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Soil Properties and Forms of Potassium in Rice Growing Soils of Kurnool district.

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ABSTRACT

The rice growing soils of Kurnool district of Andhra Pradesh were evaluated for pH, EC, organic carbon, texture, CEC, available N,P,K status and different forms of potassium (water soluble K, available K, exchangeable K, non exchangeable K and fixed K). The relationship between different forms of potassium and soil properties was studied. The mean values of water soluble K, available K, exchangeable K, non exchangeable K and fixed K were 34, 274, 240, 254 and 528 mg kg^{-1}, respectively. The order of dominance of different forms of potassium was fixed K > non exchangeable K > available K > exchangeable K > water soluble K. Water soluble K exhibited negative correlation with pH, clay, silt and organic carbon whereas available K was positively correlated with pH, organic carbon, CEC. Non exchangeable K was negatively correlated with organic carbon while exchangeable K showed positive relationship with clay, organic carbon but negative with sand fractions. Fixed K was positively correlated with silt, pH and organic carbon. Different forms of potassium were positively correlated among themselves.

Key words : CEC, Clay, Organic carbon, pH, Potassium forms, and Texture.

Potassium, one of the major nutrients needed for plants in large amounts similar to or greater than nitrogen and play a diverse role in plant metabolism. The potassium status of soils greatly depends on parent material, its degree of weathering, particle size and management practice. Soil K exists in four forms that are in equilibrium, each differing in its availability to crops. The K forms were in the order: mineral (5,000 to 25,000 ppm), non-exchangeable (50 to 750 ppm), exchangeable (40 to 600 ppm), and solution K (1 to 10 ppm) (Tisdale *et al*., 1985). Potassium is the major nutrient and also a most abundant element in soils but the K content of the soil varies from place to place based on physico - chemical properties of soil. The dynamics of potassium in soil depends on the magnitude of equilibrium among various forms and mainly governed by the physico - chemical properties of soil (Lalitha and Dakshinamoorthy 2014). The soils of Kurnool district are put to intensive cultivation with rice crop in canal ayacut to meet the urban demand. Hence, an investigation has been planned on rice growing soils of Kurnool district to study the different forms of potassium, soil properties and their inter relation for supplementing the crop with proper amounts of fertilizer K.

MATERIAL AND METHODS

The study area comprised of the Kurnool district canal ayacut area which lies in the geo-coordinates between 15^0 08' to 15^0.47' North latitudes and 78^0 20' to 78^0 38' East longitudes. Surface soils in bulk were collected from eighty locations of Kurnool district and thirty samples were screened for present investigation based on K status. The screened soils were analyzed for their salient characteristics, different forms of K .Correlation studies between soil properties and forms of potassium were carried out. The soil samples collected were air dried and passed through the 2mm sieve. Each sample was then sub-sampled, by quartering and finally a representative soil sample was preserved in a polythene bag for laboratory analysis. The particle size analysis was carried out by Bouyoucous hydrometer method (Piper 1966). The pH and EC were determined in 1:2 soil: water suspension using pH meter and EC meter (Jackson 1973). The organic carbon content in the soil samples was estimated by Walkley and Black wet oxidation method (1934). The CEC of the soils was determined by equilibrating the soil as per the procedure given by Bower *et al., (*1952). The free $CaCO_3$ content was determined as per the procedure given by Piper (1966). Available

nitrogen, phosphorous and potassium were determined as per standard procedures. Water soluble potassium was determined in 1:5 soil : water extract, after 5 minutes shaking (Kanwar and Grewal, 1966). The available potassium was determined by neutral normal ammonium acetate extract (1:5 soil : extractant) , after 5 minutes of shaking as described by Jackson (1973). The exchangeable potassium was obtained as a difference of the available and water soluble potassium. The fixed form of potassium was determined by boiling with 1 N HNO_3 (1:10 soil : acid ratio) for 10 minutes (Wood and DeTurk, 1941). The non-exchangeable potassium was obtained by deducting the available potassium from fixed potassium contents.

