Original Research Article

Study of the different forms of soil potassium in Ujjain Tehsil of Ujjain District of Madhya Pradesh, India.

Abstract

The current research was carried out in the Ujjain tehsil (Ujjain) district of Madhya Pradesh state, India, with the aim of estimation thedifferent forms of soil potassiumand differentcharacteristics of the Soil. Throughout the research region, 150surface soil samples with a depth of 0 to 15 cm were collected. Collected soil samples wereanalyzed for physico-chemical properties namely texture, pH, Electrical conductivity, organic carbon and different forms of potassium (K) *i.e.* Water Soluble Potassium, Exchangeable Potassium, Available Potassium, Non-exchangeable Potassium, Lattice Potassium and Total Potassium. To observe that the soil texture of Ujjain district is varied from silty clay to clay,soil pH ranged from 7.01 to 8.15, electrical conductivity was varied from 0.10 dSm^{-1} to 0.79 dSm^{-1}, organic carbon is varied between 0.30to 0.60 %and The research region's ranges for different forms of potassium i.e. Water Soluble Potassium,Exchangeable Potassium, Available Potassium, Non-exchangeable Potassium, Lattice Potassium and total K were 3.10-24.00 $mgkg^{-1}$,118.38-196.12$mgkg^{-1}$,129.95-206.70 $mgkg^{-1}$,200.0-410.0 $mgkg^{-1}$,7943.75-17515.71 $mgkg^{-1}$ and 8500-18000.0 $mgkg^{-1}$, in that order. The mean value of WaterSoluble Potassium, Exchangeable Potassium, Available Potassium, Non-exchangeable Potassium, Lattice Potassium and Total Potassium was 11.47 mg kg^{-1}, 148.67 mg kg^{-1}, 160.11 mg kg^{-1}, 330.16 mg kg^{-1}, 12478.11 mg kg^{-1} and 12968.96 mg kg^{-1}, respectively.

Keywords: Soil properties; Potassium; soil; correlation; lattice.

Introduction

Potassium is a major constituent of the earth crust comprises on an average 2.6 per cent (Schroeder, 1978). It isanessential macro nutrient for required of plant growth and development. It is activation of more than 60 enzymes. It’s play vital role in stomata opening and closing, osmotic regulation, ionic balance in cell, energy transportation relations control of ionic balance, energy relation, protein and starch synthesis, improving quality of flowers, fruits and vegetables, preventing lodging in crops, imparting resistance against environmental stresses such as drought, cold and frost, improving resistance to pest and diseases (Mengel and Kirkby, 1987).Soil potassium exists in different forms *i.e.* water soluble, exchangeable, non-exchangeable and lattice potassium. Water soluble and exchangeablepotassiumare available to plant. The exchangeable potassium tends to attain equilibrium rapidly with water soluble potassiumbut it’s

slowly with non-exchangeable potassium. The watersoluble potassium uptake by plants through diffusion processes.

Potassium is present in soils in various forms and combination. The available potassium in soil is difficult to ascertain because of its interaction with various intrinsic and extrinsic properties of soil. The direction of rate of reactions determines the rate of applied K and release of non-exchangeable K (Singh *et al*., 2004). A number of extractants have been used from time to time to assess quantitatively the available K. Potassium plays an important role in increasing the production and improving the quality of crops and vegetables.

Materials and methods

A study was carried out in 2018 at Ujjain Tehsil, a district of Madhya Pradesh, India. for the estimation of different forms of soil potassium. Collection of 150 soil samples from different places in Ujjain district (Madhya Pradesh) from 0–15 cm of surface soil during 2018.Collected soil samples were air dried in shade and grinded with wooden hammer. These grinded samples were passed through a 2 mm sieve and stored in polyethylene bags with proper labels for further analysis of soil to determine various soil parameters. The pH and EC of soil was measured with the help of a pH meter and electrical conductivity, maintaining the soil, water ratio of 1:2 as described by Jackson (1967).Soil organic carbon was estimated by Wakley and Black method (1934). Available nitrogen was estimated by alkaline permanganate method by Subbiah and Ashija (1956). Available phosphorous of soil samples were extracted by Olsen *et al.* (1954). Available potassiumwas determined by NH4OAc (pH 7.0) reagent using flame photometer (Jackson, 1973), Water soluble potassium was estimated by shaking the soil with distilled water in 1:5 ratio. The 1.0 N boiling HNO_3 extractable potassium was estimated by using flame photometer in 1:10 ratio of soil: acid suspension boiled for 10 minutes as described by Wood and DeTurk (1941). Non-exchangeable potassium was calculated by subtracting available potassium from 1.0 N boiling HNO_3 extractable potassium. The amount of potassium in mineral lattice was calculated by subtracting by 1.0 N boiling HNO_3 extractable potassium from total soil potassium. The statistically data were analyzed as per the procedure given by Panse and Sukhatme (1961).

