Madras Agric. J., 104 (1-3): 28-31, March 2017

Potassium Release Characteristics in Relation to Plant Uptake in Soils of Major Cropping Systems in Kurnool District

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Sixty representative surface soil samples (0-15 cm) were collected from 5 major cropping systems (viz. rice-rice, fallow-bengalgram, groundnut-groundnut maize-maize, rice-maize/mustard) covering 13 mandals in Kurnool district of Andhra Pradesh and among them 30 samples were selected for investigation based on K status. The potassium releasing characteristics of thirty soils and their relationship with plant uptake was studied. The potassium release characters were the highest in maize-maize cropping system and the lowest in groundnut - groundnut cropping system. Lower amounts of cumulative K was observed in all soils except in soils of Srinagaram and Rythunagaram under present investigation. Lower cumulative K and continuous cropping would lead to depletion of soil K reserves and result in K deficiency. All investigated soils recorded less constant rate K than critical value indicating that these soils had low supplying powers to plants. Among the K release *i.e* cum- K and step K obtained with boiling 1N HNO_3 showed maximum positive and significant correlation with dry matter, K content and K uptake while constant K showed minimum correlation.

Key words: Step-K, Constant-K, Cumulative-K, Dry matter, K content and uptake

Plants feed not only from exchangeable K but also from non exchangeable K, which mainly consists of K trapped in the interlayer of non expanding clay minerals. Major-contribution of non exchangeable K by crop removal was reported particularly in soils under continuous cropping without K application (Srinivasa Rao *et al*., 2007). In the absence of external K supply most of the crop K needs are met from soil reserve of K. In Boiling 1N HNO_3 extracts, some of Non-exchangeable K by breakdown of primary and seacondary minerals (Patiram & Prasad,1983). Crop uptake and response to potassium show a good correlation with boiling 1N HNO_3 extractable K of soils (Sharma and Sekhon,1992; Sivaprasad, 2014). Hence, there is a need to study the potassium release characters of the soil in relation with plant uptake studies. Hence, the present investigation has been undertaken to study the potassium releasing characteristics of thirty soils in major cropping systems in relation to plant uptake in soils of Kurnool district of Andhra Pradesh.

Material and Methods

Based on predominance of cropping systems, different locations were identified in major cropping systems of Kurnool district of Andhra Pradesh and surface soils were collected from 60 locations of soils and 30 samples were screened for present investigation based on K status. Texture of the soils varied from sandy loam to clay. The pH of the soils ranged from 6.9 (neutral) to 8.4 (slightly alkaline) and EC ranged from 0.10 to 0.69 dS m^{-1} indicating that soils were non saline. The organic carbon content was low (0.21 per cent) to medium (0.59 per cent). The soils were low to medium in available N with 159 to 307 kg ha^{-1}, whereas available P was high in all the villages (68 to 169 kg P_2O_5 ha^{-1}) and medium to high in available K (154 to 2088 kg K_2O ha^{-1}). The Cation Exchange Capacity of the soils varied between 13.03 c mol (p+) kg^{-1} to 29.91 c mol (p+) kg^{-1}. Base saturation of the soils varied from 62.7 to 88.1 per cent indicating that most of the soils were medium fertile in nature. Potassium release parameters *viz*.,, step K, constant rate K and cumulative K in soils were derived as per the procedure developed by Haylock (1956) and as modified by McLean (1961) using 1N HNO_3 as an extractant. This method involved removal of exchangeable K by soaking 5g of soil in 50 ml of 0.01 N HNO_3 for overnight and leaching the soil with 10 ml of 0.01N HNO_3 (4-5 times), then boiled with 1N HNO_3 (1:10 soil: 1N HNO_3) exactly for 10 min and cooled, filtered. Extractions were carried out with the same reagent to a stage where the release of K from soil continuous at more or less constant rate. By substracting the amount of constant rate K from the amount of K released in each step of successive extraction, the amount of relatively easily soluble from of K (step-K) was computed. The total amount of K released in all the extractions was taken as cumulative K (important precaution was that the soil sample come to boiling in 3 minutes and then the sample was allowed to boil for 7.5 min). A pot culture experiment was conducted by using 5 kg each of 2.0 mm sieved soil from different cropping system were taken in earthen pots and P-3396 maize hybrid was used

