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Distribution of Potassium under Prominent Cropping Systems in Scarce Rainfall Zone of Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Six prominent cropping systems in scarce rainfall zone of Andhra Pradesh *viz*., groundnut-horsegram, cotton-fallow, fallow-bengalgram, groundnut monocropping, paddy-paddy and paddy-groundnut cropping systems were selected to study the soil available potassium status and forms of potassium. Twenty soil samples from each cropping system were collected at 0-15 cm (surface soil)

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and 15-30 cm (sub-surface soil) depth. The available potassium content in the study area was varied from medium to high. The highest available K (216 and 148 mg kg^{-1}), water soluble K (19.94 and 14.25 mg kg^{-1}) and exchangeable K (196 and 133 mg kg^{-1}) were recorded under paddy-paddy cropping system in both surface and sub-surface soils, respectively. The highest non-exchangeable K (609 and 441 mg kg^{-1}) was recorded under paddy-groundnut cropping system in both surface and sub-surface soils, respectively. However, lattice K (34072 and 25614 mg kg^{-1}) and total K (34666 and 26066 mg kg^{-1}) were recorded highest under groundnut monocropping system in both surface and sub-surface soils, respectively.

Keywords: Forms of potassium; prominent cropping systems; scarce rainfall zone of Andhra Pradesh.

1. INTRODUCTION

"Soil is an exhaustible storehouse of plant nutrients. Over the past 50 years, there has been a rise in food production to meet the requirements of growing population thereby element concentration was lacking in Indian soils therefore pressurizing Indian agriculture to produce more from shrinking arable land. Balanced nutrition plays a key role in enhancing the productivity of crops and sustainability of production systems" (Ramamurthy et al., 2017).

"Potassium comprises on an average of 2.6 % of the earth crust, making it the seventh most abundant element and third most abundant mineral nutrient in the lithosphere. Among the essential plant nutrients, potassium is known to be a wonder element due to its role in crop growth and its behaviour in the soil system" (Ruparna et al., 2022). "Potassium (K) is the third most important pillar nutrient assumes greater significance because it is needed in comparatively larger amounts by plants and besides increasing the yield and immensely enhances the crop produce quality. It is a key component of the earth's crust, found more abundantly in igneous rocks compared to sedimentary rocks" (Charankumar et al., 2021). "Potassium is a neglected nutrient in an intensive agricultural production because of the general conception that Indian soils are rich in native-K resulted from the exclusion of potassium in balanced nutrition lead to the mining of soil reserve K" (Charankumar and Munaswamy, 2022). Potassium is not only being more readily available, but also reduces the negative impacts of moisture stress on the crop.

"In scarce rainfall zone, the major constraint for agricultural productivity is soil moisture availability and potassium deficiency during their crop growing season. To combat declining soil fertility and increase food security, there is a need to prioritize study in scarce rainfall zone. Crop fertilisation with potassium in rainfed agriculture in India is not practised, merely on the assumption that Indian soils are rich in potassium and crops do not need external K supply. However, under continuous cropping in scarce rainfall regions, huge crop K removals are reported, up to 150–200 kg/ha annually, depending upon amount and distribution of rainfall and biomass production" (Srinivasarao et al., 2007). "Thus, most of the crops essentially deplete soil K reserves. The present study evaluates the soil K reserves under prominent cropping systems based on different soil K fractions. Therefore, the knowledge about different forms and availability of potassium is must while studying the response of crops to K. Because potassium supply to crop plants is a complex phenomenon involving relationships among various K fractions in soil.

Potassium exists in different forms *viz.,* water soluble, exchangeable, non-exchangeable and lattice potassium. Potassium present in soil solution as soluble cation is termed as water soluble K. The exchangeable potassium is the form of K held in the solid phase of soil, on clay and organic matter in the soil matrix, by electrostatic forces and easily moves into the soil solution as this form can be readily exchanged by other cations and also is readily available to plants. The exchangeable K is important in replenishing soil solution potassium which is removed by cropping or lost by leaching. Generally, the K held at inter-lattice positions is non-exchangeable K and this form is not exchangeable by NH_4OAc. This form of K is not readily available to plants. Lattice K that gets fixed in lattice space of the 2:1 clay minerals and held between adjacent tetrahedral layers of di-octahedral and tri-octahedral wedge zones of weathered micas and vermiculite. A large portion of the total potassium in soil occurs as structural component of soil minerals and is unavailable to plants. The content of total potassium depends on the type of soil fraction, type of primary and secondary minerals and type of parent material.

The rate of change in the dynamic equilibrium between various forms of potassium in the soil, which is in turn controlled by the mineral composition, rate of weathering and exchange properties of the soil, which determines the availability of potassium for plants" (Lalitha and Dhakshinamoorthy, 2014).

2. MATERIALS AND METHODS

The present study was carried out in scarce rainfall zone of Andhra Pradesh, India lies in between the northern latitudes of $13^0 40'$ to $16^0 18'$ and eastern longitudes of $76^0 47'$ to $79^0 34'$. The geographical area of scarce rainfall zone 36,788 km^2. Out of 40 lakh ha of rainfed area, about 45 per cent area is in scarce rainfall zone of Andhra Pradesh. The total annual rainfall of the study area during the year 2023-2024 was 805.8 mm. Twenty soil samples at 0-15 cm (surface soil) and 15-30 cm (sub-surface soil) depths were collected from the six prominent cropping systems *viz*., groundnut-horsegram, cotton-fallow, fallow-bengalgram, groundnut monocropping, paddy-paddy and paddy-groundnut cropping systems. The collected soil samples were air dried in shade, ground with a wooden hammer, passed through the 2 mm sieve and used for determination of available potassium and forms of potassium. The available K was extracted with NH_4OAC with the ratio of 1:5 and shaking for 5 min (Hanway and Heidel, 1952). Water soluble K was extracted by shaking the soil water suspension in the ratio of 1:5 for 5 min then filtered, and K was determined (Jackson, 1973). Exchangeable potassium was calculated by deducting the values of water soluble potassium from available potassium. Non-exchangeable potassium was estimated from soil with 1 *N* HNO_3 in the ratio 1:10 (Soil: HNO_3) and boiled for 10 minutes as per the procedure described by Wood and De Turk (1941). The lattice potassium was computed as the difference between total K and the sum of NH_4OAC K and non-exchangeable K (Wiklander, 1954). Total potassium of soil was estimated by HF-$HClO_4$ digestion method (Pratt, 1965). All the forms of potassium were determined by aspirating the extract into the flame photometer.

