Potassium Balance and Release kinetics under rice-rice cropping system

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Potassium is one of the important macronutrients next to Nitrogen and phosphorus. This nutrient is one of the essential nutrient whose deficiency affects the crop growth and production. This element is highly essential for photosynthesis, respiration, enzyme activation and plays a pivotal role in strengthening the plant tissues, providing resistance to plant against pest and diseases and making the plant drought resistance. It has been observed that for good tillering the K content in rice plant should be above 1.5% and the rate of photosynthesis increases with increase in K content upto 2.5%. Potassium present in the soil in four different forms. These are water soluble K, exchangeable K, non-exchangeable K and lattice K. Exchangeable and nonexchangeable K (Called as fixed or reverted K) held in mineral forms. Potassium from these minerals is gradually released to more available form. About 1 to 10 percent is present in non-exchangeable forms also called as 'Slowly available" because of its fixation by the soil colloids. Water soluble (Solution) plus exchangeable form which are called readily available forms consistent 1 to 2% of the total K.

Potassium Balance

Potassium balance of a particular cropping system can be calculated by subtracting plant uptake from the total K application either in the form of organic or inorganic sources. The concentration of K in grain as well as straw is multiplied with the yield of grain and straw indicated the crop removal. The All India Coordinated Research Project on Long Term Fertilizer Experiment is conducted the experiment in the Central Farm of OUAT at Bhubaneswar since 1972-73 with rice-rice cropping system. The mean grain yield of rice K–uptake , K balance after 41 cropping cycle (1993-94) is presented in table 1. The data showed that there was a significant yield response to the application of plant nutrients over control. The yield of rice was higher in rabi than kharif. During kharif yield decreased by 52% from initial year where no fdrtilizer was applied. Application of 100% NPK, the rice yield was increased by 24% over 100% NP whereas super optimal dose (150% NPK) gave only 4% yield increase over 100% NPK. Addition of FYM alongwith 100% NPK, the yield was increased by 17% over 100% NPK.

It has been observed that mean annual K balance was negative in all the treatments. The highest value (90 kg ha^{-1}) was found where only 100% N and P was applied to rice crop in both the season. The mean annual balance was lowest (7.0 kg ha^{-1}) where 150% NPK was applied to the crop. Similarly the K balance was negative (56 kg ha^{-1}) in the control plot where no K was applied. The treatments plots where FYM was applied with 100% NPK the mean annual K balance was higher than the plots where only 100% NPK was applied perhaps due to removal of nutrients with higher rice yield. From this table it was concluded that the K dose should be increased to sustain the grain yield as well as maintain soil health.

Table -1. Mean annual yield K-uptake and balance of some selected treatments under rice-rice cropping system (41 cropping cycle)

Treatments	Mean annual grain yield q ha^{-1}		Mean annual K-uptake kg ha^{-1}	Mean annual balance
	Kharif	Rabi		
50% NPK				
100% N	20.95	20.50	84.00	-84.00
100% NP	22.52	27.98	90.00	-90.00
100% NPK	29.82	32.10	137.00	-37.00
100% NPK + FYM	34.81	37.59	167.00	-47.00
150% NPK	30.3	34.00	187.00	-7.00
Control	15.60	13.09	56.00	-56.00

The mean nutrient application, mean annual uptake and mean K balance of another experiment (1997-2004) was presented in table-2. It was observed that after 14 cropping cycles under rice rice cropping system, the highest negative K balance (61.7 kg ha^{-1}) was found with control plot where no K was applied. Similarly lowest negative K balance (9.4 kg ha^{-1}) was found where green manuring (dhaincha) was applied. On the other hand the mean K balance (46.06 kg ha^{-1}) was found where standard dose of N & K (80 kg N and 60 kg K_2O ha^{-1}) was applied with straw incorporation. This positive balance was perhaps due to inclusion straw which contain high amount of K. From this result it was indicated that present recommendation of K fertilizer should be revised or straw recycling should be advocated for better management of K deficiency in rice-rice cropping system.

Table -2 : Mean annual K application, K - uptake and K balance (kg ha^{-1}) of different treatments (14 cropping cycle)

Treatments	Mean annual application of K	Mean annual K-uptake	Mean annual balance
100% NPK + Zn + B + S	100	121.2	-21.2
100% NPK + Zn + B	100	118.0	-18.0
100% NPK + B + S	100	118.1	-18.1
100% NPK + Zn + S	100	113.6	-13.6
100% NPK + Zn + B + S + FYM	100	118.0	-18.0
100% NPK + Zn + B + S + GM	100	109.4	-9.4
100% NK + Zn + B + S + Straw	155.6	109.8	45.8
Control	-	61.7	-61.7

Potassium releasing characteristics of laterite soils of Cuttack District.

