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Improving the Efficiency of Ammonium Acetate Extraction of Soil Potassium by Saturation Extract Method

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Authors' contributions

This work was carried out as a part of author TC PhD research work. Author GP is my major advisor and author PCR is my minor advisor. I myself along with my guides all authors designed the study and I performed the field and lab work, statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GP and PCR corrected the article. All authors read and approved the final manuscript.

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ABSTRACT

The K-status in soils and its availability to plants has close relationship with field capacity or saturated conditions. Hence, there is a need to know the available K status through saturation extract and other parameters governing K-availability which bears close relation to normal field situation under which plants are grown. To improve the efficiency of ammonium acetate method by saturation extract method, saturation extract parameters were studied in vegetable growing soils of Ranga Reddy and Mahaboobnagar districts of Telangana and are correlated with forms of potassium, soil physical and chemical properties to know the importance of these parameters in release and availability of K to plants. The saturation extract obtained from the soils was analysed

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for available potassium and Ca + Mg values. Different parameters of the saturation extract *viz*., CR^K, BC^K and USQI factor were calculated to know the availability of potassium to plants. Results of correlation between BC^K and USQI with exchangeable and non exchangeable K showed that these parameters influence the release and availability of K to plants and also the correlation with soil characteristics clearly indicate that the quantity factor K_{am}, K_L and intensity factors PBC^K, BC^K are important to assess available K status. These parameters derived from K extracted by NN NH_4OAc and concentration ratio of K in the saturation extract of soil *i.e.* BC^K and USQI factor served as better indices for assessing the K supplying status of soils than K extracted by different chemical methods.

Keywords: Saturation extract; concentration ratio of potassium in the saturation extract of the soil (CR^K); buffering capacity (BC^K) and Unified Soil Quantity Intensity factor (USQI factor); ammonium acetate extractable K (K_{am}).

1. INTRODUCTION

Potassium is an essential nutrient for crops and plays an important role in several physiological processes in plant. There are about 50 enzymes, responsible for energy transfer and formation of sugars, starch and protein that are influenced by the presence of potassium in plants. It is the fourth most abundant element, constituting about 2.5 per cent of the lithosphere. However, actual soil concentrations of this element vary widely, ranging from 0.04 to 3 per cent.

Generally the crops respond to K application in low K soils. But there are reports of [1], where the crop response to K fertilization is positive even in soils high in K status. Potassium (K) availability to plants is influenced by clay minerals, concentration of K, soil pH, fixation and release of K, interaction with other elements, moisture content, mobility and accessibility, method and time of application, sources of K supply, plant factors etc. [1].

The immediate K supplying power of soils to growing plants depends mainly on the available forms of K whereas the long term K nutrition of plants depends on the non-exchangeable K. Studies also revealed that the available K content in soils is also influenced by Ca and Mg status of soils. For better understanding of the K fertility status of agricultural soils, the quantity-intensity (Q/I) relationship given by [2] has been used as a measure for available K status in soil.

A large number of chemical methods have been used to assess the available K status of the soil. In general Neutral normal ammonium acetate (NN NH_4OAc) extractable K was used as important parameter for rating the soils under low, medium and high categories. Extractants like 1N HNO_3, 0.2M $NaBPh_4$, 0.01M $CaCl_2$, 1.38N H_2SO_4 etc. are being tried to assess the suitability of these chemicals to know the K-status of soils. The purpose of using different extractants is to compare K extractions by some chemical methods as predictors of available K in a wide range of soils and to determine K critical levels by suitable extracting solutions. In spite of extensive research the predictability of response to applied K by crops still remains ambiguous. Further, it has been reported that low or no response to applied K can be obtained in soil containing low nitrogen and phosphorous. Also most of these chemical methods are empirical, cumbersome and do not give specific conclusions in the absence of plant factor.

Chemical extraction methods in the laboratory are carried out with 1:5 to 1:10 dilutions which is not similar with normal field conditions. The K-status in soils and its availability to plants has close relationship with field capacity or saturated conditions. Hence, there is a need to know the available K status through saturation extract and other parameters governing K-availability which bears close relation to normal field situation under which plants are grown. [3] suggested the possibility of increasing the efficiency of NN NH_4OAc method for assessing the available K status of soils by incorporating the concentration ratio of potassium in the saturation extract as an intensity factor. Which was a good index of K availability to plants in the soils of varying mineralogical composition. [4] observed that the parameters derived from K extracted by NN NH_4OAc and concentration ratio of potassium in the saturation extract of soils *i.e.,* BC^K and USQI factor served as better indices for assessing the K status of soils than the K extracted by different conventional chemical methods or the parameters derived from Q-I techniques of [2].

Vegetable crops respond to K nutrition and plays an important role in increasing the yield and quality of produce. However, it was found that there was imbalanced fertilizer application with or without K-fertilization to vegetable crops [2]. To meet the urban demand for vegetables, farmers are growing vegetables in surrounding districts of Hyderabad which includes Ranga Reddy and Mahaboobnagar.

