McLean (11)
12.	1M NaOAc (pH 7.0)	1 : 5	5	McLean (11)

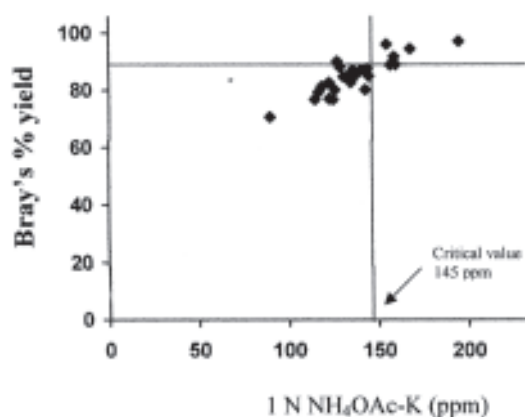


Figure 1. Relationship between soil K and relative yield of French bean.

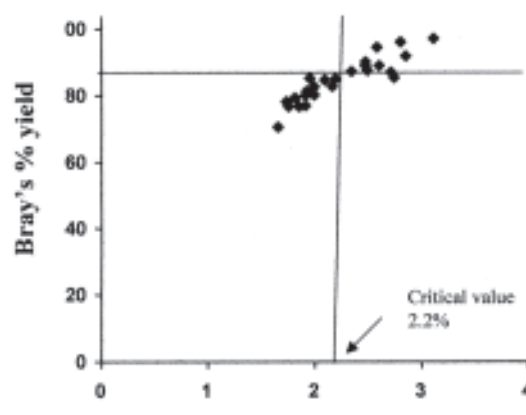


Figure 2. Relationship between the plant K concentration and relative yield of French bean.

$$\text{Bray's per cent uptake} = \frac{\text{K uptake without K fertilizer}}{\text{Maximum K uptake in K treated pots}} \times 100$$

Results and Discussion

Mean dry matter yield significantly increased up to the level of 50 kg K_2O/ha (Table 1). The dry matter yield in control ranged from 2.45 to 5.26 g per pot as compared with 2.96 to 5.42 g per pot in the K treated

pots. Treatment of K at 50 kg K_2O/ha was significantly superior (76%) to the studied soils and 70 kg K_2O/ha was significantly superior (24%) to the total soils in dry matter yield of French bean.

The K uptake increased from 80.2 (no K treatment) to 106.1 mg per pot when K was treated with 50 kg K_2O/ha . Further addition of K in soils beyond 50 kg K_2O/ha generally retarded the K uptake by the plant. This might be due to the decreased dry matter production and lower concentration of K in the plant. The per cent increase in K uptake over control was found to be 75.6 when K was applied at 50 kg K_2O/ha .

Table 3. Simple correlation coefficient between different forms of potassium and yield parameters of French bean.

Extractant	Dry matter yield (control)	K content (control)	K uptake (control)	Bray's % yield	Bray's % uptake
1. 1N NH_4OAc	0.869**	0.812**	0.849**	0.869**	0.821**
2. Distilled water	0.445*	0.344	0.421*	0.389	0.432*
3. Olsen's reagent	0.718**	0.609**	0.690**	0.665**	0.601**
4. Modified Olsen's reagent	0.805**	0.705**	0.775**	0.706**	0.624**
5. Morgan's reagent	0.569**	0.527**	0.566**	0.481*	0.440*
6. 6M H_2SO_4	0.549**	0.504**	0.542**	0.580**	0.528**
7. 0.01M $CaCl_2$	0.671**	0.576**	0.649**	0.626**	0.556**
8. 0.75M HCl	0.656**	0.599**	0.664**	0.614**	0.572**
9. 0.13M HCl	0.205	0.196	0.222	0.220	0.260
10. 1M NaOAc (pH 7)	0.661**	0.627**	0.663**	0.643**	0.657**
11. 1N HNO_3	0.437*	0.426*	0.427*	0.489*	0.384
12. 0.5M HOAc	0.687**	0.610**	0.664**	0.667**	0.549**
13. Available K	0.851**	0.778**	0.828**	0.837**	0.807**
14. Non-Exch. K	0.180	0.194	0.177	0.240	0.133
15. Lattice K (%)	-0.448*	-0.320	-0.402*	-0.441*	-0.432*
16. CR-K	-0.061	0.026	-0.055	0.070	-0.043
17. Step-K	0.090	0.066	0.083	0.048	-0.017
18. Total K (%)	-0.054	0.044	-0.025	-0.018	-0.096