Pal et al. (2001) studied the potassium releasing characteristics of soil under rice based cropping system. Twenty one (N_1-N_{21}) surface soil sample (0-15 gm) of laterite soils from different locations in Narasinghpur area of Cuttack district were collected from the farmers field. Different K fractions were determined and presented in table 3. It showed that available K varied from 45 to 380 mg kg^{-1} indicating that the soils are low to medium in K availability. Non-exchangeable-K, lattice K and total K content in soils varied form 130 to 900, 540 to 2590 and 950 to 3250 mg kg^{-1} respectively. Exchangeable, non-exchangeable K and lattice K constituted 4 to 13, 12 to 36 and 57 to 84 percent of total K respectively.

Table 3. Forms of K in the soil samples

Sample No.	Forms of K (mg kg-1 soil)			
	NH_4OAC extractable	Non – exchangeable	Lattice	Total
N_1	70 (7)*	130 (14)	750 (79)	950
N_2	70 (5)	470 (34)	860 (61)	1400
N_3	90 (6)	530 (38)	780 (56)	1400
N_4	60 (6)	260 (2)	680 (68)	1000
N_5	45 (3)	335 (22)	1120 (75)	1500
N_6	10 (4)	350 (16)	1230 (79)(	1530
N_7	125 (7)	835 (45)	890 (48)	1850
N_8	10 (4)	200 (14)	1180 (81)	1450
N_9	55 (4)	225 (19)	920 (77)	1200
N_{10}	50 (4)	150 (2)	1050 (84)	1250
N_{11}	50 (5)	180 (17)	860 (78)	1100
N_{12}	70 (7)	340 (36)	540 (57)	950
N_{13}	65 (8)	255 (24)	730 (70)	1050
N_{14}	45 (4)	215 (21)	790 (75)	1050
N_{15}	80 (3)	700 (29)	1620 (68)	2400
N_{16}	65 (5)	435 (32)	850	1350
N_{17}	125 (7)	495 (28)	1130 (65)	1750
N_{18}	125 (4)	535 (16)	2590 (80)	3250
N_{19}	95 (6)	445 (30)	960 (64)	1500
N_{20}	380 (12)	900 (70)	1720 (57)	3000
N_{21}	125 (9)	515 (34)	860 (58)	1500

* Data in parentheses indicate percent of total K

Potassium release characteristics of soil Narasinghpur area are presented in table 4 From the table it was found that amount of K released in the 1st extraction was highest in all soils and this was found to decrease gradually with successive extractions and finally remained almost constant. Total extractable K varied from 500 to 1892 mg kg^{-1} soil. Highest values of total extractable K in some soil indicated their greater K-supplying capacity than the others.

Step K provides estimation of K availability from the non-exchangeable sources and constant rate K (CR-K) is a measure of difficulty available K of the mineral lattice sources. Step K was maximum in the 1st extraction and varied from 150 to 700 mg kg^{-1} in different soils and gradually decreased to zero in 6th and 7th extraction. From the data it was indicated that the more the amount of step K, greater release of K from non-exchangeable K under stress condition. Highly significant and positive correlation between step K with $1NHNO_3$ – K indicates that $1NHNO_3$ extractable K could be serve as a good index of plant available non-exchangeable K in soil. CR-K is a measure of difficulty available K from the crystal lattice of K minerals. It ranges from 12 to 46 mg kg^{-1}. Higher value indicates that the soils could be adequately supply K to plants.

Table 4. Release of K at different extractions by boiling N HNO_3

Sample No.	K released (mg kg^{-1} soil)										CR-K	Total step K	Total extractable K
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th			
N_1	150	50	44	40	36	36	36	36	36	36	36	140	500
N_2	325	175	74	54	36	28	28	28	28	28	28	524	804
N_3	375	325	106	96	62	52	46	46	46	46	46	740	1200
N_4	200	100	68	40	30	28	28	28	28	28	28	288	568
N_5	250	150	64	50	44	28	26	26	26	26	26	430	690
N_6	175	150	75	52	46	44	44	44	44	44	44	278	718
N_7	675	525	122	80	40	30	28	28	28	28	28	1312	1592