3. RESULTS AND DISCUSSION

Available K: The available potassium content of surface soils varied from 73 mg kg^{-1}in groundnut monocropping system to 289 mg kg^{-1}in paddy-paddy cropping system with mean values of 122 and 216 mg kg^{-1}, respectively. In sub-surface soils available potassium content varied from 58 mg kg^{-1} in groundnut monocropping system to 244 mg kg^{-1} in paddy- paddy cropping system with mean values of 92 and 148 mg kg^{-1}, respectively. The available potassium content in surface and sub surface soils was varied from medium to high.

The highest available potassium was observed in soils of paddy- paddy cropping system in both surface and sub-surface soils, which might be due to continuous application of potassic fertilizers. The lowest available potassium was recorded in groundnut monocropping system in both surface and sub surface soils possibly either due to less application of potassic fertilizers than crop needed or imbalanced fertilization in crop nutrition caused mining of its native pools. Similar results were also reported by Charankumar et al. (2022).

The data further revealed that highest available potassium was observed in surface soils than in sub-surface soils in all cropping systems, which might be attributed to presence of vegetation or upward translocation of K from lower layers through capillary rise or ground water as reported by Lungmuana et al. (2014).

Water Soluble K: The water soluble potassium content of surface soils varied from 6.59 mg kg^{-1} in groundnut monocropping system to 29.10 mg kg^{-1} in paddy- paddy cropping system with mean values of 10.87 and 19.94 mg kg^{-1}, respectively. In sub-surface soils water soluble potassium content varied from 4.72 mg kg^{-1} in groundnut monocropping system to 24.25 mg kg^{-1} in paddy-paddy cropping system with mean values of 8.15 and 14.25 mg kg^{-1}, respectively.

The highest water soluble K was observed in soils of paddy-paddy cropping system in both surface and sub-surface soils, which might be due to high dose of K fertilizers were applied to paddy in both seasons. The lowest water soluble K was observed in groundnut monocropping system at both depths, which might be due to less application of K fertilizers.

The data further revealed that highest water soluble K was observed in surface soils than in sub-surface soils in all cropping systems, which might be attributed to accumulation of potassium applied through fertilizers in the surface layers. Similar results were also reported by Kumari et al. (2017) under rice-wheat cropping system.

Exchangeable K: The exchangeable potassium content of surface soils varied from 65 mg kg^{-1} in

groundnut monocropping system to 266 mg kg^{-1} in paddy- paddy cropping system with mean values of 112 and 196 mg kg^{-1}, respectively. In sub-surface soils exchangeable potassium content varied from 52 mg kg^{-1}in groundnut monocropping system to 220 mg kg^{-1} in paddy- paddy cropping system with mean values of 84 and 133 mg kg^{-1}, respectively.

"The highest exchangeable K was observed in soils of paddy-paddy cropping system in both surface and sub-surface soils, which might be due to high dose of K fertilizers were applied to paddy in both seasons or due to the fact that soils contain relatively higher clay per cent which offered more exchangeable sites for K. The lowest exchangeable K was observed in groundnut monocropping system in surface and sub-surface soils might be due to low application of potassic fertilizers under groundnut monocropping system or due to non replenishment of K from the other forms" (Rao et al., 2013).

Non-exchangeable K: The non-exchangeable potassium content of surface soils varied from 193 mg kg^{-1} in groundnut monocropping system to 858 mg kg^{-1}in paddy- groundnut cropping system with mean values of 472 and 609 mg kg^{-1}, respectively. In sub-surface soils non-exchangeable potassium content varied from 181 mg kg^{-1}in groundnut monocropping system to 730 mg kg^{-1} in paddy- groundnut cropping system with mean values of 360 and 441 mg kg^{-1}, respectively.

The highest non-exchangeable K was recorded in soils of paddy groundnut cropping system at both depths possibly due to conversion of added water soluble K into non- exchangeable forms, increased fixation induced by successive application of K fertilizers which might have decreased utilization of non-exchangeable K leading to its accumulation (Rout et al., 2017). The lowest non-exchangeable K was observed in groundnut monocropping system in both surface and sub-surface soils, which might be due to the fact that more removal of exchangeable K by crop in order to replenish decreased exchangeable K, non-exchangeable K was resealed to maintain dynamic equilibrium. The above results were in line with findings of Charankumar et al. (2022).

The data further revealed that highest non-exchangeable K was observed in surface soils compared to sub-surface soils in all cropping systems. Similar results were also reported by Kumari and Nisha (2014) in soils of rice-wheat cropping system.

Lattice K: The lattice potassium content of surface soils varied from 14173 mg kg^{-1} in paddy-groundnut cropping system to 49156 mg kg^{-1} in groundnut monocropping system with mean values of 25356 and 34072 mg kg^{-1}, respectively. In sub-surface soils, the lattice potassium content varied from 8222 mg kg^{-1} in paddy-groundnut cropping system to 33389 mg kg^{-1} in groundnut monocropping system with mean values of 16351 and 25614 mg kg^{-1}, respectively.

The lattice K was maximum in soils of groundnut monocropping system in both the surface and sub-surface soils might be due to these soils have been developed from mica rich parent material and much of potassium is present in mica lattice structure (Kundu et al., 2014). The lattice K was minimum in paddy-groundnut cropping system in both the surface and sub-surface soils.

The data further revealed that the highest lattice K was observed in surface soils than in sub-surface soils in all cropping systems. This might be due to degree of weathering and soil type the surface and sub-surface lattice K content might have been varied among the samples. The results were in comparison with those of research findings of Karwade et al. (2020).

Total K: The total potassium content of surface soils varied from 14700 mg kg^{-1} in paddy-groundnut cropping system to 49650 mg kg^{-1} in groundnut monocropping system with mean values of 26168 and 34666 mg kg^{-1}, respectively. In sub-surface soils, the total potassium content varied from 8740 mg kg^{-1} in paddy-groundnut cropping system to 33870 mg kg^{-1} in groundnut monocropping system with mean values of 16927 and 26066 mg kg^{-1}, respectively.