Among the different K extracts used (Table 2) 1N NH_4OAc showed the highest degree of significantly positive relationship with dry matter yield ($r = 0.869^{**}$), plant K in control ($r = 0.812^{**}$), K uptake in control ($r = 0.849^{**}$), Bray's per cent yield ($r = 0.869^{**}$) and Bray's per cent uptake ($r = 0.821^{**}$). The positive significant correlations of 1N NH_4OAc -K with pH, EC, organic carbon, CEC, available N and clay and negative significantly correlated with sand which may be attributed to a wide range in these parameters.

The critical level of soil K was calculated by plotting Bray's per cent dry matter yield against 1N NH_4OAc -K according to the method of Cate and Nelson (2). A value of 145 ppm in soil was critical for soil K (Fig. 1). Similar observation was also reported by Prasad (3). A soil was considered as non-responsive to K application where the Bray's per cent dry matter yield was more than 89 (4). All the soil testing below 145 ppm of 1N NH_4OAc -K responded to K application. Thus, on the basis of the 1N NH_4OAc -K and dry matter yield of French bean, the soils were divided into three groups, i.e. deficient (<145 ppm K), marginal (145–160 ppm K) and adequate (>160 ppm K). Accordingly, 18, 5 and 2 soils can be rated as deficient, marginal and adequate in K supply. This categorization indicates an increase in the average dry matter yield of plant with an increase in available K status of soil in the control treatment (Table 3).

Critical K content in French bean plant was also estimated using Cate and Nelson (2) technique. A value of 2.2% could distinguish the K-deficient plants from those sufficient ones (Fig. 2). Thus, the present study lays emphasis on K fertilization on French bean

plant on the basis of critical values in the soils and plants.

References

1. Thakur R. C., R. D. Sood, M. Bhargava, B. Singh and K. K. Mahajan. 1992. Balanced fertilization for increasing food grain production under rainfed conditions of Himachal Pradesh. *Fert. News* 37 : 29–34.
2. Cate R. B. Jr. and L. A. Nelson. 1965. A rapid method for correlation of soil test analysis with plant response data. *Tech. Bull. No. 1, ISFEL Series, North Carolina State Univ., Raleigh, WC.*
3. Prasad B. 1993. Soil test crop response correlation studies for potassium in Bihar. In : *Use of Potassium in Bihar Agriculture. Potash and Phosphate Inst. Of Canada-India Programme, Gurgaon (Haryana), pp. 38–49.*
4. Sharma B. D. and S. P. Singh. 1990. Critical zinc levels in relation to growth and development of winter maize in Aridisols. *J. Indian Soc. Soil Sci.* 38 : 89–92.
5. Woodruff C. M. and J. L. McIntosh. 1960. Testing for soil potassium. *Trans. 7th International Congress Soil Sci. Madison* 3 : 80.
6. Jaworskin G. A. and S. A. Barber. 1959. Soil properties in relation to potassium uptake by alfalfa. *Soil Sci.* 87 : 73–92.
7. Haylock O. F. 1956. A method for estimating the availability of non-exchangeable potassium. *Trans. 6th International Congress Soil Sci.* 13 : 403.
8. Hunter A. H. and P. F. Pratt. 1957. Extraction of Potassium from soils by sulphuric acid. *Proc. Soil Sci. Soc. Am.* 21 : 595.
9. Morgan M. F. 1941. *Bulletin of the Congress Agricultural Experimental Station.* 450.
10. Olsen S. R., C. V. Cole, F. S. Watanabe and L. A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *US. Deptt. Agric. Circ.* 939.
11. McLean A. J. 1961. Potassium supplying power of some Canadian soils. *Canadian J. Soil Sci.* 41 : 196.