N_8	150	100	75	60	56	50	46	46	46	46	46	215	675
N_9	175	95	80	64	60	56	40	40	40	40	40	290	690
N_{10}	150	75	56	46	40	34	34	34	34	34	34	197	537
N_{11}	175	120	76	52	38	28	20	20	20	20	20	369	869
N_{12}	375	150	54	36	24	24	24	24	24	24	24	519	759
N_{13}	225	150	75	56	42	36	26	26	26	26	26	428	688
N_{14}	175	64	54	48	44	42	42	42	42	42	42	283	703
N_{15}	475	350	104	84	66	48	38	38	38	38	38	899	1279
N_{16}	275	175	58	42	30	16	12	12	12	12	12	524	644
N_{17}	425	325	104	70	50	38	28	28	28	28	28	844	1124
N_{18}	400	325	112	92	70	58	46	46	46	46	46	781	1241
N_{19}	275	175	72	56	48	40	36	36	36	36	36	450	810
N_{20}	700	450	188	136	104	90	56	56	56	56	56	1332	1892
N_{21}	325	96	70	56	50	48	48	48	48	48	48	709	1189

The correlations coefficient of K release parameter with different forms of K was presented in table 5. The results showed that exchangeable, non-exchangable, lattice and total K were positively correlated with each other, suggesting the existence of dynamic equilibrium among the different pools of K in soil. This would mean that the depletion of K concentration more, pool is replenished from the other pools of soil K.

Table 5. - Correlation coefficient of K release parameter with forms of K

	NH_4OAC-K	Non-Exch. K	Lattice K	Total K	CR-K	Total step K	Total extractable K
NHOAC-K	1.000						
Non exch-K	0.821**	1.000					
Lattic K	0.448*	0.418	1.000				
Total K	0.689**	0.733**	0.921**	1.000			
CR-K	0.510*	0.249	0.478*	0.489*	1.000		
Total Steb K	0.736**	0.969**	0.399	0.710**	0.206	1.000	
Total Extractable K	0.810**	0.944**	0.498*	0.781**	0.676	0.959**	1.000

P.K. Sahu (1994) studied the different form of potassium from the soil sample collected from Baramba block in Cuttack district under rice based cropping system. Twenty two (B1 to B2) surface soil sample (0-15 m) of laterite soils form different locations in Baramba area of Cuttack district were collected . Sample were collected from farmers field with rice based cropping system. Different K fractions were determined and presented in Table No. 6. From the table it has been found that NH_4OAC extractable – K varied from 45 to 125 mg kg^{-1} of soil with a mean of 4.83 mg kg^{-1}. In all the places NH_4OAC extractable K is lower than the non-exchangeable K. The non exchangeable K content varied from 230 to 925 mg kg^{-1} of soil with a mean value of 532.3 mg kg^{-1} of soil. Its contribution to total K content of soil ranged from 18.78 to 51.66 percent with an average contribution of 31.95 percent. Lowest value of non exchangeable K is due to continuous depletion of K from soil by continuous crop removal. The amount of lattice K ranged from 220 to 2060 mg kg^{-1} of soil with a mean value of 1051.4 mg kg^{-1}. The contribution of this fraction to total K pod range from 36.66 to 76.58 percent with an average value of 63.11 percent.

Table – 6. Distribution of different forms of potassium (mg kg^{-1} soil) in soil samples of Baramba block of Cuttack district.

Sample No.	NH_4OAC extractable - K	Non – exchangeable-K	Lattice –K	Total-K
B_1	95	385	1470	1950
B_2	105	855	890	1850
B_3	65	315	470	850
B_4	90	230	830	1150
B_5	95	385	1570	2050
B_6	55	385	810	1250
B_7	85	415	1450	1950
B_8	75	805	870	1750
B_9	60	640	1200	1900
B_{10}	45	535	1720	2350
B_{11}	55	605	1190	1850
B_{12}	90	750	2060	2900
B_{13}	118	925	910	1950
B_{14}	125	855	1870	2850
B_{15}	65	455	480	1000
B_{16}	70	310	220	600
B_{17}	110	450	690	1250
B_{18}	100	480	1020	1600
B_{19}	80	440	1030	1550
B_{20}	90	830	980	1900
B_{21}	55	245	600	900
B_{22}	85	415	800	1300
Mean	82.26 (4.83)	532.27 (31.95)	1051.36 (63.11)	1665.90

Relationship among different forms of potassium

All the forms of K studied were positively correlated among themselves (table 7) indicating the existence of dynamic equilibrium among all the form of potassium.

