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Evaluation of critical limits of potassium in plant for upland paddy grown on shrink-swell soils

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Abstract
The critical limits of potassium in plant for upland paddy was determined through a pot culture experiment with shrink-swell soils. The samples of eighteen different locations were collected having low (<125 kg K_2O ha^{-1}), medium (125-250 kg K_2O ha^{-1}) and high (>250 kg K_2O ha^{-1}) potassium status. The present investigation was carried out in Factorial Completely Randomized Design with two treatments (*viz.* 0 and 50 kg K_2O ha^{-1}) and two replications. The paddy crop was harvested at 100 per cent flowering. The critical limits of potassium in plant were worked out according to method of Cate and Nelson (1965 and 1971).
The dry matter yield (g pot^{-1}) of paddy plant ranged from 34.49 to 49.77 g pot^{-1} amongst 18 locations. There was a significant increase in dry matter yield due to application of potassium. The critical limit of potassium in paddy plant at 100 per cent flowering for shrink-swell soils was found 1.39 per cent by graphical method (Cate and Nelson, 1965) and 1.41 per cent by statistical method (Cate and Nelson, 1971), respectively. The results indicated that, paddy plant containing less than 1.41 per cent potassium at 100 per cent flowering, respond to application of potash fertilizers.

Keywords: potassium, critical limits, upland paddy, shrink-swell soil

Introduction
Rice (*Oryza sativa* L.) is a major *Kharif* crop of India. Rice is foremost cereal crop of the world and is the staple food of over 60 per cent of the world's population. In India, particularly Southern and Western India, rice is the main constituent of the daily diet. Other rice products of common importance are parched rice (Murmura), beaten rice (Poha) and parched paddy (Lahi). Most of the paddy is consumed by human being after cooking as whole rice or by preparing products like Bhakri, Idali, Dossa or Uttappa. Rice cultivation in India is traditionally confined to the areas of high rainfall, where it is grown under lowland conditions. But with the use of irrigation resources and introduction of high yielding cultivars, rice is being cultivated under upland conditions in nontraditional areas in Maharashtra. Upland rice is grown on soils that are aerobic or oxidized for the greater part of the growing season (Ponnamperuma, 1975) [6].
Rice occupies 23.3 per cent of gross cropped area of the country, contributes 43 per cent of total grain production and 46 per cent of total cereal production. Considering worldwide distribution India has the largest area under rice cultivation (42.49 M. ha) and has occupies second position in production (88.28 MT) next to china. The position of Maharashtra in rice production is comparatively poor. In the state, rice is grown in the districts with varying extent. However, the major rice growing districts are Raigad, Thane, Ratnagiri and Sindhudurg of Konkan region, Kolhapur district of western Maharashtra region and Bhandara, Chandrapur and Gadchiroli of Vidharbha region. (Anonymous, 2006) [1].
Potassium (K), one of the three major essential plant nutrients acts as a master cation of the plant nutrient and involves in many physiological and biochemical functions of plant growth and yield processes. A concept of critical limit of nutrients was introduced by Ulrich (1959) [10] and Smith (1962) [8]. However, the graphical method (Cate and Nelson, 1965) [2] and later the statistical approach given by (Cate and Nelson, 1971) [3] are being widely used for establishment of critical limit of a nutrient. Critical limit is the level of soil available nutrient above which that nutrient is no longer a primary limiting factor. It is the limit which isolates the deficient plants or soils from the non-deficient ones. Deficiency symptoms, nutrient concentration, nutrient uptake, percentage yield and response of plants to applied nutrients are the common parameters used for establishing the critical limits. The response of plant nutrients either in terms of growth or yield is the best criteria. Critical limits varies depending on the soil types, crop and varieties, soil test methods and seasonal variations.

Information in respect to potassium nutrition in rice is very meagre. The critical concentration of potassium in rice plant and soil for better yield is also not studied in rational way. Subba Rao *et. al.* (2010) [9] reported critical limits of potassium in rice, wheat, sorghum, cotton and groundnut.

Material and Methods

A pot culture experiment was conducted in wire house of Division of Soil Science and Agricultural Chemistry, College of Agriculture, Kolhapur during *kharif* season 2012 to evaluate the critical limits of potassium in plant for upland paddy (*viz*. Bhogawati) grown on shrink-swell soils. The material and standard methods employed in the present investigation are as under.

Climate and Weather

The College of Agriculture, Kolhapur comes under the Sub-Montane Zone, with average annual rainfall is 1057 mm.

Soil Samples

The soils used for filling the earthen pots with low, medium and high potassium status were collected from 18 different locations of College of Agriculture, Kolhapur Farm. The collected soils of different potassium status were dried in shade and sieved through 2 mm sieve. The sieved soils were used for filling the earthen pots and determination of available potassium. Then the soils were categorized into low, medium and high in respect of its available 'K' content. Out of 18 locations, soil samples from six locations were in the category of low available potassium content (<125 kg K_2O ha^{-1}), Six were from medium available potassium content (125-250 kg K_2O ha^{-1}) and six in high available potassium content (>250 kg K_2O ha^{-1}).

