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GD Patil
Professor, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

AV Patil
Assistant Professor, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

VH Bhosale
PG Student, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

AB Jadhav
Assistant Professor, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

HB Kalbhor
Assistant Professor, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

Correspondence
GD Patil
Professor, Division of Soil Science and Agricultural Chemistry, College of Agriculture, Pune, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India

Evaluation of critical limits for potassium in shrink-swell soils and pearl millet

GD Patil, AV Patil, VH Bhosale, AB Jadhav and HB Kalbhor

Abstract
The pot culture experiment was conducted during 2012-13 at Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dhule, M.P.K.V., Rahuri (M.S.) for evaluation of critical limits for potassium in shrink-swell soils and pearl millet. The experiment was conducted with 18 soil samples consisting of Low (6 samples), medium (6 samples) and high (6 samples) potassium content. The dry matter of pearl millet was in the range of 19.13 to 38.17 gm pot^{-1} with 0.47 to 1.10 mg pot^{-1} potassium uptake was recorded with the application of potassium @ 30 mg kg^{-1} soil in low, medium and high K content soils. The soil critical limit of potassium was 132.15 kg ha^{-1} obtained on the basis of scattered diagram with soil available potassium and per cent potassium vs Bray's per cent yield of pearl millet. However, critical limit of potassium in pearl millet was 2.46 % obtained on the basis of scattered diagram between per cent yield of pearl millet Vs plant potassium content.

Keywords: Critical limit, potassium, shrink-swell soil, pearl millet

Introduction
Potassium is key nutrient having major role in activation of nearly 60 plant enzymes, drought stress, disease and pest resistance. Further, potassium also requires for the carbohydrate synthesis in sugar rich fruits. In cereals, potassium having important role in anti-lodging. The soils of Maharashtra are deficient in N and P but sufficient in K. The availability of potassium to plant has some constraint in clay containing soil such as fixation. Further pearl millet is a major crop in Dhule region. Hence, the critical concentration of potassium in soil and plant is essential for obtaining yield and quality of crops. The technical information on potassium status and critical limits in the shrink-swell soil in Dhule region is not available. The critical limit of available potassium in soil and plant is a useful index for the application of potassium fertilizers on farmer's field. Considering the importance and absence of information on these aspects, the present investigation was undertaken to study the critical limits of potassium in shrink-swell soils for pearl millet growing region in Dhule district.

Materials and Methods
The pot culture experiment was undertaken during the year 2012-13 at the Department of Soil Science and Agril. Chemistry, College of Agriculture, Dhule, MPKV, Rahuri, Maharashtra state (India).
The soils with low (<125 kg ha^{-1}), medium (125-250 kg ha^{-1}) and high (>250 kg ha^{-1}) potassium content were collected from different fifteen locations of black clay soil. The collected soils were dried in shade and processed. The processed soils were analyzed for texture, pH, electrical conductivity, organic C, $CaCO_3$, available N, P, K and micronutrients (Fe, Mn, Zn, Cu) by following standard methods. The soils had clay texture with organic carbon: 0.7 to 1.42 per cent; $CaCO_3$: 5.37 to 11.00 per cent; available N: 60.17-213.24 kg ha^{-1}, available P: 10.8 to 35.61 kg ha^{-1} and available K: 82.00 to 324.80 kg ha^{-1}. The Zn, Mn and Cu were found to be high. Available potassium in soil was estimated by the method given by Knudsen and Peterson (1982).
There were 6 soil samples of each potassium category i.e. low (<125 kg ha^{-1}), medium (125-250 kg ha^{-1}) and high (>250 kg ha^{-1}) were filled in polythene lined earthen pot @ 15 kg pot-1. There were two levels of potassium i.e. L1-Control (absolute control) and L2-Optimum level (30 kg K_2O ha^{-1}) imposed to all 18 pots with Factorial Completely Randomized Design.
The fertilizers were applied as per recommended dose at the time of sowing @ 60:30:30 Kg ha^{-1} $N:P_2O_5:K_2O$. Urea, single super phosphate and muriate of potash were used as source of N, P and K respectively. At field capacity moisture pearl millet seed (Cv. Shanti) was sown. The pots were irrigated at field capacity levels by deionised water. The pearl millet crop was grown up to hundred percent flowering stage and harvested and dry matter yield was recorded.