Keeping in view of the importance of K to vegetable crops and several factors influencing the K-availability to crops, the present investigation was taken in vegetable growing soils of Ranga Reddy and Mahaboobnagar districts

2. MATERIALS AND METHODS

2.1 Collection of Soil Samples

Bulk soils (0-15cm) were collected from vegetable growing areas distributed in Ranga Reddy and Mahaboobnagar districts. In Ranga Reddy district, soil samples were collected from 18 mandals covering 32 villages. In Mahaboobnagar district, soil samples were collected from 22 mandals covering 40 villages. The information pertaining to the selected mandals and villages from where the samples were collected are depicted in Figs. 1 and 2.

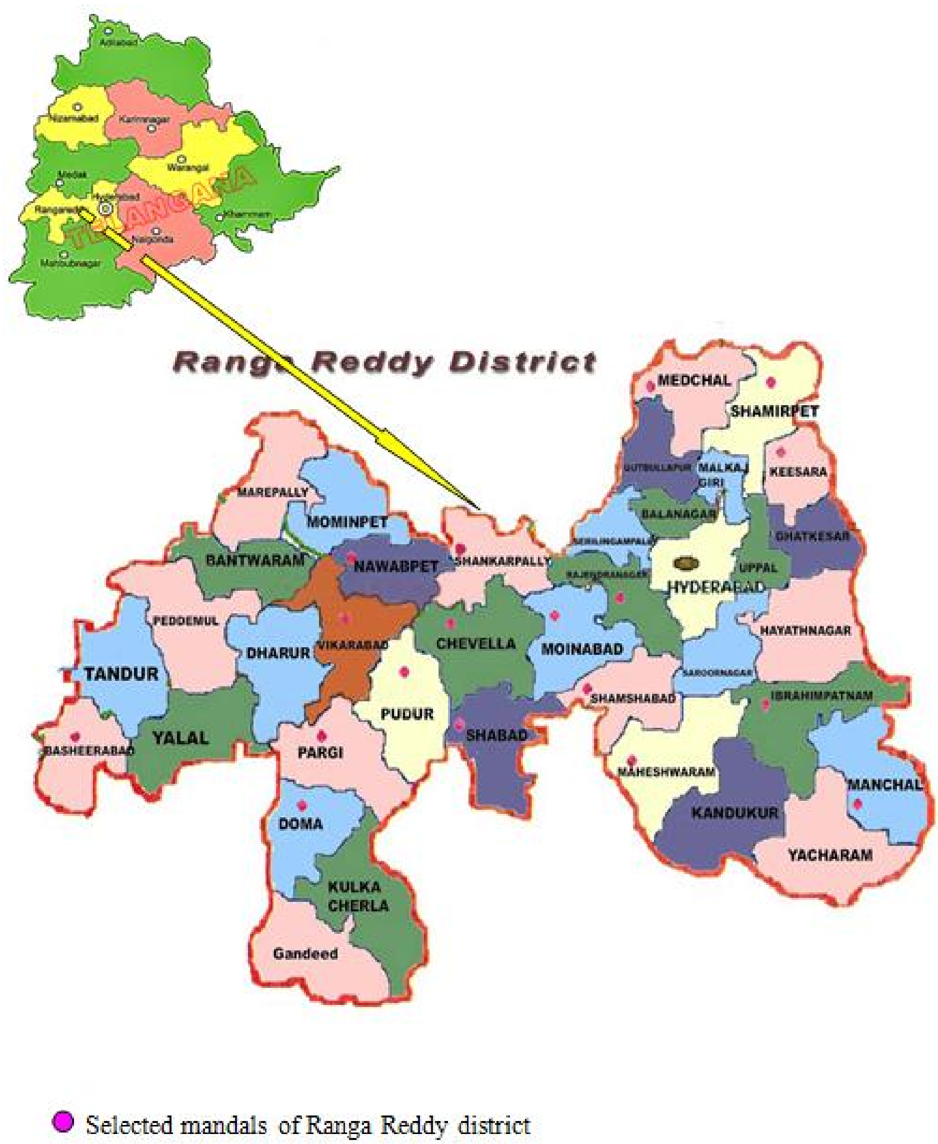

Fig. 1. Location of selected mandals from vegetable growing areas of Ranga Reddy district

Fig. 2. Location of selected mandals from vegetable growing areas of Mahaboobnagar district

2.2 Preparation of Soil Samples

Soil samples collected were dried under shade, powdered using wooden mortar and pestle, passed through a 2 mm sieve and preserved in labelled bags for laboratory analysis.

2.3 Methods of Soil Analysis

The soil samples collected from different locations of Rangareddy and Mahaboobnagar districts were analyzed for physical and chemical properties. Particle size analysis was carried out by Bouyoucos hydrometer method [5] ; Soil reaction (pH) by Glass electrode pH meter, Model DI-707 [6] ; Electrical conductivity by conductivity meter, DI-909 [6]; Organic carbon (g kg^{-1}) by Wet digestion method [7]; Cation exchange capacity (cmol (p+) kg^{-1}) by [8] as described by [9] ; Nitrogen (kg ha^{-1}) by Alkaline permanganate method [10] ; Phosphorus (kg P_2O_5 ha^{-1}) by [11].