Results and discussions

Physico-Chemical Properties of Soil

The pH values of soil samples were found in the range of 7.01-8.15 under different fields with the mean value of 7.61 (Table 1). Electricalconductivity (EC) status of collected soil samples was found in the range of 0.1-0.79 on average value of 0.28 dSm^{-1}. Soil organic carbon status

was found in the range of 0.30-0.60 with the mean value of 0.48 (Table1). Available Nitrogen status was found in the range of 139.0-235 $kgha^{-1}$with the mean value of 198.27 $kgha^{-1}$.Available phosphorous (P) status of soil samples was found in the range of 8.0-25.6 $kgha^{-1}$with mean value of 15.08 kg ha^{-1}. (Table 1).The soil texture of Ujjain district was varied from silty clay to clay. Sand, silt and clay percent were ranged from 9.15-24.06 %, 24.0-41.55 % and 32.0-55.60 %. The mean value of sand, silt and clay was 16.34 %, 33.98 % and 48.46 %, respectively. Similar results were also found by Gehlot et al. (2019).

Different forms of potassium

Water soluble potassium

Status of soil water soluble K in Ujjain tehsil of district Ujjain (Table 2.) was found in the range of 3.1-24.0 $mgkg^{-1}$ under different fields with the mean of 11.43 $mgkg^{-1}$. Maximum value of water soluble K in soil (24 mg kg^{-1}) was observed in 89^{th} field (Table 2). The minimum value of water soluble K in soil 3.1 mg $kg^{-1}$was noticed in 59^{th} field (Table 2). Results on the same line with different soil types have also been reported by Dixit *et al*. (1993) and Yadav and Meena (2009).

Exchangeable K

Status of surface soil samples was found in the range of 118.38-196.12 mg kg^{-1} with the average value of 148.67 mg kg^{-1}(Table2), contributed 1.15 % of total K. Pharande and Sonar (1996) alsoreported the similar findings related to exchangeable K and total K. The variation in exchangeable potassium content among the soil samples may be attributed to differential release of potassium from non-exchangeable and lattice potassium as well as variation in labile pool due to potassium fertilization.

Available K

Status of soil samples collected from Ujjain tehsil was found in the range of 129.95-206.70$mgkg^{-1}$with the mean value of 160.11 $mgkg^{-1}$(Table 2).This form contributes 1.24 % of total K in surface soil. **Shilpa *et al.* (2007)** also reported that available K contributed 1.97 % towards total K in soils.

Non-exchangeable K

Non-exchangeable K status of surface soil samples collected from Ujjain tehsil of district Ujjain (Table 2) was found in the range of 200-410 $mgkg^{-1}$ with the mean value of 330.16 $mgkg^{-1}$(Table 2).Non-exchangeable contributed 2.59 % towards total K. Anupama *et al* (2018) also reported 305.08 mg kg^{-1} of non-exchangeable K in soils of Ujjain tehsil.

Lattice K

Status of lattice K inUjjain tehsil was found in range of 7943.75-17515.71 $mgkg^{-1}$under different field with mean value 12478.11$mgkg^{-1}$(Table 2).These contributed 96.25 % of total K. **Choudhry and Prasad (1997)** also reported that Lattice K contributed 92.3 % towards total K in soils.

Total K

Status of total K content in soil samples collected from Ujjain tehsil was found in the range of 8500-18000 $mgkg^{-1}$with the mean value 12968.96$mgkg^{-1}$(Table 2).These results are in agreement with the findings of Dinagaran*et al.* (2006) and Jatav *et al*. (2006).

Table 1. Statistical summary of selected soil properties

Soil properties	Unit	Minimum	Maximum	Mean	Std. Deviation	CV
pH		7.01	8.15	7.61	0.23	2.99
EC	**dSm^{-1}**	0.10	0.79	0.28	0.15	51.92
SOC	**%**	0.30	0.60	0.48	0.07	14.00
N	**Kg ha^{-1}**	139.00	235.00	198.27	19.49	9.83
P	**Kg ha^{-1}**	8.00	25.60	15.08	3.96	26.25
Sand	**%**	9.15	24.06	16.34	3.57	21.86
Silt	**%**	24	41.5	33.98	3.25	9.55
Clay	**%**	32.05	55.60	48.46	3.37	6.78

Note. EC = electrical conductivity; SOC = soil organic carbon; SD = standard deviation; CV = coefficient of variation,.