The highest total K was recorded in soils of groundnut monocropping system in both the surface and sub-surface soils possibly due to predominance of potassium bearing primary minerals. These results were in line with the findings of Charankumar et al. (2022). The paddy-groundnut cropping was recorded the lowest total K content in both the surface and sub-surface soils, respectively.

Table 1. Distribution of different forms of potassium under groundnut-horsegram cropping system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	156	130	15.60	13.00	140	117	585	450	41449	22190	42190	22770
2	140	125	14.00	12.50	126	113	468	384	30722	19681	31330	20190
3	108	98	10.82	9.80	97	88	469	421	37693	32241	38270	32760
4	122	114	12.20	11.40	110	103	558	479	34810	15267	35490	15860
5	128	108	12.76	10.80	115	97	543	495	32449	22127	33120	22730
6	82	60	8.20	6.00	74	54	290	189	24298	19121	24670	19370
7	134	96	13.40	9.63	121	87	648	232	37058	28862	37840	29190
8	121	59	12.15	5.87	109	53	768	246	37781	26395	38670	26700
9	85	69	8.45	6.86	76	62	486	456	27080	23115	27650	23640
10	93	80	9.25	7.98	83	72	581	447	33337	20923	34010	21450
11	147	66	11.74	5.28	135	61	420	241	33303	23413	33870	23720
12	135	124	13.48	9.92	121	114	357	321	35928	27165	36420	27610
13	157	126	15.65	10.08	141	116	535	482	28429	31732	29120	32340
14	188	125	15.08	9.98	173	115	557	424	29825	30782	30570	31330
15	177	130	17.70	10.43	159	120	510	377	33033	20223	33720	20730
16	167	108	13.32	8.64	153	99	589	524	20865	28228	21620	28860
17	143	112	11.42	8.96	131	103	485	394	30032	26904	30660	27410
18	182	92	18.21	7.35	164	85	397	289	37351	25390	37930	25770
19	213	146	17.02	11.66	196	134	529	468	32709	22726	33450	23340
20	152	112	15.21	9.00	137	103	427	347	33401	29121	33980	29580
Min	**82**	**59**	**8.20**	**5.28**	**74**	**53**	**290**	**189**	**20865**	**15267**	**21620**	**15860**
Max	**213**	**146**	**18.21**	**13.00**	**196**	**134**	**768**	**524**	**41449**	**32241**	**42190**	**32760**
Mean	**141**	**104**	**13.28**	**9.26**	**128**	**95**	**510**	**383**	**32578**	**24780**	**33229**	**25268**
S.D	**35**	**26**	**2.87**	**2.18**	**32**	**24**	**106**	**100**	**4940**	**4630**	**4969**	**4633**
C.V	**24.82**	**25.00**	**21.61**	**23.54**	**25.00**	**25.26**	**20.78**	**26.11**	**15.16**	**18.68**	**14.95**	**18.34**

Table 2. Distribution of different forms of potassium under cotton-fallow cropping system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	85	70	8.50	6.96	77	63	641	218	38834	30332	39560	30620
2	152	132	15.23	13.16	137	118	640	445	21607	17623	22400	18200
3	145	66	14.50	6.58	131	59	314	286	26661	21328	27120	21680
4	123	109	12.25	10.85	110	98	408	255	22909	19347	23440	19710
5	135	122	13.48	12.24	121	110	447	425	25958	17423	26540	17970
6	108	80	10.80	8.00	97	72	475	360	28527	23400	29110	23840
7	136	63	13.65	6.25	123	56	670	386	23424	18462	24230	18910
8	154	76	15.35	7.60	138	68	805	538	27642	18626	28600	19240
9	85	67	8.50	6.70	77	60	754	542	37471	29281	38310	29890
10	118	123	11.84	12.29	107	111	748	521	28253	16896	29120	17540
11	224	150	17.92	12.02	206	138	540	426	29867	25944	30630	26520
12	237	146	18.96	11.66	218	134	655	580	21778	13114	22670	13840
13	191	161	15.30	12.87	176	148	517	416	29101	31503	29810	32080
14	157	87	12.52	6.96	144	80	421	389	35673	25845	36250	26320
15	278	125	22.27	12.48	226	112	504	453	38748	28202	39530	28780
16	149	62	11.94	6.24	127	56	560	390	29101	26888	29810	27340
17	145	128	11.60	10.24	133	118	361	284	26844	17818	27350	18230
18	223	166	17.83	13.30	205	153	568	479	27719	15745	28510	16390
19	246	184	19.68	9.18	226	174	522	450	19882	28706	20650	29340
20	264	150	21.14	11.98	243	138	349	236	37507	28574	38120	28960
Min	**85**	**62**	**8.50**	**6.24**	**77**	**56**	**314**	**218**	**19882**	**13114**	**20650**	**13840**
Max	**278**	**184**	**22.27**	**13.30**	**243**	**174**	**805**	**580**	**38834**	**31503**	**39560**	**30620**
Mean	**168**	**113**	**14.66**	**9.88**	**151**	**103**	**545**	**404**	**28875**	**22753**	**29588**	**23270**
S.D	**58**	**39**	**3.93**	**2.68**	**52**	**37**	**141**	**105**	**5906**	**5700**	**5901**	**5669**
C.V	**34.52**	**34.51**	**26.81**	**27.13**	**34.44**	**35.92**	**25.87**	**25.99**	**20.45**	**25.05**	**19.94**	**24.36**