Based on results of the available potassium status of vegetable growing soils of Ranga Reddy and Mahaboobnagar districts, 16 soils each from both the districts were selected covering low, medium and high K soils for conducting further detailed studies related to potassium availability in soils.

2.4 Forms of Potassium

a) **Water soluble potassium:** Water soluble potassium was determined in 1:5 soil : water extract by shaking for 5 minutes [6].
b) **Available potassium:** The available potassium was determined by NN NH_4OAc with 1:5 soil: extract, after 5 minutes shaking as described by [12].
c) **Exchangeable potassium:** The exchangeable potassium was obtained as a difference of the available and water soluble potassium [6].
d) **Non-exchangeable potassium:** The Non-exchangeable potassium was obtained by deducting the available potassium from 1N HNO_3 extractable potassium [13].
e) **Mineral potassium:** The mineral or structural potassium was obtained by deducting the 1N HNO_3 extractable K from total potassium [6].
f) **Total K:** The total K content in soils was estimated by sodium carbonate fusion method and the K dissolved in HCl was estimated by flame photometer [14].

2.5 Extraction of Potassium with Ammonium Acetate

Potassium was determined in 1N NH_4OAc (pH 7.0) extract maintaining the soil : extractant ratio of 1:5 and shaking for 5 minutes. The potassium in the extract was determined by flame photometer [6]. The estimation of potassium in all the cases was done flame photometre.

2.6 Parameters Derived from the Potassium Concentration in Saturation Extract of the Soil and the Potassium Extracted by 1N Ammonium Acetate

The saturation extract was obtained by the procedure given by [15]. In this method 500 g of soil was taken and distilled water was added slowly with constant stirring with a glass rod until a saturation paste was obtained. A Buchner funnel was taken and the saturation paste was transferred completely into the funnel by placing a filter paper. The Buchner funnel was fixed to a conical flask having side arm. Suction pump was connected to the side arm of conical flask and due to the pressure of the suction pump, saturation extract was collected in the conical flask. In the saturation extract, potassium content was determined using ELICO Flame Photometer and calcium + magnesium by Versanate method [16] and the following parameters were calculated.

2.6.1 Concentration ratio of potassium in the saturation extract of the soil ($\mathbf{CR^{K}_{Se}}$)

It was calculated by using the formula,

$$\mathrm{CR^{K}_{Se}} = \frac{\mathrm{C_K}}{\sqrt{\mathrm{Ca + Mg}}}$$

C_K = concentration of potassium in the saturation extract me l^{-1}
C $_{Ca+Mg}$ = concentration of calcium and magnesium in the saturation extract me l^{-1}

2.6.2 Buffering capacity ($\mathbf{BC^{K}_{Se}}$)

$$\mathrm{BC^{K}_{Se}} = \frac{\mathrm{K_{am}}}{\mathrm{CR^{K}_{Se}}}$$

$\mathrm{BC^{K}_{Se}}$= (me $100g^{-1}$) / (me $l^{-1})^{0.5}$
K_{am} = ammonium acetate extractable K in me 100 g^{-1}

2.6.3 Unified Soil Quantity Intensity Factor (USQI factor)

It was determined by the formula proposed by [3] .

USQI factor = $\sqrt{}$ K_{am} × þ $\mathrm{CR^{K}_{Se}}$

þ = -ve log of $\mathrm{CR^{K}_{Se}}$

3. RESULTS AND DISCUSSION

3.1 Salient Characteristics of Vegetable Growing Soils

The physical and chemical properties of the soils were analyzed and the data are presented in Tables 1 and 2, respectively.

The data revealed that the vegetable growing soils of Ranga Reddy and Mahaboobnagar districts were light textured with sand as dominant fraction. Soils under investigation were moderately acidic to alkaline and non-saline in nature. The organic carbon content of the soils of Ranga Reddy district and Mahaboobnagar district revealed that 68 per cent of the soils had high organic carbon, while 15 and 17 per cent of soils found to have medium and low organic carbon contents, respectively. The reason for high organic content is that the vegetable growing farmers are applying farmyard manure regularly as soils are light in texture to increase the yields. The cation exchange capacity (CEC) of the soils of Ranga Reddy district varied from 4.2 to 34.8 cmol (p+) kg^{-1}. The soils of Mahaboobnagar ranged from 3.9 to 29.8 cmol (p+) kg^{-1}. Similar results were also obtained by [17].

3.2 Available Nitrogen

The available nitrogen content of the soils of Ranga Reddy district varied from 138.0 to 250.9 kg ha^{-1}, indicating that the soils were low in available nitrogen. The available nitrogen content of the soils of Mahaboobnagar district showed a range from 75.3 to 313.6 kg ha^{-1}. Among the soils analyzed from Mahaboobnagar district, 12.5 per cent of the soils were medium in available nitrogen and the rest of the soils were low in available nitrogen.

3.3 Available Phosphorus

The available phosphorus content (P_2O_5) of soils of Ranga Reddy district was in the range of 10 to 64.9 kg ha^{-1}, indicating that 49 per cent of the soils were low in available phosphorus while, 33 and 18 per cent of the soils found to have medium and high available phosphorus contents, respectively. The available phosphorus status in soils of Mahaboobnagar district were in the range of 10 to 65.1 kg ha^{-1}, among which 70 per cent of the soils were low in available phosphorus while 25 and 5 per cent of the soils had medium and high available phosphorus.

