POTASSIUM RELEASE PARAMETERS AND THEIR RELATION WITH YIELD OF RICE BASED CROPPING SYSTEMS IN BAPATLA DISTRICT

ABSTRACT

An investigation was carried out to study the different potassium release parameters in rice based cropping systems (viz. Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems) of Bapatla district of Andhra Pradesh and their relation with rice yield and rice equivalent yield of different cropping systems. Step-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of ~~528~~505~~-~~-1266, 414 -884, ~~727~~742-1296 and 776-1369 mg kg^{-1} with the mean values of 954, 563, 965 and 1067 mg kg^{-1}, respectively. Constant-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of 17-28, 11-22, 17-25and 14-27mg kg^{-1} with the mean values of 23, 17, 21 and 20 mg kg^{-1}, respectively. Cumulative-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of 607-1466, 480-1038, 889-1496 and 930-1585 mg kg^{-1} with the mean values of 1119, 672, 112~~4~~3 and 1223 mg kg^{-1}, respectively. The highest potassium release parameters such as step-K and cumulative K observed in rice-sorghum cropping system and the lowest in rice-groundnut cropping system. Lower amounts of cumulative K were observed in all soils except in soils of Kodiparru and Ananthavaram villages under present investigation. Lower cumulative K and continuous cropping would lead to depletion of soil K reserves and result in K deficiency. Among the K release i.e cum- K and step K obtained with boiling 1N HNO_3 showed maximum positive and significant correlation with rice yield and rice equivalent yield while, constant K showed minimum correlation.

Key words: Step-K, Constant-K, Cumulative-K, rice equivalent yield

Introduction

Plants consume not only exchangeable K, but also non-exchangeable K, which mainly consists of K trapped in the interlayer of non-expanding clay minerals. Major contributions of non-exchangeable K were reported by crop removal, particularly in soils under continuous cropping without K application. The soil reserve of K is the primary source of K for the crop's K needs in the absence of external supply. There is a need to study the relation among potassium release parameters. Hence, the present investigation has been undertaken to study the potassium releasing characteristics of ~~fourty~~forty soils in major cropping systems in relation to yield in soils of Bapatla district of Andhra Pradesh.

Material and Methods

Based on predominance of cropping systems, different locations were identified in major cropping systems of Bapatla district of Andhra Pradesh and surface soils were collected from 40 locations. of soils. Texture of the soils varied from sandy to clay. 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 Ssoil: 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 subtracting the amount of constant rate K from the amount of K released in each step of successive extraction, the amount of relatively easily soluble form of K (step-K) was computed. The total amount of K released in all the extractions was taken as cumulative K (Iimportant precaution was that the soil sample come to boiling in 3 minutes and then the sample was allowed to boil for 7.5 min). The data pertaining to productivity of different cropping systems was collected during survey and Rice equivalent yield (REY) was calculated to compare system performance by converting the yield of non-rice crops into equivalent rice yield on a price basis, using the following formula.

REY = Yx (Px/Pr),

Where,

Yx is the yield of non-rice crops (kg ha^{-1})

Px is the price of non-rice crops (Rs. Kg^{-1})

Pr is the price of rice crop (Rs. Kg^{-1})

The relation between potassium release parameters and yield is studied by correlation using Statistical Package for Social Sciences software.

Results and Discussion

Potassium release attained constancy at the end of 7^{th} extraction in most of black soils where as in most of sandy soils at the end of 6^{th} extraction. Potassium release was rapid in first four extractions in most of the soils, and there was a gradual decrease and reached to constancy value in either 7^{th} or 8^{th} extraction. Mean extractable non-exchangeable potassium was the highest in Rice-Sorghum cropping system followed by Rice-Pulse cropping system, Rice-Maize cropping system and lowest in Rice-Groundnut cropping system (Table1).

Step-K

Step-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of 528505 -1266, 414 -884, 727742-1296 and 776-1369 mg kg^{-1} with the mean values of 954, 563, 965 and 1067 mg kg^{-1}, respectively. The highest mean step-K was observed in Rice-Sorghum cropping system followed by Rice-Maize cropping system, Rice-Pulse cropping system and lowest in Rice-Groundnut cropping system. More the amount of step-K more will be the plant utilizable non-exchangeable K under unavailable K condition (Table 2).