Table 7. Correlation coefficient among different forms of K

Form of potassium	Water soluble K	Exchan-geable- K	Available K	Non-Exch. K	Lattic K	Total K
Water soluble K	1.000					
Exchangeable K	0.714**	1.000				
Available K	0.812**	0.989**	1.000			
Non – Exch. K	0.53**	0.365	0.421	1.000		
Lattice K	0.381	0.200	0.279	0.381	1.000	
Total K	0.517*	0.322	0.300	0.671**	0.940**	1.000

* Significant at P = 0.05, ** - Significant at P = 0.01

Potassium release characteristics of soils of Baramba block is presented in table 8. The results showed that the amount of K released in 1st extraction was higher in all the soils of 22 sites. Thereafter it gradually decreased with successive extractions and remained almost constant. Total extractable K varied from 442 to 1792 mg kg^{-1} soil. Highest value of total extractable K in some soil indicating their greater K supplying capacity than the others.

Step K provides estimation of K availability from the non-exchangeable sources and constant rate K (CR-K) is a measure of difficulty available K of mineral lattice source. Step K was maximum in the 1st extraction and varied from 104 to 1510 mg kg^{-1} in different soils and gradually decreased. The release of same quantity of step K in two consecutive extractions may be due to release of K from the specified mineral sources which is not fully exhausted in a single extraction. Higher amount of step K indicates greater research for the release from initially non-exchangeable form under stress condition. CR-K values varied from 8 to 44 mg kg^{-1} which indicate adequate supply of K to plans.

Table 8. Potassium release characteristics of sol sample collected in Baramba block

Sample No.	K released (mg kg^{-1} soil)										Total extract - K mg kg^{-1}	Step K mg kg^{-1}	CR – K mg kg^{-1}
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th			
B_1	300	200	84	68	56	46	40	40	40	40	914	514	40
B_2	625	325	136	102	80	60	44	44	44	44	1554	1114	44
B_3	100	50	44	40	40	34	34	34	34	34	444	104	34
B_4	150	100	88	76	60	46	38	36	36	36	666	306	36
B_5	200	125	66	48	36	36	36	36	36	36	655	295	36
B_6	225	100	50	36	28	22	22	22	22	22	549	329	22
B_7	450	250	124	104	66	40	28	26	26	26	1140	880	26
B_8	575	375	126	92	62	40	24	22	22	22	1360	1140	22
B_9	525	175	72	56	44	32	28	28	28	28	1016	736	28
B_{10}	350	200	92	44	28	16	14	14	14	14	786	646	14
B_{11}	375	250	100	44	44	22	22	22	22	22	923	703	22
B_{12}	525	450	136	74	56	30	12	12	12	12	1319	1199	12
B_{13}	550	350	142	68	60	52	48	48	48	48	1414	934	48
B_{14}	700	600	160	96	74	44	32	28	28	28	1790	1510	28
B_{15}	200	200	72	38	28	16	8	8	8	8	586	508	8
B_{16}	175	75	52	36	28	20	14	14	14	14	442	302	14
B_{17}	400	175	112	72	42	22	12	10	10	10	865	765	10
B_{18}	375	250	96	66	40	18	10	8	8	8	879	799	8
B_{19}	300	175	76	48	36	34	34	34	34	34	805	465	34
B_{20}	575	475	124	76	62	44	28	22	22	22	1450	1230	22
B_{21}	100	75	52	42	28	16	10	10	10	10	353	253	10
B_{22}	225	150	72	42	28	18	16	16	16	16	599	539	16

Das et al. (1997) conducted another study with the soil sample collected from Sidingi village under Khajuriapara block of Phulbani district. In these area rice-pulse was the dominant cropping system. Profile samples from foot hills, upper ridges, mid upland, medium land and medium valley land were collected and the distribution of various forms of K in these profiles are presented in table – 9. From the table it was found that water soluble K decreased, where as non – exchangeable, lattice K and total K increased with soil depth. Exchangeable K percent at the surface horizons varied from 2.8 to 4.0 and changed inconsistently with soil depth with a little variation within the profile. Non-exchangeable K per cent at the surface horizons varied from 24.8 to 41.8 changing in consistently with soil depth.