RESULTS AND DISCUSSION

Physico-chemical and physical characteristics of the soils

The pH of the soils used in the study varied from 7.0 (Boyarevula) to 8.5 (Pusuluru), with the mean value of 7.8 (Table 1). Thus, the soils under study are neutral to slightly alkaline in reaction. The EC of soils varied from 0.06 dS m^{-1} in Nakkaladinnae to 1.71 dS m^{-1} in S.Nagulavaram with a mean value of 0.42 dS m^{-1}. The soils were non-calcareous and texture of the soils varied from sandy loam to clay, which are moderately coarse to fine in texture. The organic carbon of the soils varied from 0.32 per cent (Nakkaladinnae) to 0.87 per cent (Parnapalli) with a mean of 0.58 per cent (Table 1).

Available nutrients:

The available nitrogen content of the soils (Table 1) showed a range from a minimum value of 188 kg ha^{-1} in Nakkaladinnae to maximum value of 327 kg ha^{-1} in Parnapalli. The average available nitrogen content was 272 kg ha^{-1} (Table 1). The available phosphorus of investigated soils are presented in Table.1, which shows that the available P ranges from 67 to 226 kg P_2O_5 ha^{-1} (Table 1). The lowest value was recorded in S.Nagulavaram while the highest value was recorded in Ayyavari Koduru with a mean value was 159 kg P_2O_5 ha^{-1}. The soils were medium to high in available Phosphorus. The available potassium (K_2O) content of the soils was in the range of 158 to 2343 kg K_2O ha^{-1} (Table 1) with a mean value of 737 kg K_2O ha^{-1}. The lowest value was recorded in Nakkaladinnae and the highest value in Munagala. The investigated soils were medium to high in available potassium. The Cation Exchange Capacity(Table 1) of the soils varied between 14.43 to 31.65 C mol(p^+)kg^{-1} soil with the mean value of 17.56 cmol(p^+)kg^{-1}. The CEC was highest in Ammireddy Nagar while lowest in Panyam rural.

Different forms of potassium in the selected soils:

The data pertaining to content of different forms of potassium viz water soluble, exchangeable, available, non exchangeable and fixed potassium are presented in the table.2.

The water soluble potassium (K_{WS}) varied from 7 mg kg^{-1} (Ramchandrapuram) to 114 mg kg^{-1} (Gajulapalli) with a mean value of 34 mg kg^{-1}. The available potassium (K_{av}) varied from 59 mg kg^{-1} (Nakkaladinnae) to 872 mg kg^{-1} (Munagala). The mean value of available potassium (K_{av}) was 274 mg kg^{-1}. The exchangeable potassium (K_{ex}) content varied from 8 to 801 mg kg^{-1} with a mean value of 240 mg kg^{-1}. The lowest value was observed in Nakkaladinnae soils and the highest in Munagala soils. The non-exchangeable potassium ($K_{non\text{-}ex}$) ranged between 37 mg kg^{-1} (Chennuru) and 569 mg kg^{-1} (MC.Farm College) with a mean value of 254 mg kg^{-1}. The fixed potassium in the selected soils varied from 123 mg kg^{-1} (Nakkaladinnae) to 1365 mg kg^{-1} (Mungala) with a mean amount of 528 mg kg^{-1}. The order of dominance of different forms of potassium was fixed K > non exchangeable K > available K > exchangeable K > water soluble K. (Fig.1)

Correlation coefficients (r) among different forms of potassium

Water soluble K showed positive correlation with available K, exchangeable K, non exchangeable K and fixed K as whereas available K showed positive and significant correlation with exchangeable K (r = 0.981**), non exchangeable K (r = 0.480**) and fixed K (r =0.862**) (Table 3). Similar results were reported by Singh *et al.*(2010). Exchangeable K showed positive and significant correlation with non-exchangeable K (r= 0.453**) and fixed K (r=0.835**). The results are in conformity with the findings of Islam *et al.*(1994) and Das *et al.*(2000). Different forms of potassium exhibited positive correlation among themselves.

Table 1. Salient properties of Rice growing soils of Kurnool district.