It was reported that step-K was highest in fine textured soils than coarse textured soils. This might be due to 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. Soils with lower step K value than critical value as 585 mg kg^{-1} as suggested by Hungi and Srivastava (1981) will show more response to potassium than soils having higher step-K value. Results were in conformity confirmed with the findings of Rajeevana *et al.* (2022).

Constant-K

It is a measure of difficulty of release K from the inter layers of mineral lattice structure (Haylock 1956). Metson (1969) found that constant rate K serves as empirical guide to long term K supplying power of soil.

Constant-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of 17-28, 11-22, 17-25and 14-27mg kg^{-1} with the mean values of 23, 17, 21 and 20mg kg^{-1}, respectively. The highest mean constant-K was observed in Rice-Pulse cropping system followed by Rice-Maize cropping system, Rice-Sorghum cropping system and Rice-Groundnut cropping system (Table 2).

In study area black soils have more constant-K as these soils have got more potential to release potassium from inter layers compared to other soils. Similar findings with were also reported by Swamanna *et al.* (2015). Metson (1969) reported that soils having constant rate K more than 78 mg kg^{-1} will have sufficient constant K value indicating existence of dynamic equilibrium among different forms. All investigated soils recorded less constant rate K than critical value of constant rate K. It indicated that these soils have 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.

Table1.Release of ~~n~~Non-exchangeable K (mg kg^{-1}) in soils of different rice based cropping systems of Bapatla district

S. No	Name of the villages	Number of extractions							
		1st	2nd	3rd	4th	5th	6th	7th	8th
A. Rice-Pulse cropping system									
1	Arepalli	410	266	170	110	58	25	25	
2	Illvaram	562	370	200	152	92	40	25	25
3	Peddapalli	315	158	86	45	19	19	-	-
4	Bethapudi	515	320	185	135	70	32	21	21
5	Pallepatla	312	142	78	41	17	17	-	-
6	Modukuru	465	289	163	117	65	28	28	-
7	Turumella	430	270	175	115	63	23	23	-
8	Vaddevaripalem	535	326	182	142	76	35	24	24
9	Eepuru	528	345	196	150	89	38	20	20
10	Jillelamudi	457	281	157	113	68	26	26	-
	Mean	**453**	**277**	**159**	**112**	**62**	**28**	**24**	**23**
B. Rice-Groundnut cropping system									
11	Cherukupalli	345	190	98	55	30	18	18	
12	Arepalli	415	250	165	108	56	22	22	
13	Pallepatla	350	210	123	65	38	17	17	
14	Kuchinapudi	302	146	75	41	18	18		
15	Chinnamatlapudi	295	148	72	38	17	17		
16	Peddapalli	312	165	84	42	20	20		
17	Bhavanamvaripalem	260	139	68	35	13	13		
18	Thummalapalli	305	158	82	45	17	17		
19	Perali	315	162	85	46	19	19		
20	Chandole	245	126	59	28	11	11		
Mean		**314**	**169**	**91**	**50**	**24**	**17**	**19**	
C. Rice-Maize cropping system									
21	Gullapalli	415	265	169	108	55	24	24	
22	Govada	375	260	172	110	59	23	23	
23	Bethapudi	470	287	163	117	73	28	20	20
24	Bhattiprolu	420	285	175	115	62	35	18	18
25	Kodiparru	475	328	182	119	79	52	20	20
26	Amruthalur	328	215	156	95	53	21	21	
27	Tsunduru	335	228	155	103	58	19	19	
28	Gudipudi	425	290	180	118	65	36	21	21
29	Ananthavaram	565	380	208	155	96	42	25	25
30	Bhartipudi	418	275	172	117	59	34	17	17
Mean		**423**	**281**	**173**	**116**	**66**	**31**	**21**	**20**
D. Rice-Sorghum cropping system									
31	Addepalli	505	305	172	135	83	35	16	16
32	Illvaram	453	275	154	122	75	28	15	15
33	Kodiparru	596	402	226	165	97	45	27	27
34	Chavali	445	293	165	118	65	35	19	19
35	Tsunduru	380	255	169	112	58	18	18	
36	Pedapudi	468	287	163	118	65	25	25	
37	Kuchipudi	345	232	155	105	49	22	22	
38	Poondla	415	282	169	115	61	33	23	23
39	Ananthavaram	573	383	210	158	96	43	25	25
40	Chilumuru	530	342	194	145	86	36	14	14
Mean		**471**	**306**	**178**	**129**	**74**	**32**	**20**	**20**