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as test crop. A common recommended dose of nitrogen and phosphorous was applied to all the treatments as per recommended dose (250:60 kg ha^{-1} N and P_2O_5 respectively). Potassium was not applied to crop. The maize seedlings @ three per pot was sown in each pot and two plants will be removed at 10 DAS and incorporated in same pot then only one plant was maintained in each pot. The crop was harvested at 60 DAS and plant samples were collected, processed and analyzed for K content in the tri acid digest (HNO_3: $HClO_4$: H_2SO_4 - 9:4:1) was determined by using flame photometer (Piper, 1966). The dry matter and K content was determined and the potassium uptake was calculated and expressed in g pot^{-1}.

$$\text{Nutrient uptake (g pot}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Dry matter production (g pot}^{-1})}{100}$$

The formulae given by Panse and Sukhatme (1978) was used for calculating the co-efficients of correlation

Results and Discussion

Potassium release characters The highest mean constant rate-K was observed in rice-rice cropping system and the lowest in groundnut-groundnut cropping system (Table 1). All investigated soils recorded less constant rate K than the critical value of 0.2 (c mol (p+) kg^{-1}) or 78 mg kg^{-1} of constant rate K as suggested by Metson(1969). It indicated that these soils had low supplying powers to plants and also the non-exchangeable potassium pool could slowly replenish the water soluble and exchangeable K fractions by affecting the crop growth to considerable extent.

Step K is the estimation of mineral K that is potentially available in due course of time under intensive cropping system (Haylock, 1969). The highest mean step-K was observed in maize-maize cropping system and it was the lowest in groundnut-groundnut cropping system (Table 1). The higher step-K was observed in soils of maize –maize cropping system due to the result of change in potassium equilibrium in forward direction (Krishna Kumari *et al*., (1984). The reserve potassium involved in replenishment process of available K during the growing period mainly released from clay and micas have a fine textured soil showing better K- supplying power. The results were in conformity with the findings of Datta and Sastry (1993) and Pal and Durge (1993). Some of the soils under present investigation recorded the lower step-K value than critical value of 1.5 (C mol (p+) kg^{-1}) or 585 mg kg^{-1} as suggested by Hunsigi and Srivastava (1981).

Mean cumulative-K was the highest in maize-maize cropping system and it was the lowest in groundnut-groundnut cropping system. Lower amounts of cumulative K (less than 1500 mg kg^{-1} with 1N HNO_3 as given by Srinivasa Rao *et al*., (2007) and was observed in all soils except soils of Srinagaram and Rythunagaram under present investigation. Lower cumulative K and continuous cropping would lead to the depletion of soil K reserves and result in K deficiency (Table1).

Table 1. K release parameters in different cropping system

Cropping system	Constant K	Step-K	Cumulative K
Rice-rice cropping system			
RARS,Nandyal	22	880	1056
Battaluru	26	688	870
Nallagatla	31	707	924
Kaminenipalli	19	368	482
Yerragudidinna	23	496	634
M.C. farm	29	881	1084
Mean	25	670	842
Maize-maize cropping system			
Srinagaram	35	1416	1661
Tamadapalli	20	1032	1192
Velpanuru	30	895	1135
Mahanandi	10	877	957
Nallakalva	23	487	625
M.C.farm, maize	27	964	1180
Mean	24	945	1125
Rice-mustard cropping system			
Kanala	12	1062	1158
Bhemunipadu	10	485	555
Rythunagaram	32	1269	1525
Mean	18	939	1079
Rice-maize cropping system			
Bollavaram	20	882	1042
Ayyavarikoduru	30	790	1000
Gajulapalli	15	560	665
Mean	22	744	902
Fallow Bengal gram cropping system			
RARS,Nandyal	15	835	985
Venkateswarwpuram	15	1095	1215
Neravada	21	598	745
Balapanuru	18	862	1006
Kouluru	17	1305	1441
Boyirevula	18	505	631
Mean	17	866	1004
Groundnut-groundnut cropping system			
M.C.farm,groundnut	22	610	742
Shankarapalli	21	538	664
Muddaram	12	228	300
Balapuram	21	898	1045
Balapalapalli	10	234	294
yembavi	13	319	317
Mean	12	472	573

Finally, it can be concluded that by considering all the potassium releasing parameters variation with in a group or with in a cropping system of soils was due to variation in texture of soils. Similar results were obtained by Dhillon and Dhillon (1994), Srinivasa Rao *et al*.,(2007) and Swamanna (2015).