Table 3. Distribution of different forms of potassium under fallow-bengalgram cropping system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	197	134	19.50	13.40	177	121	559	442	37284	13514	38040	14090
2	149	112	20.95	17.65	128	94	504	223	34237	22816	34890	23150
3	152	118	16.00	13.35	136	105	552	532	32056	31710	32760	32360
4	135	122	10.85	12.25	124	110	512	427	28093	30531	28740	31080
5	173	137	17.25	13.74	155	124	531	428	35866	27745	36570	28310
6	153	126	15.29	18.10	138	108	525	495	28222	13669	28900	14290
7	167	133	19.75	13.25	147	119	569	383	20725	30375	21460	30890
8	183	126	18.80	16.00	164	110	830	656	22237	28238	23250	29020
9	145	122	18.80	12.18	126	110	444	381	41381	21148	41970	21650
10	139	117	23.75	11.66	115	105	511	382	22160	24011	22810	24510
11	143	116	14.26	12.00	128	104	513	470	33765	23425	34420	24010
12	189	130	24.55	12.96	164	117	625	394	29747	20946	30560	21470
13	153	141	7.40	11.26	145	130	581	371	26846	23078	27580	23590
14	156	114	28.00	11.38	128	102	610	428	23364	17778	24130	18320
15	98	70	12.00	7.00	86	63	637	519	21406	18511	22140	19100
16	249	140	19.92	11.24	229	129	550	372	30901	28178	31700	28690
17	213	131	17.04	12.20	196	119	631	528	32766	26400	33610	27060
18	282	210	28.20	10.50	254	200	558	422	34360	30158	35200	30790
19	174	132	13.94	10.56	160	121	476	344	31260	26334	31910	26810
20	157	139	12.60	11.11	145	128	328	311	29235	29441	29720	29890
Min	**98**	**70**	**7.40**	**7.00**	**86**	**63**	**328**	**223**	**20725**	**13514**	**21460**	**14090**
Max	**282**	**210**	**28.20**	**18.10**	**254**	**200**	**830**	**656**	**41381**	**31710**	**41970**	**32360**
Mean	**170**	**128**	**17.94**	**12.59**	**152**	**116**	**552**	**425**	**29796**	**24400**	**30518**	**24954**
S.D	**41**	**25**	**5.48**	**2.51**	**39**	**25**	**96**	**93**	**5734**	**5493**	**5707**	**5501**
C.V	**24.12**	**19.53**	**30.55**	**19.94**	**25.66**	**21.55**	**17.39**	**21.88**	**19.24**	**22.51**	**18.70**	**22.04**

Table 4. Distribution of different forms of potassium under groundnut monocropping system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	147	104	14.73	10.43	133	94	346	304	49156	31632	49650	32040
2	76	61	7.60	6.11	68	55	547	407	37237	29672	37860	30140
3	108	101	10.80	10.07	97	91	559	282	33533	22977	34200	23360
4	73	66	7.25	6.61	65	59	434	343	33163	27111	33670	27520
5	113	64	11.25	6.37	101	57	502	381	31205	26505	31820	26950
6	138	104	13.84	10.43	125	94	508	373	37134	28413	37780	28890
7	80	72	8.00	7.20	72	65	598	409	26852	33389	27530	33870
8	113	73	11.32	7.30	102	66	325	293	35012	30874	35450	31240
9	141	83	14.11	8.33	127	75	350	279	42499	27498	42990	27860
10	83	58	8.30	5.80	75	52	446	259	28231	28833	28760	29150
11	84	68	6.72	5.44	77	63	518	406	36688	28976	37290	29450
12	191	128	15.30	10.21	176	117	572	425	31847	18807	32610	19360
13	125	134	9.98	10.74	115	124	493	410	33643	27495	34260	28040
14	91	59	7.30	4.72	84	54	478	345	26211	21526	26780	21930
15	134	112	10.72	9.00	123	103	612	477	24744	17851	25490	18440
16	82	74	6.59	5.89	76	68	531	466	37207	22390	37820	22930
17	184	134	14.72	10.72	169	123	193	181	36023	18405	36400	18720
18	131	69	10.50	5.50	121	63	504	423	37055	28678	37690	29170
19	175	144	14.00	11.52	161	132	492	380	34093	21416	34760	21940
20	179	133	14.31	10.61	165	122	422	353	29909	19835	30510	20320
Min	**73**	**58**	**6.59**	**4.72**	**65**	**52**	**193**	**181**	**24744**	**17851**	**25490**	**18440**
Max	**191**	**144**	**15.30**	**11.52**	**176**	**132**	**612**	**477**	**49156**	**33389**	**49650**	**33870**
Mean	**122**	**92**	**10.87**	**8.15**	**112**	**84**	**472**	**360**	**34072**	**25614**	**34666**	**26066**
S.D	**39**	**30**	**3.06**	**2.27**	**36**	**28**	**103**	**75**	**5690**	**4776**	**5650**	**4757**
C.V	**31.97**	**32.61**	**28.15**	**27.85**	**32.14**	**33.33**	**21.82**	**20.83**	**16.70**	**18.65**	**16.30**	**18.25**

Table 5. Distribution of different forms of potassium under paddy-paddy system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	229	189	22.40	18.87	206	170	376	234	32916	28217	33520	28640
2	161	143	20.35	11.80	141	131	397	299	23182	20408	23740	20850
3	208	168	20.76	16.84	187	152	751	712	30931	17239	31890	18120
4	118	89	16.35	11.65	102	57	664	538	23348	19284	24130	19910
5	143	120	14.60	12.10	128	108	378	295	28229	16205	28750	16620
6	256	244	25.60	24.25	230	220	407	230	20657	19976	21320	20450
7	241	138	24.08	13.85	217	125	711	617	28458	26635	29410	27390
8	191	129	19.12	14.95	172	114	416	353	30363	20638	30970	21120
9	127	122	12.55	12.20	114	110	813	645	23790	23283	24730	24050
10	268	142	29.10	13.70	241	128	527	446	28145	26083	28940	26670
11	201	110	16.11	10.55	185	99	612	361	31336	17760	32150	18230
12	289	172	23.10	13.72	266	158	653	434	26588	8565	27530	9170
13	273	156	21.88	15.80	252	140	510	276	31137	13778	31920	14210
14	203	121	20.26	9.78	182	111	739	577	28918	11102	29860	11800
15	217	136	17.33	13.70	199	122	550	482	30214	10372	30980	10990
16	274	166	21.95	20.35	252	146	625	457	37660	15366	38560	15990
17	230	176	18.39	13.58	211	162	528	382	23803	21622	24560	22180
18	205	145	16.36	10.35	188	135	511	433	31144	17402	31860	17980
19	263	153	21.00	12.20	242	140	642	524	16205	14053	17110	14730
20	220	150	17.57	14.70	202	135	417	351	21833	16369	22470	16870
Min	**118**	**89**	**12.55**	**9.78**	**102**	**57**	**376**	**230**	**16205**	**8565**	**17110**	**9170**
Max	**289**	**244**	**29.10**	**24.25**	**266**	**220**	**813**	**712**	**37660**	**28217**	**38560**	**28640**
Mean	**216**	**148**	**19.94**	**14.25**	**196**	**133**	**561**	**432**	**27443**	**18218**	**28220**	**18799**
S.D	**50**	**33**	**3.96**	**3.59**	**47**	**33**	**136**	**138**	**5003**	**5354**	**5015**	**5347**
C.V	**23.15**	**22.30**	**19.86**	**25.19**	**23.98**	**24.81**	**24.24**	**31.94**	**18.23**	**29.39**	**17.77**	**28.44**