The total potassium in plant was estimated from the extract of diacid mixture (HNO_3: $HClO_4$) by using flame photometer. The percent Bray's yield and dry matter was calculated.
The critical limits of K for soil and plant (pearl millet) was determined by the method described by Cate and Nelson (1965 and 1971) with scatter diagram and statistical method. In this method the calculation of coefficient of determination (R^2) and critical level for best two population split, using the two mean discontinuous models was carried out for the area.

Result and Discussion

Effect of different potassium status and levels of potassium on potassium concentration, dry matter yield and potassium uptake

The potassium concentration, dry matter yield and potassium uptake by pearl millet in shrink-swell soil were significantly influenced by soil potassium status and level of potassium application (Table 1).

Table 1: Effect of status of soils and levels of potassium on concentration, uptake of potassium and dry matter yield of pearl millet

	Potassium concentration (%)	Dry matter yield (gm pot^{-1})	Potassium uptake (mg pot^{-1})
A. Status of potassium			
Low	2.45	19.13	0.47
Medium	2.51	28.20	0.71
High	2.61	38.71	1.01
S.E.±	0.032	2.02	0.052
C.D. at 5%	0.092	5.83	0.152
B. Potassium level			
K_0	2.49	24.25	0.61
K_{30}	2.56	33.11	0.85
S.E.±	0.025	1.59	0.041
C.D. at 5%	0.073	4.61	0.120
Interaction (AxB)			
S.E.±	0.071	4.52	0.012
C.D. at 5%	NS	NS	NS

The concentration of potassium in pearl millet at 100 % flowering was significantly influenced by different potassium status soils and levels of potassium. The Higher potassium containing soils recorded significantly higher potassium concentration (2.61 %) in pearl millet which was statistically at par with medium potassium containing soils (2.51 %). While lower concentration of potassium (2.45 %) recorded with lower potassium status soil. Application of 30 kg K_2O ha^{-1} to pearl millet recorded significantly higher potassium concentration (2.56 %) which was found to be on par with no potassium application (2.49 %). The interaction between different potassium status soils and potassium levels was statistically non-significant for potassium concentration in pearl millet. Brohi *et al*. (2000) [1] reported significant increase in paddy straw nutrient content by potassium application to rice. Wakeel (2001) [15] also reported that potassium application had increase N content of maize crop.
The high potassium status soils recorded significantly higher dry matter yield (38.71 g pot^{-1}) followed by medium potassium status (28.20 g pot^{-1}). However, lower yield of dry matter was obtained in low potassium status soil (19.13 g pot^{-1}). The significantly higher dry matter yield of pearl millet was obtained with the application of potassium @ 30 kg ha^{-1} (33.11 g pot^{-1}) than without potassium application (24.25 g pot^{-1}). The interaction between potassium status soils and levels of potassium on pearl millet dry matter was found non-significant. Ghosh and Mukhopadhya (1996) [5] reported that the dry matter yield of musterd crop increased significantly with increasing level of potassium application up to 20 mg kg^{-1}. Similar results were also reported by Brohi *et al*. (2000) [1] and Wakeel (2001) [15].
Potassium uptake by pearl millet was also significantly influenced by the different potassium status soils and application of potassium. Higher potassium containing soils recorded significantly higher potassium uptake (1.01 mg pot^{-1}) by pearl millet as compare to medium (0.71 mg pot^{-1}) and low (0.47 mg pot^{-1}) potassium containing soils. Application of potassium @ 30 kg ha^{-1} recorded numerically higher potassium uptake (0.85 mg pot^{-1}) which was at par with no potassium application (0.61 mg pot^{-1}). The potassium uptake of pearl millet did not affected significantly due to soils of different potassium status and levels of potassium. The results are agreement with those obtained by Patil *et al*. (2011) [9]. They reported the potassium application had increased uptake of nutrients in soybean crop. Prasad *et al*. (1998) [10] also reported that the potassium application had increase N and K uptake by summer moong.
Significantly higher potassium concentration (2.61 %), dry matter yield (38.71 g pot^{-1}) and uptake of potassium (1.01 mg pot^{-1}) by pearl millet were recorded in higher potassium status soils with application of 30 kg K_2O ha^{-1} over rest of medium and low potassium status soils.