Comment [w1]: Please do not leave the blank

~~**Table 4.5.1 (Contd.)**~~

Table 2. K release parameters (mg kg^{-1}) of soils and crop yield data in different rice based cropping systems of Bapatla district

S. No.	Villages	Step-K	Constant-K	Cumulative-K	Rice yield (kg ha^{-1})	Rice equivalent yield (kg ha^{-1})
A. Rice-Pulse cropping system						
1	Arepalli	889	25	1064	6950	4258
2	Illvaram	1266	25	1466	7325	4325
3	Peddapalli	528	19	642	6988	4035
4	Bethapudi	1131	21	1299	7250	4030
5	Pallepatla	505	17	607	6950	3550
6	Modukuru	959	28	1155	7080	3690
7	Turumella	938	23	1099	7228	4105
8	Vaddevaripalem	1152	24	1344	7325	4329
9	Eepuru	1226	20	1386	7150	4258
10	Jillelamudi	946	26	1128	6743	4320
	Mean	**954**	**23**	**1119**		
	Range	**~~528~~505-1266**	**17-28**	**607-1466**		
B. Rice-Groundnut cropping system						
11	Cherukupalli	628	18	754	6575	7225
12	Arepalli	884	22	1038	6890	8235
13	Pallepatla	701	17	820	6785	7620
14	Kuchinapudi	492	18	600	6590	7280
15	Chinnamatlapudi	485	17	587	6950	8331
16	Peddapalli	523	20	643	6600	7855
17	Bhavanamvaripalem	450	13	528	6720	8255
18	Thummalapalli	522	17	624	6675	7225
19	Perali	532	19	646	6870	7320
20	Chandole	414	11	480	6672	7222
	Mean	**563**	**17**	**672**		
	Range	**414-884**	**11-22**	**480-1038**		
C. Rice-Maize cropping system						
21	Gullapalli	892	24	1060	6755	8225
22	Govada	861	23	1022	6660	7280
23	Bethapudi	1018	20	1178	7000	8390
24	Bhattiprolu	984	18	1128	6460	7538
25	Kodiparru	1115	20	1275	6870	8275
26	Amruthalur	742	21	889	6875	7834
27	Tsunduru	784	19	917	6650	8241
28	Gudipudi	988	21	1156	6500	7310
29	Ananthavaram	1296	25	1496	7212	8455
30	Bhartipudi	973	17	1109	6875	7993
	Mean	**965**	**21**	**1123**		
	Range	**~~727~~742-1296**	**17-25**	**889-1496**		
D. Rice-Sorghum cropping system						
31	Addepalli	1139	16	1267	7120	6610
32	Illvaram	1017	15	1137	6645	6170
33	Kodiparru	1369	27	1585	7200	7050
34	Chavali	1007	19	1159	7010	6980

Formatted: Indent: Left: 0", Space After: 0 pt, Line spacing: single

35	Tsunduru	884	18	1010	6570	6294
36	Pedapudi	976	25	1151	7021	6640
37	Kuchipudi	776	22	930	6610	6117
38	Poondla	937	23	1121	6750	6555
39	Ananthavaram	1313	25	1513	7325	6815
40	Chilumuru	1249	14	1361	6937	6585
Mean		**1067**	**20**	**1223**		
Range		**776-1369**	**14-27**	**930-1585**		

Cumulative-K

Cumulative-K values in Rice-Pulse, Rice-Groundnut, Rice-Maize and Rice-Sorghum cropping systems was in the range of 607-1466, 480-1038, 889-1496 and 930-1585 mg kg^{-1} with the mean values of 1119, 672, 11243 and 1223 mg kg^{-1}, respectively.