Table 6. Distribution of different forms of potassium under paddy-groundnut system in scarce rainfall zone of Andhra Pradesh

S. No	Available K (mg kg-1)		Water soluble K (mg kg-1)		Exchangeable K (mg kg-1)		Non-Exchangeable K (mg kg-1)		Lattice K (mg kg-1)		Total K (mg kg-1)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
1	127	112	12.73	11.00	115	101	400	266	14173	20252	14700	20630
2	279	150	27.95	15.00	251	135	448	380	17833	10030	18560	10560
3	282	130	28.20	13.00	254	117	734	524	20434	24006	21450	24660
4	113	72	11.32	7.20	102	65	599	432	20268	8766	20980	9270
5	146	77	17.70	7.35	128	69	490	416	16104	9087	16740	9580
6	101	92	10.09	9.24	91	83	587	426	15402	8222	16090	8740
7	284	226	28.44	22.60	256	203	767	543	25819	17241	26870	18010
8	160	129	16.02	22.66	144	106	529	368	23321	15263	24010	15760
9	134	85	13.38	8.50	120	77	553	356	18043	14449	18730	14890
10	110	74	10.85	7.40	99	67	404	277	19266	9109	19780	9460
11	230	124	18.39	10.22	211	114	591	458	31419	21468	32240	22050
12	272	146	24.35	11.66	248	134	858	730	30580	24854	31710	25730
13	247	166	19.74	8.65	227	158	713	554	32690	15910	33650	16630
14	200	117	16.00	15.75	184	101	560	384	22520	15179	23280	15680
15	220	176	17.57	14.08	202	162	677	485	25833	17149	26730	17810
16	206	166	16.48	13.30	190	153	600	414	33964	15500	34770	16080
17	234	125	18.71	12.90	215	113	744	532	34842	21793	35820	22450
18	246	158	19.68	12.64	226	145	638	448	37427	19684	38310	20290
19	249	184	16.50	14.27	232	169	627	487	36284	18090	37160	18760
20	219	176	17.49	14.08	201	162	656	346	30906	20968	31780	21490
Min	**101**	**72**	**10.09**	**7.20**	**91**	**65**	**400**	**266**	**14173**	**8222**	**14700**	**8740**
Max	**284**	**226**	**28.44**	**22.66**	**256**	**203**	**858**	**730**	**37427**	**24854**	**38310**	**25730**
Mean	**203**	**134**	**18.08**	**12.57**	**185**	**122**	**609**	**441**	**25356**	**16351**	**26168**	**16927**
S.D	**63**	**42**	**5.52**	**4.36**	**58**	**39**	**121**	**106**	**7600**	**5205**	**7710**	**5277**
C.V	**31.03**	**31.34**	**30.53**	**34.69**	**31.35**	**31.97**	**19.87**	**24.04**	**29.97**	**31.83**	**29.46**	**31.18**