Soil and plant critical level of potassium for pearl millet

The data of dry matter yield pot^{-1} and Bray's percent yield of pearl millet (Table 2) were utilized for evaluating soil and plant critical level of potassium for pearl millet in shrink-swell soil. The scatter diagram with soil available potassium and per cent plant K vs. Bray's percent yield in pearl millet are reported in (Table 3) and graphically depicted in Fig.1 & 2 respectively.

Table 2: Dry matter yield pot^{-1} and Bray's per cent yield of pearl millet

Sr. No.	Different Potassium Level	Control (gm)	Control (gm)	Average	Treated (gm)	Treated (gm)	Average	Control/ Treated	Bray's % Yield
		RI	RII		RI	RII			
1	Low potassium level	14.4	15.4	14.9	18.6	20.4	19.5	0.76	76.41
2		13.2	15.8	14.5	18.0	19.2	18.6	0.77	77.96
3		16.2	18.6	17.4	22.2	24.0	23.1	0.75	75.32
4		17.6	16.8	17.2	21.0	24.6	22.8	0.75	75.44
5		15.6	18.06	16.8	24.0	28.8	26.4	0.63	63.75
6		22.8	22.2	22.5	25.8	32.4	29.1	0.77	77.32
7	Medium potassium level	25.2	24.0	24.6	34.2	29.7	31.9	0.77	77.00
8		24.6	26.4	25.5	28.8	33.3	31.0	0.82	82.13
9		25.2	24.6	24.9	30.6	32.7	31.6	0.78	78.67

10		27.0	29.4	28.2	30.6	34.5	32.5	0.86	86.64
11		25.4	28.9	27.1	33.6	38.2	35.9	0.75	75.63
12		26.1	34.2	30.1	32.1	44.1	38.1	0.79	79.13
13	High potassium level	29.5	41.4	35.4	31.8	50.7	41.2	0.85	85.94
14		29.1	27.0	28.0	31.5	45.9	38.7	0.72	72.48
15		42.6	33.1	37.8	66.6	40.4	53.5	0.70	70.75
16		32.3	31.0	32.7	46.8	41.4	43.6	0.75	75.00
17		36.6	34.2	35.4	44.2	41.6	42.9	0.82	82.50
18		32.8	36.4	34.6	40.4	42.8	41.6	0.83	83.17

Table 3: Critical level of potassium in soil and plant by statistical method (Cate and Nelson, 1971)

Sr. No.	Bray's per cent yield	Soil			Plant		
		Soil K (kg ha^{-1})	R^2 for Soil Critical level	Soil Critical level	Plant K (%)	R^2 for Plant Critical level	Plant Critical level
1	76.41	82.0			2.42	0.000	
2	77.96	89.6	0.000		2.43	0.0185	
3	75.32	100.8	0.006		2.44	0.0337	
4	75.44	112.0	0.015		2.46	**0.2614**	**2.46**
5	63.75	123.2	**0.187**	**132.15**	2.46	0.1447	
6	77.32	141.1	0.172		2.47	0.1410	
7	77.00	145.6	0.169		2.51	0.1320	
8	82.13	156.8	0.094		2.52	0.1171	
9	78.67	168.0	0.079		2.52	0.0270	
10	86.64	179.6	0.009		2.57	0.0343	
11	75.63	191.2	0.018		2.58	0.0564	
12	79.13	202.4	0.011		2.59	0.1607	
13	85.94	202.4	0.008		2.61	0.0583	
14	72.48	291.2	0.001		2.62	0.0538	
15	70.75	302.4	0.050		2.64	0.1666	
16	75.00	313.6	0.121		2.66	0.0958	
17	82.50	324.8	0.063		2.71	0.000	
18	83.17	335.6	0.000		2.72	0.000	

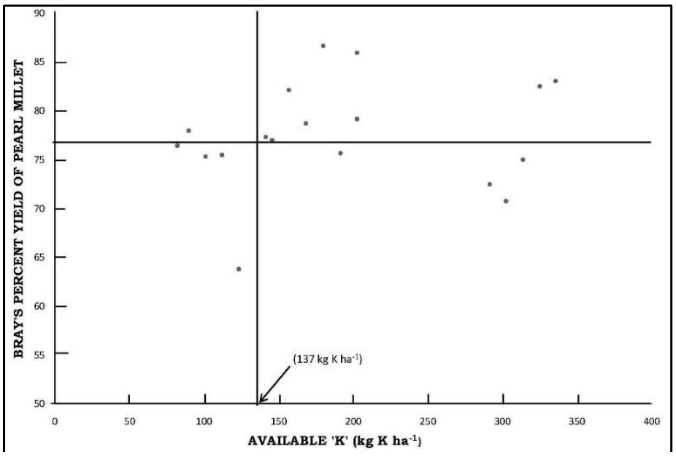

Fig 1: Scatter diagram showing Bray's per cent yield of pearl millet vs. available 'K' in soil