3.4 Available Potassium

The available potassium content (K_2O) of the soils of Ranga Reddy district was in the range of 182.8 to 1856.1 kg ha^{-1}. The per cent samples falling under medium and high available K status were 16 and 84, respectively. The available potassium content of the soils of Mahaboobnagar district was in the range of 71.2 to 1022.8 kg ha^{-1}. Among the soils analyzed 15, 32.5 and 52.5 per cent samples were under low, medium and high categories as per the ratings of available potassium. Similar results were also obtained by[17] .

3.5 Forms of Potassium

The analysis results of different forms of potassium *viz*., water soluble, exchangeable, available, non-exchangeable, mineral and total K in soils of Ranga Reddy and Mahaboobnagar districts were presented in the Tables 3 and 4, respectively.

In the soils of Ranga Reddy district Water soluble potassium content varied from 8 mg kg^{-1} to 22 mg kg^{-1} and the available potassium (1N NH_4OAc extractable K) varied from 68 to 446 mg kg^{-1} with a mean value of 223 mg kg^{-1} (Table 3).

The exchangeable potassium content varied from 54 to 431 mg kg^{-1} with a mean value of 208 mg kg^{-1}, whereas non-exchangeable potassium ranged between 782 to 1894 mg kg^{-1} with a mean value of 1241 mg kg^{-1}. The mineral K varied from 7100 to 36260 mg kg^{-1} with a mean of 20985 mg kg^{-1}. The total potassium found to be in the range of 8400 to 38600 mg kg^{-1} with a mean of 22381 mg kg^{-1}.

The different forms of potassium *viz.*, water soluble, exchangeable, non-exchangeable and mineral K constituted to 0.07, 0.93, 5.5 and 93.7 per cent of total K, respectively, in soils of Ranga Reddy district.

In soils of Mahaboobnagar district, water soluble potassium content varied from 6 to 21 mg kg^{-1}, with an average of 12 mg kg^{-1}. The available potassium varied from 27 to 381 mg kg^{-1} with a mean value of 154 mg kg^{-1}. The exchangeable potassium content varied from 18 to 366 mg kg^{-1} with a mean value of 142 mg kg^{-1}, whereas non-exchangeable potassium ranged between 937 to 1832 mg kg^{-1} with a mean value of 1305 mg kg^{-1}. The mineral K in the selected soils varied from 6600 to 36630 mg kg^{-1} with a mean of 21054 mg kg^{-1}. The total potassium content varied from 8700 to 37600 mg kg^{-1} with a mean value of 22513 mg kg^{-1} (Table 4).

Table 1. Salient characteristics of the vegetable growing soils of Ranga Reddy district