Table 9: Distribution of various forms of K in the profiles

Genetic horizon	Depth (cm)	Forms of K (mg kg^{-1} sol)				
		Water Soluble K	Exch. K	Non-exch K	Lattice K	Total K
Profile -1						
A 2	0-14	20.0 (1.52)	40.0 (3.6)	460 (41.8)	580 (52.8)	1100
B 21	14-40	19.5 (1.0)	70.5 (3.5)	510 (25.5)	1400 (70.0)	2000
B 22t	40-72	11.5 (0.5)	83.5 (3.5)	665 (27.7)	1640 (68.1)	2400
B 23t	72-150	8.0 (0.3)	97.0 (3.2)	695 (23.2)	2200 (73.3)	3000
Profile – 2						
Ap	0-11	18.5 (0.7)	96.5 (3.7)	645 (24.8)	1840 (70.8)	2600
B 21t	11-52	10.0 (0.4)	110.0 (3.8)	820 (29.3)	1860 (66.4)	2800
B 22t	52-88	6.5 (0.2)	93.5 (3.1)	860 (28.7)	2040 (68.0)	3000
B 23t	88-115	6.5 (0.2)	103.5 (3.6)	850 (29.3)	1940 (66.9)	2900
C	115-150	8.0 (0.3)	107.0 (4.0)	925 (34.3)	660 (61.4)	2700
Profile – 3						
Ap	0-14	17.5 (0.8)	62.5 (2.8)	60 (27.3)	1520 (69.1)	2200
B 21t	14-42	12.0 (0.4)	83.0 (3.0)	945 (33.7)	1760 (62.9)	2800
B 22t	42-90	11.5 (0.4)	88.5 (2.9)	1100 (36.7)	1800 (60.0)	3000

B 23t	90-172	10.0 (0.3)	100.0 (2.9)	1130 (32.2)	2260 (64.6)	3500
Profile – 4						
Ap	0-14	13.5 (0.7)	71.5 (4.0)	675 (37.5)	1040 (57.8)	1800
B 21t	14-27	13.0 (0.6)	62.0 (2.8)	765 (34.8)	1360 (61.8)	2200
B 22t	27-60	12.0 (0.5)	78.0 (3.1)	830 (33.2)	1580 (63.3)	2500
B 23t	60-150	7.5 (0.2)	67.5 (2.1)	1045 (32.7)	2080 (65.0)	3200
Profile – 5						
Ap	0 -14	15.5 (1.2)	39.5 (2.8)	505 (36.0)	840 (60.0)	1400
B 21t	14-32	11.0 (0.7)	59.0 (3.9)	570 (38.0)	860 (57.4)	1500
B 22t	32-84	10.5 (0.4)	94.5 (3.2)	775 (26.7)	2020 (69.7)	2900
C	84-155	10.0 (0.3)	105.0 (3.4)	885 (28.5)	2100 (67.8)	3100

Inter-relationships of the forms of K is presented in table –10. From the table it was observed that exchangeable K, non-exchangeable K, lattice K and total K were positively correlated with each other but respectively correlated with water soluble K . Corresponding regression coefficients indicated that for each unit increase in total K, there was an increase of 0.72 units of lattice K, 0.25 units of non-exchangeable K, 0.03 units of exchangeable K and -0.004 units of water soluble K.

Table – 10 Inter-relationship of the forms of K (n = 21)

X	Y			
	Water soluble K	Exchangeable K	Non-exchangeable K	Lattice K
Exchangeable K	-0.60*			
Non-exchangeable K	-0.68**	0.60**		
Lattice K	-0.62**	0.82**	0.72**	
Total K	-0.68**	0.82**	0.84**	0.98**

Changes in the values of various K release parameters with depth in the soil profile are presented in table 11. Total extractable K varied from 1109 to 1432 mg kg^{-1}

at the surface horizons and increased with depth. Maximum amount of K was released in the first extraction which decreased gradually with successive extractions to attain constant values after 7th & 8th extract ions at different horizons.

Percent of total extractable K released at the end of different extraction was presented in table 11. From the table it was observed that total extractable K varied form 54.9 to 83.2 per cent at the surface horizons. It increased with the proportions of different weatherable to resistance K bearing minerals with depth.