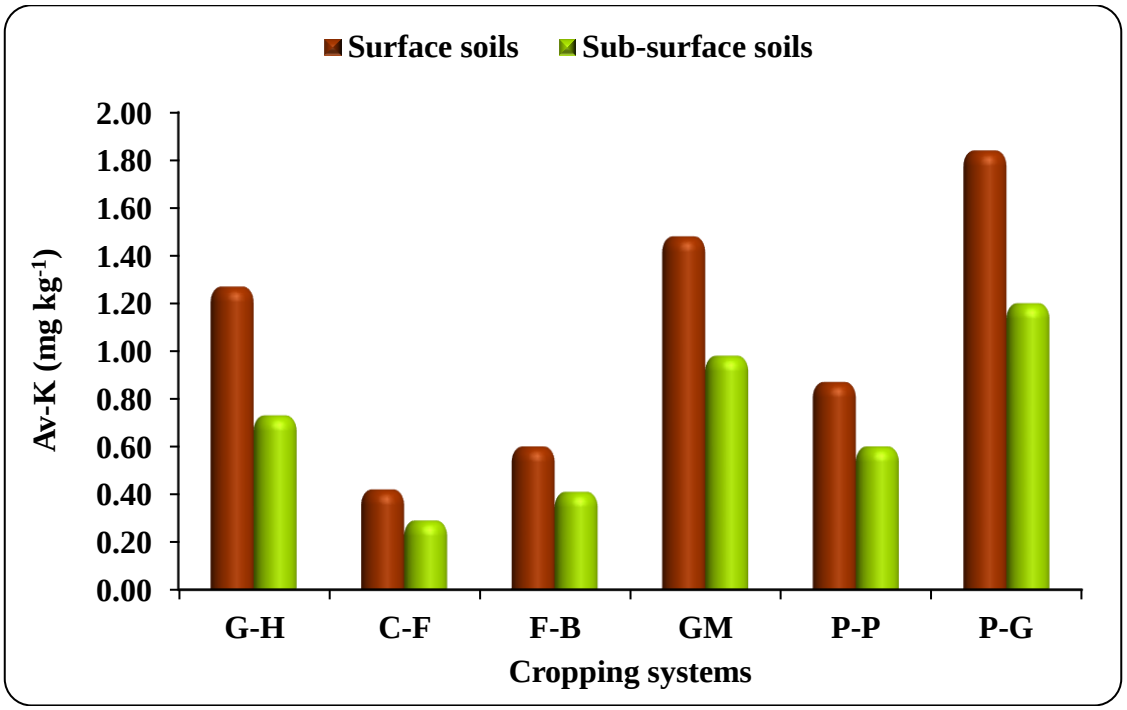

Fig. 1. Available K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

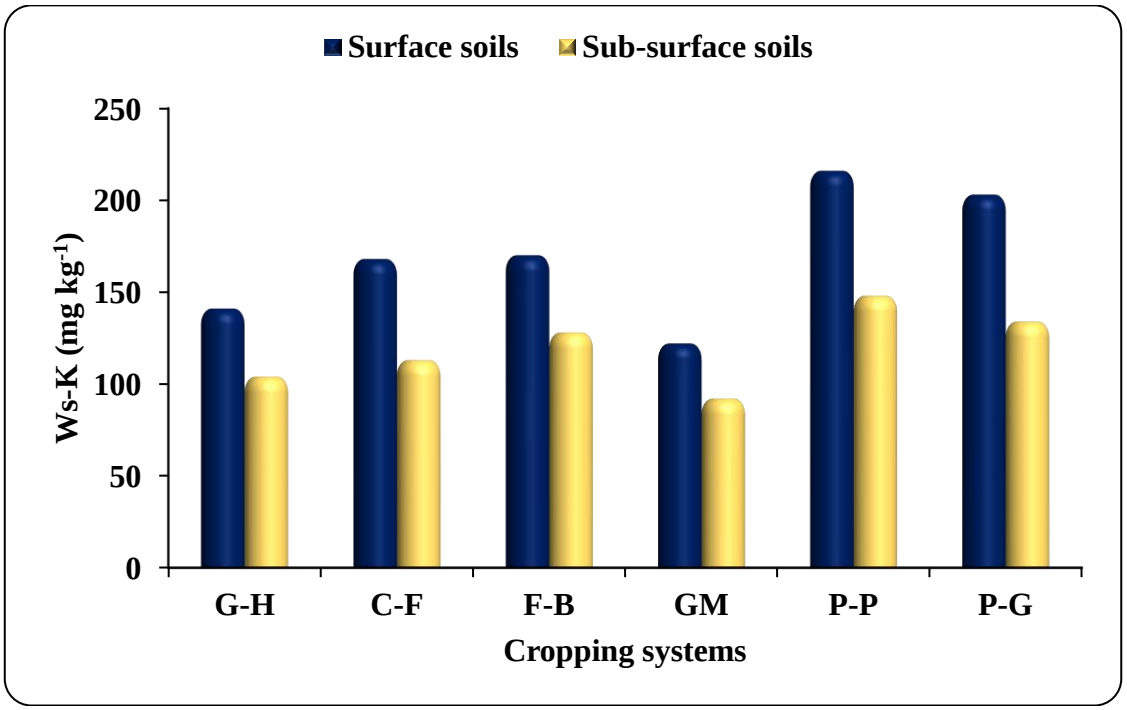

Fig. 2. Water soluble K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

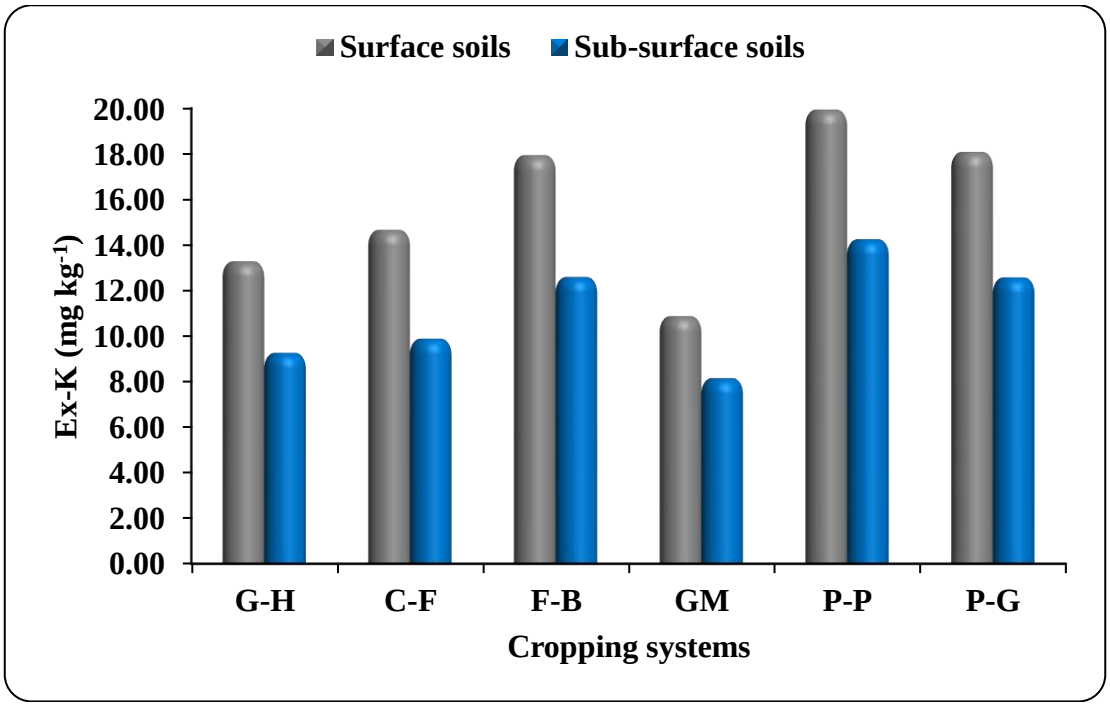

Fig. 3. Exchangeable K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

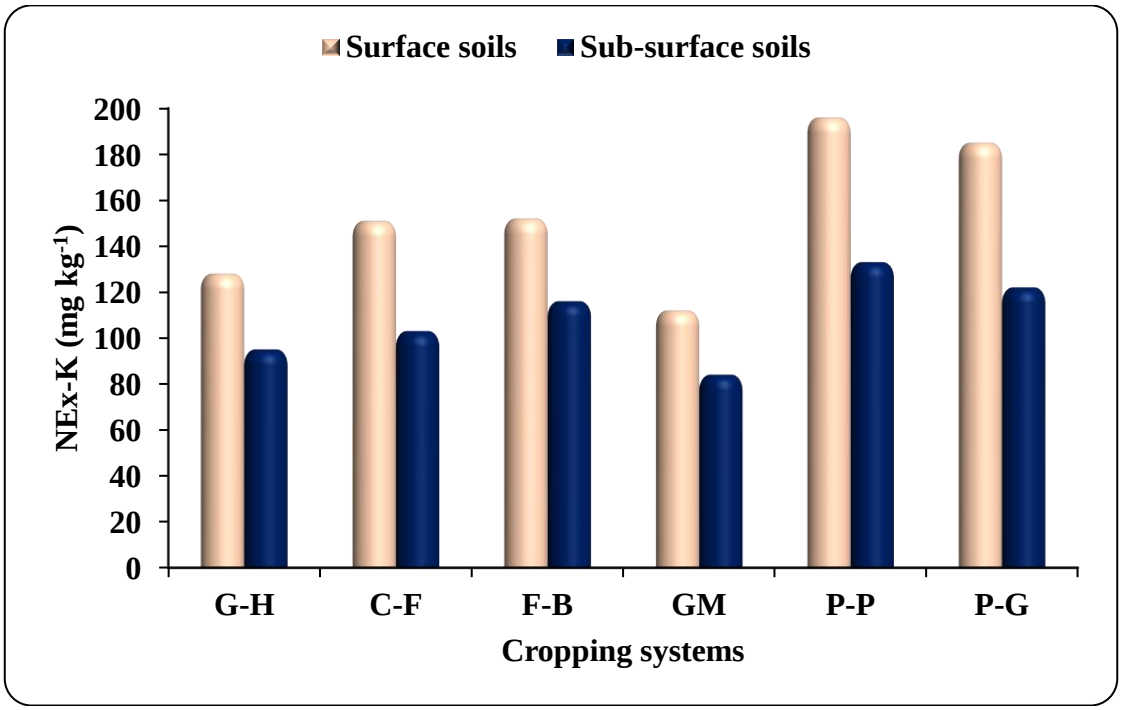

Fig. 4. Non-exchangeable K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

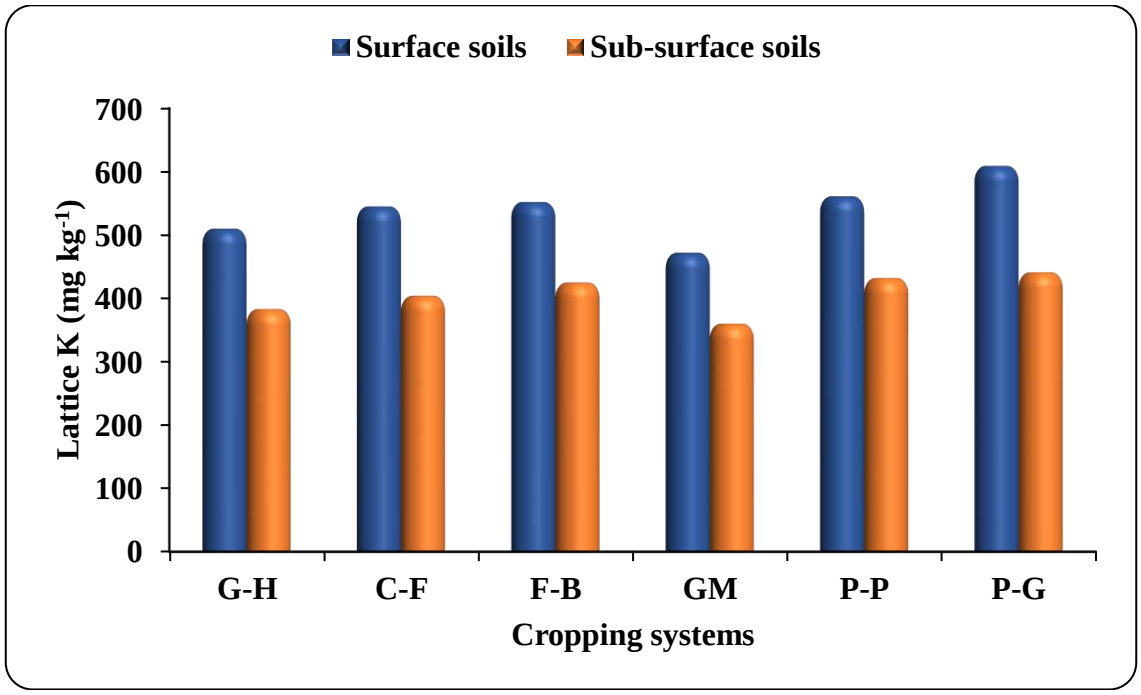

Fig. 5. Lattice K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