Table 2. Dry matter, K content and K uptake of maize crop in experimental soils

Cropping system	Dry matter	K content	K uptake
Rice-rice cropping system			
RARS,Nandyal	28.91	2.20	0.64
Battaluru	27.86	2.03	0.57
Nallagatla	25.98	2.08	0.54
Kaminenipalli	11.74	1.45	0.17
Yerragudidinna	23.99	1.95	0.47
M.C. farm	32.07	2.59	0.83
Mean	25.09	2.05	0.54
Maize-maize cropping system			
Srinagaram	44.26	3.50	1.55
Tamadapalli	34.89	2.70	0.94
Velpanuru	35.98	3.25	1.17
Mahanandi	25.05	2.35	0.59
Nallakalva	21.76	1.91	0.42
M.C.farm, maize	33.35	2.70	0.90
Mean	32.55	2.74	0.93
Rice-mustard cropping system			
Kanala	26.77	2.46	0.66
Bhemunipadu	18.37	1.73	0.32
Rythunagaram	33.36	3.21	1.07
Mean	26.17	2.47	0.68
Rice-maize cropping system			
Bollavaram	36.06	3.20	1.15
Ayyavarikoduru	23.19	2.03	0.47
Gajulapalli	29.47	2.33	0.69
Mean	29.57	2.52	0.77
Fallow Bengal gram cropping system			
RARS,Nandyal	28.42	2.35	0.67
Venkateswarwpuram	32.37	2.95	0.95
Neravada	24.99	2.26	0.56
Balapanuru	31.36	2.45	0.77
Kouluru	38.16	2.75	1.05
Boyirevula	14.37	1.71	0.02
Mean	28.28	2.41	0.67
Groundnut-groundnut cropping system			
M.C.farm,groundnut	22.84	2.15	0.49
Shankarapalli	24.80	2.24	0.56
Muddaram	10.52	1.41	0.15
Balapuram	28.93	2.40	0.69
Balapalapalli	9.63	1.35	0.13
yembavi	11.17	1.40	0.16
mean	17.98	1.83	0.36

Potassium study by pot culture

The plant parameters i.e dry matter, K content and K uptake of maize crop were the highest in Srinagaram village of maize-maize cropping system and lowest in Balapala palli village of groundnut –groundnut cropping system. There was a wide variation in plant parameters shown with different soils due to the variation in potassium supplying power of soils. Nath and Dey, (1982) also observed variation in dry matter yields in the alluvial soils of Assam and in Aridisols of Rajasthan (Sharma and Swami, 2000). Plant parameters like dry matter ranged from 44.26 in Srinagaram village to 9.63 g pot^{-1} in Balapalapalli village, (Table 2) K content ranged from 3.5 per cent in Srinagaram village to 1.35 percent in Balapalapalli village and K uptake was ranged from 1.55 g pot^{-1} in Srinagaram village to 0.13 g pot^{-1} in Balapalapalli village.

Table 3. Correlation co efficient between potassium release parameters and plant parameters

	Drymatter	K content	K uptake
Con-K	0.436**	0.491**	0.509**
Step-K	0.891**	0.884**	0.879**
Cum –K	0.907**	0.897**	0.891**

**Significant at 0.01 per cent level

Correlation co-efficient (r) between K release parameters and plant parameters

Among the K release parameters such as i.e cum- K and step K showed maximum positive and significant correlation with dry matter(r= 0.907, 0.891), K content(r=0.897, 0.884) and K uptake(r=0.891, 0.879) while constant K showed minimum correlation (Table 3). Step-K and cumulative-K showed maximum positive and significant correlation indicating that soils are rich in available potassium and able to supply potassium to crops on short term basis and also external application is needed especially for high K requirement crop. Minimum correlation with constant-K indicated that K availability reduced and low K power supply on long term basis.

Conclusion

The potassium release characters were the highest in maize-maize cropping system and lowest in groundnut –groundnut cropping system. All investigated soils recorded less constant rate K than critical value indicating that these soils had low supplying powers to plants and also that non-exchangeable potassium pool could slowly replenish the water soluble and exchangeable K fractions by affecting the crop growth to considerable extent. Lower amounts of cumulative K was observed in all soils except in soils of Srinagaram and Rythunagaram under present investigation. Lower cumulative K and continuous cropping would lead to depletion of soil K reserves and result in K deficiency. Constant K showed minimum correlation indicating, low K power supply on long term basis hence, judicious and frequent application of potassic fertilizers is required for better crop production.

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Received after revision : March 6, 2017; Accepted : March 30, 2017