Table 2 Status of different forms of potassium (mg kg^{-1}) in soils of Ujjain Tehsil

Sample No.	W.S.K ($mgkg^{-1}$)	Ex. K ($mg\ kg^{-1}$)	Avail. K ($mg\ kg^{-1}$)	Non-ex. K ($mg\ kg^{-1}$)	Lattice K ($mg\ kg^{-1}$)	Total K ($mg\ kg^{-1}$)
1	10.1	196.1	206.2	350	7943.8	8500
2	12.5	158.4	170.9	325	10004	10500
3	8.2	145.7	154	220	9626	10000
4	8	168.7	176.7	345	9601.2	10123
5	7.9	130.4	138.3	350	8957.6	9446
6	8.5	130.7	139.2	389	8927.7	9456
7	23.6	136.1	159.8	400	9225.2	9785
8	20	144.7	164.7	365	9335.3	9865
9	18	141.8	159.8	345	9366.2	9871
10	3.2	154.7	158	378	9122	9658
11	5.2	163.5	168.7	225	9231.3	9625
12	4.6	160.1	164.7	370	9339.3	9874
13	5.5	152.5	158	342	9375	9875

14	10	129.6	139.7	365	9127.3	9632
15	6.3	147.7	154	385	9283	9522
16	7.4	156.8	164.2	348	9361.7	9874
17	8.2	177	185.2	260	9979.7	10425
18	4.3	185.3	189.7	385	9670.3	10245
19	8.5	174.5	183	362	9944	10489
20	9	174.9	183.9	384	9910.1	10478
21	12	189.7	201.7	337	10148	10687
22	15	174.7	189.7	364	11931	12485
23	16.1	190.5	206.7	345	11923	12475
24	15	167.5	182.5	358	12146	12687
25	12	170.1	182.1	372	13035	13589
26	14	165.4	179.4	389	12903	13471
27	5	173.4	178.5	373	12906	13458
28	7.5	170.1	177.6	375	12995	13548
29	6.5	165.8	172.3	352	10734	11258
30	7	161.7	168.7	360	10728	11257
31	8.5	150.4	158.9	367	10899	11425

32	5	150.3	155.3	373	11165	11693
33	10	154.7	164.7	342	10978	11485
34	12.0	142.0	154.0	290	10803	11247
35	10.5	128.7	139.2	382	12027	12548
36	12.1	130.7	142.8	250	12092	12485
37	11.4	142.6	154.0	324	11997	12475
38	10.0	146.2	156.2	280	12203	12639
39	10.3	152.5	162.9	365	11830	12358
40	9.5	162.3	171.8	245	12058	12475
41	10.0	179.6	189.7	203	13865	14258
42	15.0	168.0	183.0	216	14564	14963
43	17.0	164.2	181.2	219	14353	14753
44	20.0	165.2	185.2	223	14444	14852
45	22.3	155.3	177.6	278	14507	14963
46	18.0	156.1	174.1	300	14883	15357
47	15.5	161.2	176.7	320	14872	15369
48	7.3	157.3	164.7	295	14888	15348
49	6.2	153.6	159.8	310	14897	15367

50	8.3	145.7	154.0	325	16063	16542
51	7.3	137.7	145.0	350	16401	16896
52	6.3	157.9	164.2	320	17516	18000
53	5.5	163.2	168.7	211	16405	16785
54	10.0	142.6	152.6	203	14879	15235
55	16.1	124.5	140.6	243	14984	15368
56	15.0	119.8	134.8	282	15006	15423
57	14.0	128.8	142.8	337	13778	14258
58	12.5	144.6	157.1	372	13994	14523
59	3.1	159.8	162.9	350	15744	16257
60	7.8	152.0	159.8	332	16046	16538
61	5.6	152.4	158.0	337	14847	15342
62	7.0	152.8	159.8	233	13865	14258
63	8.5	156.2	164.7	305	15784	16254
64	3.2	156.1	159.3	313	11886	12358
65	5.2	139.8	145.0	330	12000	12475
66	8.1	135.1	143.3	356	11990	12489
67	8.5	150.4	158.9	365	14003	14527

68	9.2	150.6	159.8	290	11909	12359
69	7.4	128.3	135.7	310	13101	13547
70	10.0	126.6	136.6	325	14862	15324
71	8.0	128.6	136.6	243	13896	14276
72	6.3	129.3	135.7	211	14246	14593
73	12.0	127.2	139.2	231	14419	14789
74	10.0	130.6	140.6	270	14152	14563
75	13.0	128.0	141.0	285	13827	14253
76	15.0	140.3	155.3	320	13210	13685
77	12.0	156.7	168.7	342	12075	12586
78	12.5	152.2	164.7	289	11891	12345
79	14.0	145.8	159.8	285	12344	12789
80	14.7	139.2	154.0	290	12012	12456
81	15.0	149.2	164.2	340	11619	12123
82	17.0	153.5	170.5	345	11853	12369
83	20.0	139.8	159.8	400	12896	13456
84	4.6	140.4	145.0	410	13234	13789
85	5.5	154.3	159.8	396	12900	13456