S. No	Village Name	Mandal	pH	EC (dS m^{-1})	Ca CO_3(%)	OC (%)	Avail-able N	Available P_2O_5 (kg ha^{-1})	Available K_2O	CEC cmol(p+) Kg^{-1}	Clay	Silt %	Sand	Texture
1	Ramchandrapuram	Dornipadu	8.1	0.25	4.20	0.59	307	177	289	15.02	43.08	8.36	48.56	Sandy clay
2	Poluru	Nandyala	7.6	1.37	4.40	0.47	279	144	771	17.85	41.00	10.36	48.64	Sandy clay
3	S.Nagulavaram	Gospadu	7.8	1.71	4.70	0.39	251	67	298	15.72	41.08	20.36	38.56	Clay loam
4	Panyam Rural	Panyam	7.5	1.35	4.30	0.45	280	199	461	14.43	39.08	10.36	50.56	Sandy clay
5	Jutur	Pampulapadu	7.7	0.24	4.20	0.61	298	179	592	16.26	31.08	0.36	68.56	Sandy clay loam
6	Allagadda Rural	Allaggada	8.1	0.27	3.60	0.57	285	177	610	16.39	41.08	12.36	46.56	Sandy clay
7	Pusuluru	Nandyala	8.5	0.19	3.80	0.33	232	74	668	15.24	43.08	16.36	40.56	Clay
8	Nallagatla	Allagada	7.8	0.70	3.10	0.66	287	205	718	16.13	39.08	16.36	44.56	Sandy clay
9	Ammireddy Nagar	Dornipadu	8.2	0.24	3.20	0.75	299	215	751	31.65	33.08	12.36	54.56	Sandy clay loam
10	RARS, Nandyala	Nandyala	7.6	0.49	3.10	0.59	307	133	783	16.63	43.08	14.36	42.56	Clay
11	Gorukallu	Panyam	8.1	0.22	2.70	0.50	201	212	879	15.48	35.08	6.36	58.56	Sandy clay
12	Bollavaram	Mahanandhi	7.7	0.30	3.20	0.76	294	154	959	16.63	31.08	12.36	56.56	Sandy clay loam
13	Thamadapalli	Mahanandhi	7.7	0.21	2.90	0.63	287	200	1386	17.20	39.08	12.36	48.56	Sandy clay
14	Velpanuru	Velugodu	8.0	0.39	3.60	0.82	286	79	1087	22.17	35.08	2.36	62.56	Sandy clay
15	Nakkaladinnae	Rudravaram	7.7	0.06	2.60	0.32	188	111	158	21.09	15.08	0.36	84.56	Sandy loam
16	Bachapuram	Rudravaram	7.8	0.17	3.20	0.52	281	128	243	15.30	31.08	10.36	58.56	Sandy clay loam
17	Boyarevula	Velugodu	7.0	0.18	3.50	0.37	259	121	293	22.11	19.00	14.36	66.64	Sandy loam
18	Yerraguntla	Srivella	8.0	0.26	2.70	0.83	314	163	538	14.78	34.08	11.36	54.56	Sandy clay loam
19	Parnapalli	Bandi Atmakur	7.3	0.86	3.80	0.87	327	207	486	17.61	29.08	12.36	58.56	Sandy clay loam
20	Padakandla	Allagada	7.5	0.28	1.70	0.55	281	117	548	15.43	33.08	15.36	51.56	Sandy clay loam
21	Ayyaluru	Nandyala	7.2	0.35	3.60	0.37	217	126	778	14.70	29.08	10.36	60.56	Sandy clay loam
22	Kanala	Nandyala	7.9	0.14	3.80	0.48	245	113	703	15.00	25.08	14.36	60.56	Sandy clay loam
23	M.C.Farm, College	Mahanandhi	7.7	0.22	2.70	0.59	263	174	1205	17.74	19.00	12.36	68.64	Sandy loam
24	Rayapadu	Gospadu	8.0	0.23	2.80	0.76	283	216	1146	14.57	29.08	16.36	54.56	Sandy clay loam
25	Munagala	Nandyala	8.3	0.47	3.20	0.60	286	204	2343	19.65	29.08	18.36	52.56	Sandy clay loam
26	Mandaluru	Rudravaram	7.3	0.20	2.60	0.54	278	185	652	20.00	33.08	16.36	50.56	Sandy clay loam
27	Gajulapalli	Mahanandhi	7.5	0.10	3.10	0.41	246	149	820	16.52	29.08	8.36	62.56	Sandy clay loam
28	Chennuru	Srivella	8.1	0.55	3.20	0.33	213	144	351	19.35	31.08	10.36	58.56	Sandy clay loam
29	Thellapuri	Gospadu	8.2	0.34	2.70	0.57	282	185	1053	17.17	39.08	16.36	44.56	Sandy clay
30	Ayyavari Koduru	Bandi Atmakur	7.7	0.21	2.80	0.74	301	226	554	18.91	31.08	4.36	64.56	Sandy clay loam
Mean			7.8	0.42	3.30	0.58	272	159	737	17.56	33.17	11.53	55.30	