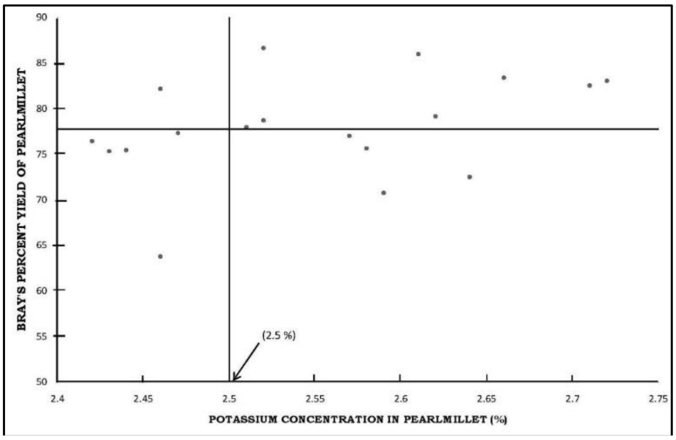

Fig 2: Scatter diagram showing Bray's per cent yield of pearl millet vs. plant 'K' content

The data indicated that the soil critical level for Pearl millet was 132.15 and 137.0 kg ha^{-1} by statistical and graphical method, respectively. The data suggest that if the soil containing less than 137.0 kg ha^{-1} available potassium by neutral normal ammonium acetate extract gives the better crop respond to application of potassium. This critical limit is important in predicting sufficiency and deficiency levels of potassium in soil of Dhule region of Maharashtra.

In case of critical limit of potassium in pearl millet, the two mean discontinuous models for best two population split provides a critical limit between 2.46 and 2.47 percent can be taken as the critical limit of potassium for pearl millet growing region in Dhule District. The data showed that the plant critical limits of potassium for pearl millet were 2.46 and 2.50 percent by statistical and graphical method, respectively at 100 percent flowering. Similar results were obtained by Meisheri *et al.* (1995) [8] that interaction obtained by the scatter diagram technique was also fully supported by the statistical techniques such as the critical limit of potassium concentration in pearl millet plant was 2.4 percent. The data suggest that if the plant containing less than 2.50 percent potassium in plants the crop would respond to application of potassium and this critical limit is important in predicting sufficiency and deficiency level of potassium in plant. Similar results were obtained by Ghosh and Mukhopadhyay (1996) [5] in rice plant in Belar and Bankati series of West Bengal. Sailakshmiswari *et al.* (1985) [12] observed the critical available potassium in alluvial soils of Andhra Pradesh and it was 358 kg ha^{-1} for pearl millet crop. Venkatasubbaiah *et al.* (1976) [14] reported that the critical limits of black soils of West Godawari, Andhra Pradesh for pearl millet growing soil was 213 kg K_2O ha^{-1}. The critical limit of available Potassium (110 kg ha^{-1}) in soil was also studied for wheat by Kumar *et al.* (1991) [7]. Cox and Uribe (1992) [4] recorded the critical level of potassium for corn crop and it was 110 and 90 kg ha^{-1} for loam soil and sandy soil. Rao and Takkar (1997) [11] stated that 1*N* NH_4OAC potassium can be used as a measure of plant available potassium. Further they reported that critical K content in smectitic soils of sorghum was 240 mg kg^{-1}. Tiwari and Mishra (1995) [13] observed the critical concentration of potassium in six week old plants of wheat (on dry matter basis) under green house condition was 2.7 per cent.

Conclusion

The critical limit of potassium for soil was between 132.15 and 137.2 kg potassium ha^{-1} and for plant was found to be 2.46 and 2.50 percent by statistical and graphical methods of Cate and Nelson (1971 and 1965) [2, 3], respectively.

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