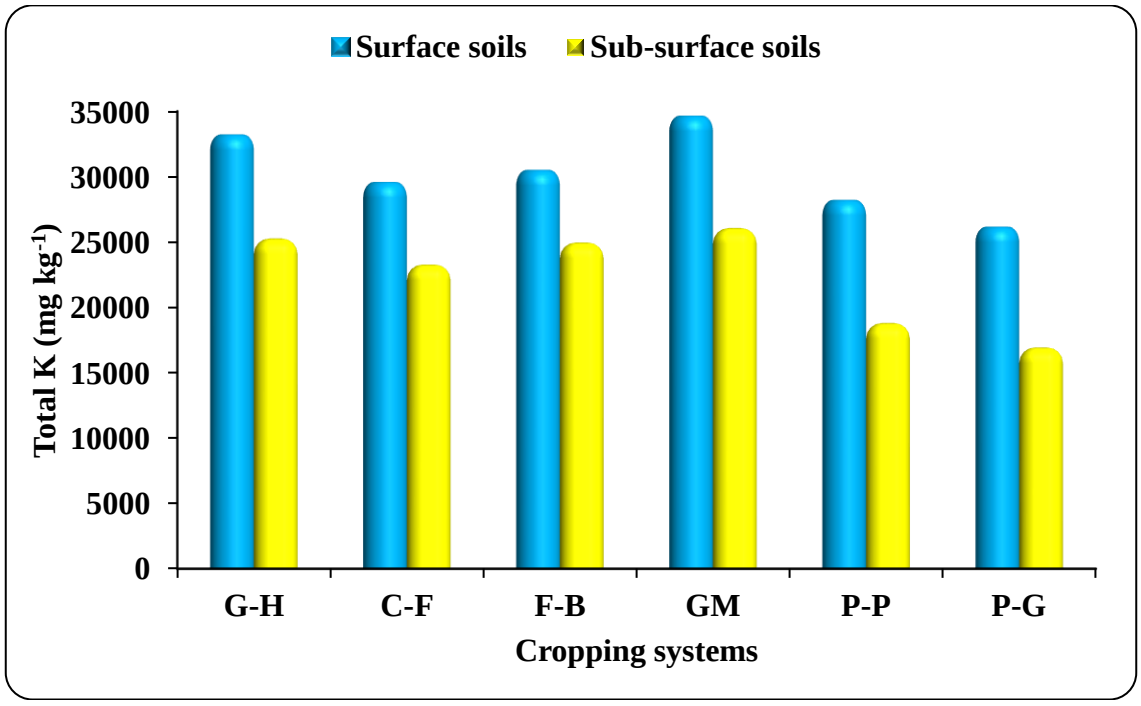

Fig. 6. Total K (mg kg^{-1}) status of soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh

Note: G-H: Groundnut-Horsegram; C-F: Cotton-Fallow; F-B: Fallow-Bengalgram; GM: Groundut Monocropping; P-P: Paddy-Paddy; P-G: Paddy-Groundnut

"The data further revealed that highest total K was observed in surface soils than in sub-surface soils in all cropping systems which might be due to the presence of substantial quantities of K bearing minerals as a reserve, as the treatment received sufficient amount of K from external application to meet out the crop demand" (Divya et al., 2016).