S. No	Mandal	Village Name	pH	EC ($dS\ m^{-1}$)	CEC cmol (p^+) kg^{-1}	OC ($g\ kg^{-1}$)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ P_2O_5\ ha^{-1}$)	Available K ($kg\ K_2O\ ha^{-1}$)	sand (%)	silt (%)	clay (%)	Textural class
1	Moinabad	Kothireddypalli	7.1	0.118	4.6	9	138.0	10.8	322.6	92	4	4	Sand
2	Chevella	Chenvelli	8.2	0.170	27.7	13	200.7	24.4	505.3	63	24	13	Sandy loam
3	Chevella	Lakshmiguda	8.0	0.253	21.3	10	188.2	26.4	732.5	74	16	10	Sandy loam
4	Pudur	Pothireddyguda	8.4	0.237	32.6	9	175.6	11.5	1116.9	74	20	6	Sandy loam
5	Pudur	Changomul	8.0	0.150	18.0	9	200.7	12.8	829.2	65	24	11	Sandy loam
6	Parigi	Narayanpur	7.6	0.135	31.0	6	163.1	11.0	428.7	68	16	16	Sandy loam
7	Parigi	Ragapur	7.9	0.174	21.8	13	200.7	37.2	1092.7	62	24	14	Sandy loam
8	Doma	Wootpally	6.3	0.086	4.2	7	175.6	10.3	224.4	86	4	10	Loamy sand
9	Doma	Sivareddypalli	7.6	0.156	17.9	13	200.7	29.0	1618.2	62	22	16	Sandy loam
10	Shankarpally	Parveda	7.9	0.220	34.8	13	188.2	17.2	1182.7	64	20	16	Sandy loam
11	Shankarpally	Mahalingapuram	8.0	0.205	29.0	7	175.6	22.3	599.4	63	20	17	Sandy loam
12	Nawabpet	Nawabpet	7.6	0.172	24.7	8	175.6	33.6	289.0	76	16	8	Sandy loam
13	Nawabpet	Chittigadda	8.0	0.163	22.1	7	175.6	12.3	725.8	74	14	12	Sandy loam
14	Vikarabad	Kathagadi	7.7	0.104	29.6	10	175.6	10.0	419.3	82	12	6	Loamy sand
15	Vikarabad	Girgidpalli	6.9	0.397	18.0	10	250.9	43.1	295.7	72	20	8	Sandy loam
16	Shabad	Antharam	7.5	0.202	15.8	11	213.2	54.9	595.4	69	18	13	Sandy loam
17	Shabad	Kakkuluru	7.6	0.173	15.2	11	213.2	64.1	408.6	82	12	6	Loamy Sand
18	Medchal	Railapur	7.8	0.184	14.3	12	200.7	50.3	1856.1	76	14	10	Sandy loam
19	Medchal	Masireddypalli	6.1	0.054	8.9	13	163.1	10.0	182.8	86	4	10	Loamy sand
20	Shameerpet	Adraspally	7.4	0.157	12.5	12	200.7	64.9	979.8	69	16	15	Sandy loam
21	Basheerabad	Muduchinthalapalli	6.4	0.143	14.6	9	213.2	50.5	1198.8	81	6	13	Sandy loam
22	Keesara	Keesara	7.9	0.141	8.5	8	175.6	10.5	672.0	76	12	12	Sandy loam
23	Keesara	Bogaram	6.9	0.108	7.1	5	150.5	11.0	338.7	86	6	8	Loamy sand
24	Manchal	Arutla	7.6	0.222	16.8	12	250.9	64.1	1729.7	69	18	13	Sandy loam
25	Manchal	Manchal	7.6	0.137	13.9	10	200.7	48.0	337.3	84	10	6	Loamy sand
26	Ibrahimpatnam	Kappapahad	7.8	0.233	16.5	12	213.2	61.6	930.0	82	12	6	Loamy sand
27	Ibrahimpatnam	Kongarakonal	7.8	0.132	11.9	8	188.2	11.8	606.1	84	8	8	Loamy sand
28	Maheshwaram	Ravirala	7.4	0.219	14.8	13	188.2	60.3	1120.9	84	6	10	Loamy sand
29	Shamshabad	Kocharam	6.2	0.353	16.0	13	213.2	58.5	438.1	82	6	12	Sandy loam
30	Shamshabad	Malkaram	7.4	0.225	14.1	10	200.7	40.0	934.1	82	10	8	Loamy sand
31	Moinabad	Venkatapur	7.4	0.108	19.3	4	175.6	15.6	426.0	83	14	3	Loamy sand
32	Rajendranagar	College farm	7.9	0.286	15.9	8	175.6	20.5	419.3	78	10	12	Sandy loam

S. No	Mandal	Village Name	pH	EC (dS m^{-1})	CEC cmol (p^+) kg^{-1}	OC (g kg^{-1})	Available N (kg ha^{-1})	Available P (kg P_2O_5 ha^{-1})	Available K (kg K_2O ha^{-1})	sand (%)	silt (%)	clay (%)	Textural class
Mean			7.5	0.18	17.92	10	191.0	31.5	736.1	76	14	10	
Range			6.1-8.4	0.054 - 0.397	4.2 - 34.8	4 - 13	138 - 250.9	10 - 64.9	182.8-1856.1	62 - 92	4 - 24	3-17	

Table 2. Salient characteristics of the vegetable growing soils of Mahaboobnagar district

S. No	Mandal	Village Name	pH	EC (dS m^{-1})	CEC cmol (p^+) kg^{-1}	OC (g kg^{-1})	Available N (kg ha^{-1})	Availabl P (kg P_2O_5 ha^{-1})	Available K (kg K_2O ha^{-1})	sand %	silt %	clay %	Textural Class
1	Kothur	Penjerla	7.7	0.087	11.8	6	138.0	46.7	532.2	83	8	9	Loamy sand
2	Kothur	Kodicherla	7.7	0.102	10.5	4	188.2	52.1	172.0	86	4	10	Loamy sand
3	Keshampet	Papireddy Gudem	6.1	0.042	15.8	6	250.9	65.2	268.8	68	10	22	Sandy clay loam
4	Keshampet	Pomalapally	7.8	0.094	12.9	7	188.2	17.2	598.1	83	6	11	Loamy sand
5	Farookhnagar	Farookhnagar	8.1	0.091	19.9	7	313.6	12.1	224.4	71	12	17	Sandy loam
6	Farookhnagar	Mogiligidda	7.6	0.129	14.7	7	200.7	24.9	272.8	77	14	9	Sandy loam
7	Balanagar	Ammapally	6.1	0.123	14.7	11	288.5	59.0	794.3	73	10	17	Sandy loam
8	Balanagar	Chinna Revalli	7.7	0.059	10.3	4	250.9	15.1	71.2	85	4	11	Loamy sand
9	Jedcharla	Gangapuram	7.7	0.105	12.9	10	301.1	20.5	349.4	69	16	15	Sandy loam
10	Midjil	Midjil	8.0	0.056	4.3	3	125.4	17.2	96.8	90	4	6	Sand
11	Midjil	Vurukonda	5.7	0.023	10.5	3	276.0	11.0	139.8	83	4	13	Sandy loam
12	Kalwakurthy	Kalwakurthy	5.3	0.02	3.9	3	100.4	10.0	90.0	87	6	7	Loamy sand
13	Veldanda	Kotra	7.1	0.037	7.1	3	200.7	11.5	104.8	90	2	8	Sand
14	Amangal	Kadthal	8.1	0.091	13.8	8	188.2	32.8	266.1	78	6	16	Sandy loam
15	Kodangal	Kodangal	8.2	0.106	22.4	8	200.7	13.6	306.4	70	20	10	Sandy loam
16	Tadoor	Indrakal	8.0	0.097	13.1	11	163.1	23.6	358.8	79	8	13	Sandy loam
17	Tadoor	Yatamatapur	8.4	0.171	28.7	9	200.7	11.0	448.9	68	16	16	Sandy loam
18	Nagurkurnool	Nagarkurnool	8.3	0.126	15.8	9	313.6	32.1	370.9	67	18	15	Sandy loam
19	Nagurkurnool	Uyalawada	7.6	0.180	18.0	12	175.6	22.3	532.2	77	12	11	Sandy loam
20	Bijinapalle	Bijinapalle	8.5	0.117	16.2	12	276.0	10.3	380.4	73	14	13	Sandy loam
21	Bijinapalle	Mahadevnipet	7.0	0.073	11.3	11	200.7	55.7	184.1	77	6	17	Sandy loam
22	Waddepalli	Waddepalli	8.1	0.215	24.6	13	225.8	15.4	916.6	67	22	11	Sandy loam
23	Waddepalli	Jilledidinne	8.1	0.236	27.5	11	213.3	23.1	1022.8	64	22	14	Sandy loam
24	Alampur	Koneru	8.3	0.250	21.2	12	200.7	14.6	1002.6	72	16	12	Sandy loam
25	Alampur	Utkur	8.1	0.258	28.7	13	175.6	11.8	971.7	64	22	14	Sandy loam