Table 2. Different forms of Potassium in Rice growing soils of Kurnool district.

S.No	Village Name	Water soluble K	Available K	Exchange-able K	Non-Ex-changeable K	Fixed K
1	Ramchandrapuram	7.00	108	100	145	253
2	Poluru	24.00	287	262	96	383
3	S.Nagulavaram	16.00	111	95	129	240
4	Panyam Rural	13.00	171	159	266	438
5	Jutur	131.00	220	89	367	588
6	Allagadda Rural	20.00	227	207	231	458
7	Pusuluru	22.00	248	226	519	768
8	Nallagatla	20.00	267	247	263	530
9	Ammireddy Nagar	16.00	280	264	628	908
10	RARS, Nandyala	12.00	291	280	299	590
11	Gorukallu	17.00	327	310	121	448
12	Bollavaram	68.00	357	289	301	658
13	Thamadapalli	43.00	516	473	334	850
14	Velpanuru	29.00	404	375	73	478
15	Nakkaladinnae	51.00	59	8.0	64	123
16	Bachapuram	14.00	90	77.0	147	238
17	Boyarevula	82.00	109	28.0	201	310
18	Yerraguntla	12.00	200	188	235	435
19	Parnapalli	15.00	181	166	107	288
20	Padakandla	12.00	204	192	114	318
21	Ayyaluru	27.00	289	263	468	758
22	Kanala	15.00	262	247	263	525
23	M.C.Farm, College	58.00	448	391	569	1018
24	Rayapadu	21.00	427	406	226	65
25	Munagala	70.00	872	801	493	1365
26	Mandaluru	39.00	243	203	350	593
27	Gajulapalli	114.00	305	192	163	468
28	Chennuru	13.00	131	118	37	168
29	Thellapuri	22.00	392	370	288	680
30	Ayyavari Koduru	18.00	206	188	121	328
Mean		34.00	274	240	254	528
Range		7.00-114	59-872	8-801	37-569	123-1365

This indicates the existence of dynamic equilibrium among the forms of K (Jagadish Prasad, 2010).

Correlation coefficients between different forms of potassium and soil characteristics

Coefficients of correlations were worked out to assess the influence of soil properties on various forms of K. Water soluble K had negative correlation with pH and organic carbon but significant negative correlation with clay and silt (Table 4).

Available K was positively correlated with pH (r=0.295) similar results obtained by Islam *et al*., 1994 and negative non significant correlations with EC (r=-0.123). AV_K showed positive correlation with organic carbon (r=0.258) suggesting its dependence on organic matter. Similar reports were made by Sharma *et al*., 2009. Available K showed positive correlation with CEC (r=0.075), indicating that the clay humus complex formed from increased organic matter provides more exchangeable sites and access to K (Basumatary and Bordoloi 1992). Available K showed negative correlation with sand (r=-0.140) which suggests that the finer texture and higher biomass contribution promoted the available K in the soils. Similar results were reported by Singh *et al*., 2006.

Table 3. Inter correlation between different forms of potassium.