Experimental layout

The present investigation was carried out in Factorial Completely Randomized Design. Treatments comprise two levels of potassium (0 and 50 kg K_2O ha^{-1}) through source of Muriate of potash (MOP) and were replicated twice.

Filling Of Pots

The 72 pots were filled with 10 kg of soil and moisture was maintained to field capacity with deionized water.

Fertilizers application

The recommended dose of N, P and K for paddy (100:50:50 N: P_2O_5: K_2O kg ha^{-1}) was calculated on per ten kilogram soil basis and two levels of potash (0 and 50 kg K_2O ha^{-1}) were taken for experimental purpose. All fertilizers quantity including potash fertilizer were doubled in pot culture experiment.

Harvesting

The rice plants were harvested at 110 DAS (at 100 per cent flowering stage). The plants were harvested with almost care and labeled them.

Result and Discussion

A pot culture experiment was conducted in wire house at the Division of Soil Science and Agricultural Chemistry, College of Agriculture, Kolhapur during *kharif* season 2012. The experimental results are presented and discussed under the appropriate heading in this chapter.

Effect of potassium application on dry matter yield (g pot^{-1}) of paddy plant

The data in respect to dry matter yield (g pot^{-1}) of paddy plant at 100 per cent flowering grown on low, medium and high potassium status soils as influenced by potassium application with K_0 and K_{50} are presented in Table 1.

The results reported that the significantly highest dry matter yield (g pot^{-1}) was found in high potassium status soils (45.06 g pot^{-1}) as compared to medium (43.34g pot^{-1}) and low (38.00 g pot^{-1}). The dry matter accumulation (g pot^{-1}) of paddy plant at 100 per cent flowering was found to increase significantly due to application of 50 kg K_2O ha^{-1} (49.77 g pot^{-1}) over control (34.49 g pot^{-1}). The interaction effect between potassium status (low, medium and high) and treatment (K_0 and K_{50}) was non-significant in respect of dry matter yield of paddy plant.

The increase in vegetative growth obtained with the application of higher doses of N, P and K would result in higher dry matter yield of the plants. Nutrient status would have helped to synthesis and assimilate more nutrients which could have converted to synthesis of photo assimilates.

The results are in confirmative with those reported by Zia *et al*. (1987) [11], Panda and Panda (1993) [5] and Ghosh and Mukhopadhyay (1996a) [4] in paddy plant.

Critical limits of potassium in paddy plant by graphical method

The data on dry matter yield of paddy plant at 0 and 50 kg K2O ha-1, concentration of potassium in paddy plant and Bray's per cent yield are presented in Table 2.

In the graphical method as suggested by Cate and Nelson (1965) [2] yield obtained in the experiment was converted into Bray's per cent yield and was calculated as follows.

The plant potassium in upland paddy ranged from 0.71 to 1.53 per cent. The calculated Bray's per cent yield ranged from 67.84 to 73.52. After plotting the Bray's percent yield v/s plant potassium, the critical limits were determined.

A cross was placed over the data and moved until the upper left and lower right quadrant have a minimum number of points. The critical value was read from the X-axis where the vertical line intersects it. The established critical limits of potassium for paddy plant were depicted in Fig. 1. Thus, according to graphical method, scatter diagram indicated 1.39 per cent potassium as critical limit of potassium in paddy plant at 100 per cent flowering, below which the response to potassium application to soil may be expected in case of paddy crop.

Critical limit of potassium in paddy plant by statistical method

Plant test data obtained from the experiment were subjected to the statistical approach for computing the critical level of potassium in paddy plant as suggested by Cate and Nelson (1971) [3], and presented in Table 3.

The threshold value of plant potassium can be isolated by considering highest R2 value with corresponding postulated critical value for paddy at 100 per cent flowering, which was identified as 1.41 per cent.

It was indicated that below this critical level of potassium in plant response of potassium application to paddy may be expected in case of paddy grown on shrink-swell soils.

Similar result was reported by Singh *et al*. (2000) [7] in which the critical limit of paddy crop was 1.92 per cent at 100 per cent flowering stage.

Table 1: Effect of potassium application on dry matter yield (g pot^{-1}) of paddy plant grown on low, medium and high potassium status soils.

	Dry matter yield (g pot^{-1})
A. Potassium status (Ps)	
Low	38.00
Medium	43.34
High	45.06
SE ±	0.392
CD @ 5%	1.106
B. Treatment (T)	
K_0	34.49
K_{50}	49.77
SE ±	0.320
CD @ 5%	0.903
Interaction (Ps X T)	
SE ±	0.554
CD @ 5%	NS

Table 2: Effect of potassium application on dry matter yield and its corresponding Bray's per cent yield of upland paddy.