Table – 11. Changes in the values of K release parameters with depth in the profiles

Genetic horizon	Depth (cm)	Total extract. K	Total step K	CR – K	% of non-exch. K + Lattice K		
		Mg kg-1			Total extract K	Total Step K	CR-K
Profile – 2 Upper ridge (Aridic Kanhapulstlfs)							
Ap	0-11	1365	1325	04	54.9	53.3	0.2
B 21t	11-52	2008	1768	24	74.9	66.6	0.9
B 22t	52-88	2228	1908	32	76.8	65.8	1.1
B 23t	88-115	2466	2066	40	88.4	74.1	1.4
C	115-150	2505	2105	40	96.9	81.4	1.5
Profile – 3 Mid upland (Aridic Kanhaplustalfs)							
Ap	0-14	1348	1188	16	63.6	56.0	0.8
B 21t	14-42	2085	18545	24	77.1	68.2	0.9
B 22t	42-90	2776	2216	56	95.7	76.4	0.9
B 23t	90-172	2882	2282	60	85.0	67.3	0.8
Profile – 4 Medium land (Aridic Kanhaplustalfs)							
Ap	0-14	1432	1352	08	83.4	78.8	0.5
B 21t	14-27	1629	1389	24	76.7	65.4	1.1
B 22t	27-60	2106	1786	32	87.4	74.1	1.3
B 23t	60-150	2709	2069	64	86.7	66.2	2.0
Profile – 5 Medium valley alnd (Aridic Ustochrepts)							
Ap	0-14	1109	909	20	82.5	67.6	1.5
B 21t	14-32	1390	1070	32	97.2	74.8	2.2
B 22t	32-84	1787	1587	20	63.9	56.8	0.7
C	84-155	2185	1865	32	73.2	62.5	1.1

Per cent of total extractable K released at the end of different extraction are presented in table - 12. In the initial three extracting 67.7 to 80.7 percent of the total extractable K was released at different horizons whereas only 13.0 to 22.2 percent was released in the rest three extractions and 3.2 to 11.5 percent was released in the last four extractions

Table – 12 . Per cent of total extractable K released at the end of different extractions.

Genetic horizon	Depth (cm)	No. of extractions		
		$1^{st} + 2^{nd} + 3^{rd}$	$4^{th} + 5^{th} + 6^{th}$	$7^{th}+8^{th}+9^{th} + 10^{th}$
Profile - 2				
Ap	0-11	78.0	18.8	3.2
B 21t	11-52	71.7	20.4	8.2
B 22t	52-88	71.8	20.3	7.9
B 23t	88-115	67.7	22.2	10.1
C	115-150	70.5	20.3	9.2
Profile – 3				
Ap	0-14	80.1	14.3	5.6
B 21t	14-42	75.1	17.4	7.5
B 22t	42-90	69.1	19.9	11.0
B 23t	90-172	71.2	19.4	9.4
Profile – 4				
Ap	0-14	80.7	16.0	3.3
B 21t	14-27	75.2	17.2	7.6
B 22t	27-60	75.5	17.1	7.4
B 23t	60-150	69.6	18.9	11.5
Profile – 5				
Ap	0-14	78.0	14.1	7.9
B 21t	14-32	77.0	13.2	9.8
B 22t	32-84	80.3	13.0	6.7
C	84-155	77.1	15.0	7.9

Relationship of the K release parameters with sand, silt & clay is presented in table. -13. Total extractable K showed a positive correlation with clay (r = 0.95**) negative correlation with sand (r= -0.89**) and a non-significant correlation with silt indicating the release of K mainly from the clay fraction of soil. Similar trend was also observe with step K and CR-K.

Table – 13 . Relationships of the K – release parameters with sand, silt and clay (n = 17)

(y) K – release parameters	(x)		
	Sand	Silt	Clay
Total extractable K	-0.89**	NS	0.95**
Total step K	-0.89**	NS	0.94**
CR-K	-0.73**	NS	0.81**

Relationship of the K released with forms of K presented in table 14. Total extractable K was positively correlated with non-exchangeable K (r = 0.96**), lattice K (r=0.73**) and total K (r = 0.84**).

Table – 14. Relationship of the K-release with forms of K (n = 17)

(y) K – release parameters	(x)		
	Non-exchangeable K	Lattice K	Total K
Total extractable K	0.96**	0.73**	0.84**
Total step K	0.95**	0.79**	0.89**
CR-K	0.80**	NS	0.58*

Total K showed a positive correlation with clay negative correlation with sand and non-significant relationship with silt. CR-K is a measure of the difficulty available K from the mineral lattice source CR-K varied from 4 to 64 mg kg^{-1} at different horizons consisting 0.2 to 2.2 per cent of non-exchangeable K+ lattice K.

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