4. CONCLUSION

The results of this study indicated that the soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh were medium to high in available potassium. The available K, water soluble K and exchangeable K in the prominent cropping systems were in the order of paddy-paddy > paddy-groundnut > fallow-bengalgram > cotton-fallow > groundnut-horsegram > groundnut monocropping. The non-exchangeable K content in the prominent cropping systems was in the order of paddy-groundnut > paddy-paddy > fallow bengalgram > cotton-fallow > groundnut-horsegram > groundnut monocropping. The lattice K and total K in the prominent cropping systems were in the order of groundnut monocropping > groundnut-horsegram > fallow bengalgram > cotton-fallow paddy-paddy > paddy-groundnut. Soil K fractions in all cropping systems were in the order of total K > lattice K > non-exchangeable K > available K > exchangeable K > water soluble K.

Understanding the availability and forms of soil potassium status in soils of scarce rainfall zone will assist in assessing long term nutrient availability and making judicious fertilizer recommendation for ensuring sustainable crop production. A future study on clay mineralogy of the soils may help calibrating the reserve pool of K and the extent of its mining. This may help to formulate an effective K fertilizer program for the soils of the region. Investigating the potential impact of climate change on potassium cycling in surface and subsurface soils. Integrating advanced modeling techniques to simulate potassium dynamics and predict future trends under changing environmental conditions.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Charankumar, G.R., & Munaswamy, V. (2022). Forms of potassium and their distribution under prominent cropping systems of Chittoor District of Andhra Pradesh, India. *Indian Journal of Ecology*, *49*(1), 109-113.

Charankumar, G.R., Jayasree, B., Kalitha, P., & Munaswamy, V. (2021). Dynamics of soil potassium under different cropping systems. *Innovations in Life Science Research*, *1*(1), 9-19.

Charankumar, G.R., Munaswamy, V., Krishna, T.G., & Subramanyam, D. (2022). Dynamics of soil potassium under different cropping systems in YSR Kadapa district of Andhra Pradesh. *Environment and Ecology*, *40*(2), 425-431.

Divya, M., Jagadeesh, B.R., Srinivasa, D.K., & Yogesh, G.S. (2016). Effect of long-term soil fertilizer application on forms and distribution of potassium in soil under rice-cowpea cropping system. *An Asian Journal of Soil Science*, *11*(1), 10-19.

Hanway, J.J., & Heidel, H. (1952). Soil analysis methods, as used in Iowa State. College Soil Testing Laboratory, Iowa, Agriculture, *57*, 1-31.

Jackson, M.L. (1973). *Soil chemical analysis*. Prentice Hall of India Private Limited.

Karwade, S., Badole, W.P., Thombe, S., & Patel, B. (2020). Distribution of different forms of soil potassium in surface and sub-surface layers of paddy growing areas of Nagpur District. *Journal of Pharmacognosy and Phytochemistry*, *9*(2), 909-915.

Kumari, M., & Nisha, K. (2014). Depthwise distribution of potassium under various nutrient management practices in rice-wheat cropping system. *Environment and Ecology*, *32*(1), 51-55.

Kumari, M., Pandey, A.K., & Singh, A. (2017). Effect of continuous cropping and fertilization on distribution of potassium fractions under rice wheat cropping system in calciorthents. *Chemical Science Review and Letters*, *6*(24), 2353-2359.

Kundu, M.C., Hazra, G.C., Biswas, P.K., Mondal, S., & Ghosh, G.K. (2014). Forms and distribution of potassium in some soils of

Hooghly district of West Bengal. *Journal of Crop and Weed*, *10*(2), 31-37.

Lalitha, M., & Dhakshinamoorthy, M. (2014). Forms of soil potassium—a review. *Agricultural Reviews*, *35*(1), 64-68.

Lungmuana, Bose, A., Ghosh, I., Ghosh, S.K., & Patra, P.K. (2014). Distribution and variation of potassium in rice growing soils of red and laterite zone of West Bengal. *Journal of the Indian Society of Soil Science*, *62*(1), 84-87.

Pratt, P.F. (1965). Potassium. In C.A. Black (Ed.), *Methods of soil analysis part 2* (pp. 1022-1030). American Society of Agronomy Inc.

Ramamurthy, V., Naidu, L.G.K., Chary, G.R., Mamatha, D., & Singh, S.K. (2017). Potassium status of Indian soils: Need for rethinking in research, recommendation, and policy. *International Journal of Current Microbiology and Applied Sciences*, *6*(12), 1529-1540.

Rao, K.N., Yeledhalli, N.A., & Channal, H.T. (2013). Soil potassium dynamics under intensive rice cropping in TBP command area of north Karnataka. *An Asian Journal of Soil Science*, *8*(2), 319-324.

Ruparna, V.B., Banwasi, R., & Bhagat, D. (2022). Soil potassium fractions as influenced by varying level of K mineral in an Inceptisols. *The Pharma Innovation Journal*, *11*(9), 1616-1620.

Srinivasarao, C.H., Vittal, K.P.R., Tiwari, K.N., Gajbhiye, P.N., & Kundu, S. (2007). Categorisation of soils based on potassium reserves and production systems: Implications in K management. *Soil Research*, *45*(6), 438-447.

Wiklander, E.A. (1954). Forms of potassium in the soil. *Potassium Symposium*, International Potash Institute, Berne, Switzerland, 109-121.

Wood, L.K., & De Turk, E.E. (1941). The adsorption of potassium in soil in non-exchangeable forms. *Proceedings of the Soil Science Society of America*, *5*, 152-161.

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