The highest mean Cumulative-K was observed in Rice-Sorghum cropping system followed by Rice-Maize cropping system, Rice-Pulse cropping system and lowest in Rice-Groundnut cropping system (Table 2). Mean Cumulative-K was higher in Black soils than sandy soils. Srinivasarao *et al*. (2007) reported that cumulative K was higher if it exceeds more than 1500 mg $kg^{-1}$of soil with 1N HNO_3. Lower amounts of cumulative K (less than 1500 mg kg^{-1}) were observed in all soils except soils of Kodiparru and Ananthavaram villages of Rice-Sorghum cropping system.

All the potassium releasing parameters varied with in a cropping system of soils was due to variation in texture of soils. Coarse textured soils with low levels of clay and Kaolinite as dominant mineral with little quantities of associated K contributing mineral showed lesser step and cumulative K. Results were in conformity with Srinivasarao *et al.* (2007) and Rajeevana *et al.* (2022).

Correlation coefficient (r) between potassium release parameters, yield of rice and rice equivalent yield of different crops

Potassium release parameters are positively correlated with rice yield and rice equivalent yield of different crops. Rice yield and rice equivalent yield of sorghum are significantly correlated with step K and Cumulative K and failed to correlate significantly with constant K in rice-sorghum cropping system. (Table-3).

Table 3. Correlation coefficients (r) among yield (rice yields and rice equivalent yields) of different cropping systems and potassium release parameters

Yield of Crops	**Step-K**	**Constant-K**	**Cumulative-K**
A. Rice-Pulse cropping system			

Rice	0.617	0.017	0.599
Pulse	0.621	0.329	0.622
B. Rice-Groundnut cropping system			
Rice	0.321	0.201	0.309
Groundnut	0.242	0.164	0.235
C. Rice-Maize cropping system			
Rice	0.519	0.368	0.532
Maize	0.374	0.120	0.366
D. Rice-Sorghum cropping system			
Rice	0.819^{**}	0.406	0.853^{**}
Sorghum	0.693^{*}	0.442	0.744^{*}

Conclusions

The potassium release parameters ~~were the~~ highest reported in Rice-Sorghum cropping system and lowest in Rice-Groundnut cropping system. All investigated soils recorded less constant rate K than critical value representing 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 were observed in all soils except in soils of Kodiparru and Ananthavaram under present investigation. Lower cumulative K and continuous cropping would lead to depletion of soil K reserves and result in K deficiency.

References

Comment [w2]: Plesae check and correct as per journal format

Haylock, O.F. 1956. A method for estimating the availability of non-exchangeable potassium. *Proceedings of 6th International Congress of Soil Science*.403-408.

Hunsigi, G. and Srivastava, S.C. 1981. Some measures of potassium availability to sugarcane. *Fertilizer news*. 26-35.

Mclean, A.J. 1961. Potassium supplying power of some Canadian soils. *Canadian Journal of Soil Science*. 59 (30): 295-299.

Metson, A.J. 1969. Trans 9th international congress soil science Adelaide, 2, 300.

Rajeevana, I., Kavitha, P., Chari, M.S and Reddy, M.S. 2022. Potassium release characteristics in relation to soil properties in soils of major cropping systems in Kurnool District. *Agropedology*. 27 (1): 10-18.

Srinivasarao, Ch., Vittal, K.P.R., Tiwari, K.N., Gajbhiye, P.N., Sumanta Kundu., Pharande, A.L, Yellamanda Reddy and Shankar, M.A.2007. Potassium supplying characteristics of twenty-one profiles under diverse rainfed production systems. *Journal of the Indian Society of Soil Science*. 55(1): 14-22.

Swamanna, J. 2015. Potassium release characteristics and response to potassium application in rice (*Oryza sativa* L.) growing soils of Kurnool district. M.Sc. (Ag) Thesis, Acharya N.G. Ranga Agricultural University. Hyderabad, India.