S. No	Mandal	Village Name	pH	EC (dS m^{-1})	CEC cmol (p^+) kg^{-1}	OC (g kg^{-1})	Available N (kg ha^{-1})	Availabl P (kg P_2O_5 ha^{-1})	Available K (kg K_2O ha^{-1})	sand %	silt %	clay %	Textural Class
26	Manopadu	Kalukuntla	8.1	0.252	29.8	7	138.0	13.6	1016.1	62	28	10	Sandy loam
27	Manopadu	A.Budidapadu	8.1	0.243	19.4	12	200.7	10.8	731.1	61	24	15	Sandy loam
28	Itikyal	Duvasipalli	8.2	0.260	19.1	10	200.7	10.5	1022.8	64	22	14	Sandy loam
29	Itikyal	Jinkalapalli	8.1	0.249	19.0	10	188.2	11.0	903.2	67	24	9	Sandy loam
30	Balmoor	Kandanagula	8.1	0.094	7.3	10	138.0	10.0	176.1	84	4	12	Loamy sand
31	Balmoor	Ghattuthumen	8.2	0.108	11.8	10	150.5	13.3	375.0	85	4	11	Loamy sand
32	Achampet	Nadimpally	7.9	0.146	14.5	12	200.7	42.3	224.4	76	12	12	Sandy loam
33	Achampet	Pulijala	8.2	0.065	10.9	5	188.2	12.6	246.0	76	10	14	Sandy loam
34	Uppunutala	Uppunutala	8.3	0.128	13.6	11	200.7	43.1	655.9	68	10	22	Sandy clay loam
35	Uppunutala	Molgara	8.6	0.067	8.7	10	163.1	21.0	279.6	84	4	12	Loamy sand
36	Kodangal	Udimeshwaram	7.1	0.030	8.0	9	75.3	10.3	130.4	93	4	3	Sand
37	Bomraspeta	Yenkepalli	8.4	0.168	14.9	9	213.3	10.3	255.4	89	4	7	Sand
38	Bomraspeta	Vadicherla	7.8	0.159	22.7	13	288.5	10.3	793.0	65	20	15	Sandy loam
39	Kosigi	Nacharam	6.9	0.138	15.0	12	200.7	10.0	240.6	81	8	11	Sandy loam
40	Kosigi	Kosigi	7.9	0.316	14.4	12	175.6	11.5	416.6	77	10	13	Sandy loam
Mean			7.7	0.133	15.5	9	202.0	21.7	448.6	76	12	12	
Range			5.3 -8.6	0.020 - 0.316	3.9 -29.8	3 - 13	75.3 - 313.6	10.0 - 65.1	71.2 -1022.8	61 -93	2 - 28	3 -22	

Table 3. Forms of potassium (mg kg^{-1} soil) in soils of Ranga Reddy district

S.No	Village Name	Water soluble K	Available K	Exchangeable K	Non Exchangeable K	Mineral K	Total K
1	Chenvelli	8	188	181	912	10000	11100
2	Pothireddyguda	21	416	395	1785	7100	9300
3	Wootpally	11	84	73	817	26600	27500
4	Parveda	10	440	431	1860	8500	10800
5	Kathagadi	10	156	147	844	7400	8400
6	Kakkuluru	19	152	134	918	16330	17400
7	Masireddypalli	15	68	54	782	15550	16400
8	Muduchinthalapalli	21	446	425	1894	36260	38600
9	Keesara	15	250	235	1450	24700	26400
10	Bogaram	16	126	111	1084	31990	33200
11	Manchal	15	126	111	1015	29860	31000
12	Kongarakonal	22	226	204	1075	29700	31000
13	Ravirala	22	417	396	1783	35300	37500
14	Kocharam	15	163	148	1527	19810	21500
15	Venkatapur	9	159	150	972	16870	18000
16	Rajendranagar	14	156	142	1144	18700	20000
	Mean	15	223	208	1241	20985	22381
	Range	8- 22	68 - 446	54 - 431	782 - 1894	7100 - 36260	8400 - 38600