S. No.	**Plant K (%)**	**Dry matter yield(g pot^{-1})**		**Bray's per cent yield**
		Potassium levels (kg ha^{-1})		
		K_0	**K_{50}**	
1.	0.71	27.85	37.88	73.52
2.	0.93	31.25	45.98	67.96
3.	1.07	31.35	46.08	68.03
4.	1.02	33.90	49.78	68.09
5.	1.02	31.58	46.35	68.13
6.	1.04	30.80	43.19	71.31
7.	1.07	34.69	50.72	68.39
8.	1.32	34.45	49.62	69.42
9.	1.32	34.86	51.33	67.91
10.	1.34	35.13	51.78	67.84
11.	1.34	35.90	52.32	68.61
12.	1.41	36.47	52.86	68.99
13.	1.41	36.11	52.24	69.12
14.	1.41	36.85	52.32	70.43
15.	1.45	37.30	52.89	70.52
16.	1.49	37.56	53.57	70.11
17.	1.49	37.39	53.27	70.18
18.	1.53	37.49	53.72	69.78

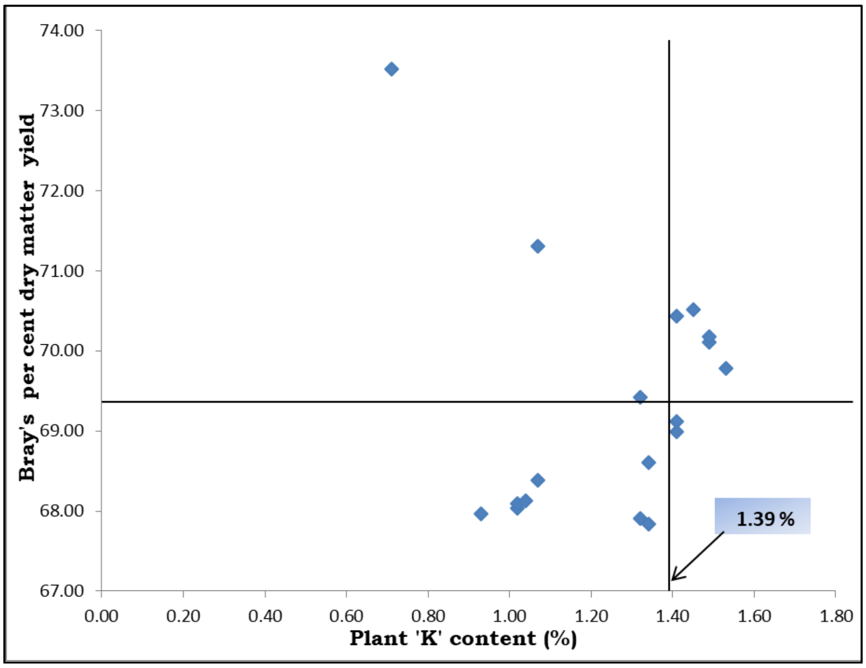

Fig 1: Scatter diagram for Bray's per cent yield of upland paddy v/s plant 'K' content.

Table 3: Critical limit of plant potassium by statistical method (Cate and Nelson, 1971) [3]

Sr. No.	Plant K per cent population-1	Bray's per cent yield	Last value in population-1	Mean Bray's per cent yield in population-1	Corrected SS of deviations from mean of population-1	Mean Bray's per cent yield in population-2	Corrected SS of deviations from mean of population-2	Postulated critical limit	R^2 for Postulated critical limit
1	0.71	73.52							
2	0.93	67.96	0.93	70.74	15.43	69.18	18.65	0.98	0.1131
3	1.02	68.09	1.02	69.86	20.12	69.25	17.39	1.02	0.0240
4	1.02	68.13	1.02	69.43	22.36	69.33	16.04	1.03	0.0007
5	1.04	71.31	1.04	69.80	25.20	69.18	11.82	1.06	0.0366
6	1.07	68.03	1.07	69.51	27.82	69.27	10.39	1.07	0.0056
7	1.07	68.39	1.07	69.35	28.89	69.36	9.54	1.20	0.0000
8	1.32	69.42	1.32	69.36	28.90	69.35	9.53	1.32	0.0000
9	1.32	67.91	1.32	69.20	30.76	69.51	7.23	1.33	0.0114
10	1.34	67.61	1.34	69.04	33.02	69.75	3.18	1.34	0.0581
11	1.34	68.84	1.34	69.02	33.06	69.88	2.24	1.38	0.0815
12	1.41	68.99	1.41	69.02	33.06	70.02	1.33	1.41	0.1053
13	1.41	69.12	1.41	69.02	33.07	70.20	0.34	1.41	0.1307
14	1.41	70.43	1.41	69.12	34.90	70.15	0.28	1.43	0.0846
15	1.45	70.52	1.45	69.22	36.72	70.02	0.09	1.47	0.0422
16	1.49	70.11	1.49	69.27	37.46	69.98	0.08	1.49	0.0231
17	1.49	70.18	1.49						
18	1.53	69.78	1.53						

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