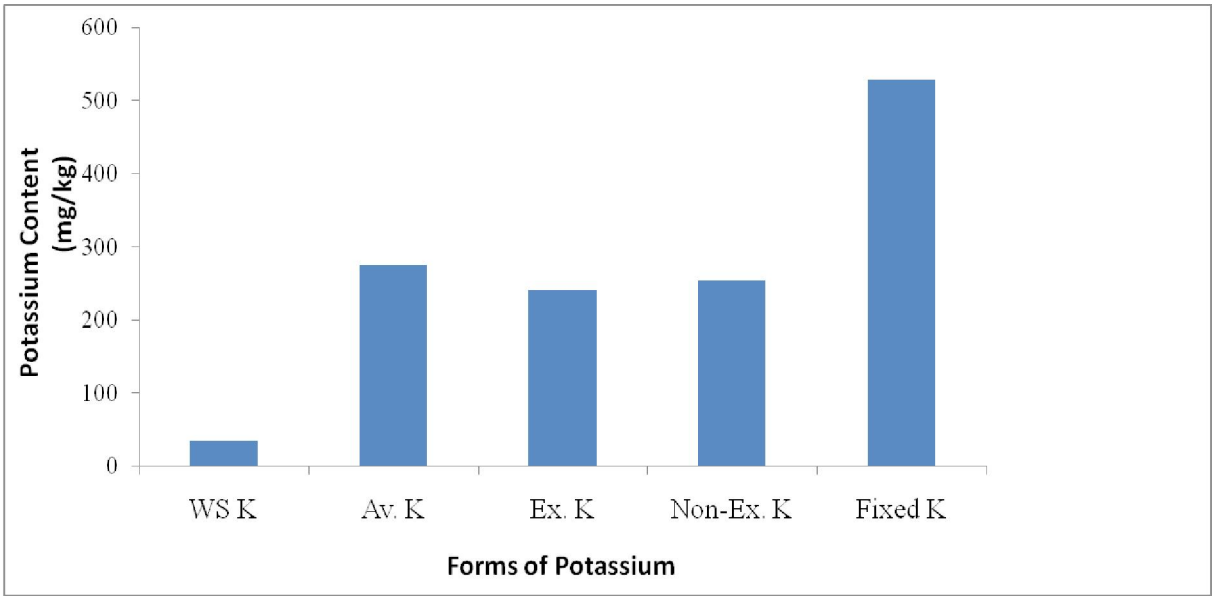
	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
Water soluble K	1.000				
Available K	0.240	1.000			
Exchangeable K	0.047	0.981**	1.000		
Non-Exchangeable K	0.208	0.480**	0.453**	1.000	
Fixed K	0.261	0.862**	0.835**	0.858**	1.000

Table 4. Correlation coefficients between different forms of potassium and soil characteristics.

	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
pH	-0.254	0.295	0.355	0.169	0.270
EC	-0.278	-0.123	-0.071	-0.223	-0.201
$CaCO_3$	0.032	-0.212	-0.224	-0.027	-0.140
OC	-0.124	0.258	0.291	-0.011	0.145
CEC	0.110	0.075	0.055	0.235	0.179
clay %	-0.437*	0.007	0.094	-0.023	-0.009
silt %	-0.287	0.267	0.332***	0.327***	0.345***
sand %	0.468**	-0.140	-0.238	-0.149	-0.168

* Significant at 0.05 per cent level
**Significant at 0.01 per cent level
***Significant at 0.1 per cent level

Fig.1. Relative distribution of K forms (Mean Values) in Kurnool district soils.



Exchangeable K showed positive relationship with clay (r=0.094) but negative with sand fractions (r= -0.238). These results are in conformity with the findings of Das *et al*., 2000 and Abu Taleb *et al*., 2010 and significant positive relationship with organic carbon (r=0.291). Similar reports were made by Sharma *et al.*, 2009. High amount of clay (r=0.094) played an important role in increasing the exchangeable K level by holding more potassium in the exchange sites thereby preventing it from leaching. Non exchangeable K showed negative correlation with organic carbon (r= -0.011). Similar reports were made by Abu Taleb *et al*., 2010.

Among the different soil properties pH, CEC, organic carbon, clay percent and silt percent showed the positive correlation with all forms, except water soluble form whereas EC, $CaCO_3$ and sand percent showed negative correlation

The results of the experiment reveled that the majority of potassium is found in fixed form which replenishes soil solution potassium. Hence, if potassium not adequately supplied during plant growth, fixed K will be depletes and helps in attaining sustainability on a long term basis. Among the different soil properties pH, CEC, organic carbon , clay percent and silt percent showed positive correlation with four forms of potassium , it indicating these soil properties are more influence on the exist of different forms of potassium.

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