Table 4. Forms of potassium (mg kg^{-1} soil) in soils of Mahaboobnagar district

S.No	Village Name	Water soluble K	Available K	Exchangeable K	Non Exchangeable K	Mineral K	Total K
1	Penjerla	16	198	182	1232	21570	23000
2	Papireddy Gudem	21	100	79	1200	16500	17800
3	Mogiligidda	9	102	93	1139	24460	25700
4	Chinna Revalli	9	27	18	1084	31690	32800
5	Midjil	8	36	29	984	33180	34200
6	Kalwakurthy	9	34	25	937	36630	37600
7	Kotra	9	39	31	1031	23330	24400
8	Kadthal	12	99	87	1181	20720	22000
9	Indrakal	21	134	113	1267	19900	21300
10	Nagarkurnool	14	138	124	1832	17530	19500
11	Koneru	14	373	359	1727	9300	11400
12	Duvasipalli	15	381	366	1720	6600	8700
13	Jilledidinne	15	381	366	1630	9390	11400
14	Uppunutala	15	244	230	1796	20560	22600
15	Pulijala	8	92	84	1159	25750	27000
16	Nacharam	6	90	84	961	19750	20800
	Mean	12	154	142	1305	21054	22513
	Range	6 - 21	27 - 381	18 - 366	937 - 1832	6600 - 36630	8700 - 37600

Table 5. Parameters derived from concentration of K in saturation extract and 1N NH_4OAC extractable K of Ranga Reddy district

S.No	Village Name	Composition of the saturation extract		CR_{Se}^{K} (me l^{-1})$^{0.5}$	K_{am} in me $100g^{-1}$	BC_{Se}^{K} (me$100g^{-1}$)/(me l^{-1})$^{0.5}$	USQI Factor (me $100g^{-1}$)$^{0.5}$×(me l^{-1})$^{0.5}$
		K me l^{-1}	Ca+Mg in me l^{-1}				
1	Chenvelli	0.24	7.6	0.086	0.48	5.62	0.741
2	Pothireddyguda	0.25	7.6	0.091	1.06	11.67	1.073
3	Wootpally	0.36	7.0	0.136	0.21	1.58	0.401
4	Parveda	0.26	8.4	0.091	1.13	12.36	1.104
5	Kathagadi	0.23	6.4	0.089	0.40	4.48	0.663
6	Kakkuluru	0.28	11.4	0.083	0.39	4.70	0.675
7	Masireddypalli	0.27	5.4	0.118	0.17	1.47	0.387
8	Muduchinthalapalli	1.41	13.8	0.378	1.14	3.02	0.451
9	Keesara	0.32	6.2	0.128	0.64	5.01	0.715
10	Bogaram	0.39	6.0	0.158	0.32	2.04	0.455
11	Manchal	0.38	22.2	0.081	0.32	3.99	0.620
12	Kongarakonal	0.40	9.2	0.133	0.58	4.35	0.666
13	Raviryala	1.30	14.6	0.341	1.07	3.13	0.483
14	Kocharam	0.56	22.0	0.119	0.42	3.50	0.597
15	Venkatapur	0.30	7.2	0.112	0.41	3.63	0.606
16	Rajendranagar	0.26	7.0	0.100	0.36	3.56	0.597
	Range	0.23 – 1.41	5.4 – 22	0.081 – 0.378	0.21 – 1.14	1.47 – 12.36	0.387 – 1.104

Table 6. Parameters derived from concentration of K in saturation extract and 1N NH_4OAC extractable K of Mahaboobnagar district

S. No	Village Name	Composition of the saturation extract		CR^{K}_{Se} (me l^{-1})$^{0.5}$	K_{am} in me $100g^{-1}$	BC^{K}_{Se} (me$100g^{-1}$)/(me l^{-1})$^{0.5}$	USQI Factor (me $100g^{-1}$)$^{0.5}$×(me l^{-1})$^{0.5}$
		K me l^{-1}	Ca+Mg in me l^{-1}				
1	Penjerla	0.93	8.6	0.318	0.507	1.59	0.354
2	Papireddy Gudem	0.29	10.0	0.091	0.256	2.82	0.527
3	Mogiligidda	0.27	16.4	0.067	0.260	3.87	0.598
4	Chinna Revalli	0.24	7.2	0.091	0.068	0.75	0.271
5	Midjil	0.30	7.2	0.112	0.092	0.82	0.289
6	Kalwakurthy	0.42	6.6	0.162	0.086	0.53	0.232
7	Kotra	0.79	5.6	0.333	0.100	0.30	0.151
8	Kadthal	0.54	9.0	0.179	0.253	1.41	0.376
9	Indrakal	0.31	12.6	0.087	0.342	3.94	0.621
10	Nagarkurnool	0.29	12.6	0.081	0.353	4.37	0.649
11	Koneru	0.27	9.0	0.089	0.955	10.74	1.027
12	Duvasipalli	0.29	13.0	0.080	0.974	12.23	1.084
13	Jilledidinne	0.29	14.0	0.079	0.974	12.36	1.089
14	Uppunutala	0.37	9.4	0.122	0.625	5.12	0.722
15	Pulijala	0.48	26.0	0.095	0.234	2.48	0.496
16	Nacharam	0.35	15.4	0.088	0.229	2.60	0.505
	Range	0.24 – 0.93	5.6 - 26	0.067 – 0.333	0.068 – 0.974	0.30 – 12.36	0.232 – 1.089