86	12.0	146.0	158.0	320	13645	14123
87	5.0	138.3	143.3	350	14296	14789
88	7.8	147.5	155.3	345	11858	12358
89	24.0	140.2	164.2	356	13715	14235
90	20.0	125.0	145.0	350	14874	15369
91	22.0	133.3	155.3	365	14738	15258
92	15.0	149.7	164.7	358	14624	15147
93	16.0	167.0	183.0	348	14716	15247
94	12.0	175.5	187.5	369	15197	15753
95	10.0	174.3	184.3	358	15309	15851
96	8.5	172.7	181.2	345	15220	15746
97	6.2	174.6	180.8	375	16276	16832
98	8.3	179.2	187.5	354	15279	15820
99	17.0	162.4	179.4	358	9720.5	10258
100	14.0	165.0	179.0	359	9937	10475
101	13.0	168.2	181.2	345	9720.8	10247
102	12.2	177.5	189.7	342	9726.3	10258
103	16.0	139.3	155.3	362	9718.6	10236

104	22.0	137.8	159.8	359	9850.2	10369
105	21.0	137.9	158.9	347	10730	11236
106	19.0	138.1	157.1	352	10726	11235
107	14.0	146.2	160.2	387	10711	11258
108	15.0	157.7	172.7	324	10978	11475
109	10.0	145.3	155.3	200	11999	12354
110	8.5	155.7	164.2	201	12004	12369
111	7.2	137.8	145.0	203	12238	12586
112	14.0	120.8	134.8	305	12107	12547
113	16.0	118.3	134.3	358	11983	12475
114	12.0	124.1	136.1	341	12008	12485
115	11.2	153.5	164.7	387	12988	13540
116	14.2	142.8	157.1	397	9703.9	10258
117	18.2	146.0	164.2	378	8907.7	9450
118	20.0	121.0	141.0	356	8953.9	9451
119	21.0	119.6	140.6	374	8937.4	9452
120	18.0	124.4	142.4	371	9006.6	9520
121	12.5	129.0	141.5	341	9077.5	9560

122	4.5	150.8	155.3	356	9350.6	9862
123	5.6	148.8	154.4	325	9178.5	9658
124	7.0	157.7	164.7	331	9161.3	9657
125	8.5	151.7	160.2	369	9718.7	10248
126	12.5	158.4	170.9	357	9719	10247
127	14.0	127.5	141.5	345	9767.5	10254
128	13.2	129.2	142.4	371	9731.6	10245
129	15.0	125.6	140.6	398	11506	12045
130	16.0	138.0	154.0	354	11527	12035
131	12.0	143.3	155.3	320	12001	12476
132	10.0	144.4	154.4	310	12119	12583
133	8.0	137.0	145.0	325	14286	14756
134	9.5	135.1	144.6	347	14360	14852
135	10.2	154.5	164.7	314	14390	14869
136	13.0	149.9	162.9	368	13997	14528
137	11.0	151.5	162.5	304	14062	14528
138	13.2	151.0	164.2	304	13790	14258
139	16.0	143.8	159.8	358	14010	14528

140	19.5	139.8	159.3	359	14768	15286
141	15.0	142.1	157.1	369	14843	15369
142	12.0	147.8	159.8	387	14822	15369
143	10.2	134.8	145.0	345	16042	16532
144	13.0	132.5	145.5	347	15831	16324
145	12.0	134.8	146.8	345	15850	16342
146	15.0	129.2	144.2	368	16229	16741
147	14.0	133.3	147.3	342	16363	16852
148	12.5	123.2	135.7	341	16486	16963
149	10.0	126.1	136.1	320	16076	16532
150	12.0	124.1	136.1	310	16007	16453
Min.	**3.1**	**118.38**	**129.95**	**200**	**7943.75**	**8500**
Max.	**24**	**196.12**	**206.70**	**410**	**17515.71**	**18000**
Mean	**11.43**	**148.67**	**160.07**	**330.16**	**12478.11**	**12968.96**

Conclusion

Soils of Ujjain tehsil was slightly alkaline in reaction and safe limit of EC. Most of the fields were low in organic carbon and available nitrogen. Low to medium status of available phosphorous was observed in surface soils under different fields of Ujjain tehsil. The texture of the soils of Ujjain tehsil varied from silty clay to clay. The mean values of percent sand, silt and clay were 16.34, 33.98, and 48.46 per cent in the surface soil samples. More than half of the soil samples were in medium range of water soluble K, exchangeable K and non- exchangeable K content**.**

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