The different forms of potassium *viz.*, water soluble, exchangeable, non-exchangeable and mineral K constituted to 0.05, 0.63, 0.68, 5.79 and 93.52 per cent of total K, respectively, in soils of Mahaboobnagar district.

In Ranga Reddy and Mahaboobnagar soils the mineral K was more than ninety per cent of the total K followed by non-exchangeable, available, exchangeable and water soluble K. As the contribution of slowly available forms of K is very less compared to non-exchangeable or mineral K, the available potassium content in soils alone cannot be considered for rating the soils into low, medium and high categories. The replenishing capacity of available K from non-exchangeable or mineral K also plays an important role in indicating K status of soils. Similar observations were also made by [18].

3.6 Assessment of Available Potassium through Different Parameters Derived from Saturation Extract

[19] stressed the importance of K concentration in soil saturated solution as a parameter of available potassium for crop growth. Potassium in the saturation extract of soil is a good index of Potassium availability to plants in the soils of varying mineralogical composition.

The saturation extract obtained from different soil samples were analyzed for K. Ca and Mg contents and expressed in me l^{-1}. Different parameters *viz*., $\mathrm{CR}^{\mathrm{K}}_{\mathrm{Se}}$, $\mathrm{BC}^{\mathrm{K}}_{\mathrm{Se}}$ and USQI factor were derived and the values were given in Tables 5 and 6

3.7 Concentration Ratio of Potassium in Saturation Extract ($\mathbf{CR}^{\mathbf{K}}_{\mathbf{Se}}$)

$\mathrm{CR}^{\mathrm{K}}_{\mathrm{Se}}$ values varied from 0.081 to 0.378 (me /l)$^{0.5}$ in Ranga Reddy soils and from 0.067 to 0.333 (me /l)$^{0.5}$ in Mahaboobnagar soils. The lowest values were recorded in Manchal (0.081) of Ranga Reddy and Mogiligidda (0.067) of Mahaboobnagar. The highest values were recorded in Muduchinthalapalli (0.378) of Ranga Reddy and Kotra (0.333) of Mahaboobnagar.

3.8 Potassium Buffering Capacity in Saturation Extract ($\mathbf{BC}^{\mathbf{K}}_{\mathbf{Se}}$)

$\mathrm{BC}^{\mathrm{K}}_{\mathrm{Se}}$values varied from 1.47 to 12.36 (me/100g)/(me/l)$^{0.5}$ in Ranga Reddy soils and from 0.30 to 12.36 (me/100g)/ (me/l)$^{0.5}$ in Mahaboobnagar soils. The lowest values were recorded in Masireddypalli (1.47) of Ranga Reddy, Kotra (0.30) of Mahaboobnagar. The highest were recorded in Pothireddyguda (11.67) and Parveda (12.36) of Ranga Reddy and Duvasipalli (12.23), Jilledidinne (12.36), koneru (10.74) of Mahaboobnagar.

3.9 Concentration of Potassium by 1N $\mathbf{NH_4OAc}$

The values of K_{am} varied from 0.21 – 1.14 (me/100g) in Ranga Reddy soils and from 0.068 – 0.974 (me/100g) in Mahaboobnagar soils. The lowest values were recorded in Masireddypalli (1.47) of Ranga Reddy, Chinna Revalli (0.068) and Midjil (0.092) of Mahaboobnagar. The highest were recorded in Muduchinthalapalli (1.14), Parveda (1.13), Raviryala (1.07) and Pothireddyguda (1.06) of Ranga Reddy, Jilledidinne (0.974), Duvasipalli (0.974) and Koneru (0.955) of Mahaboobnagar.

3.10 Unified Soil Quantity Intensity (USQI) Factor

It varied from 0.387 – 1.104 (me/100g)$^{0.5}$ × (me/l)$^{0.5}$ in Ranga Reddy soils and from 0.232 – 1.089 (me/100g)$^{0.5}$ × (me/l)$^{0.5}$ in Mahaboobnagar soils. The lowest values were recorded in Masireddypalli (0.387) of Ranga Reddy and Kalwakurthy (0.232) of Mahaboobnagar. The highest were recorded in Parveda (1.104) and Pothireddyguda (1.073) of Ranga Reddy, Jilledidinne (1.089), Duvasipalli (1.084) and Koneru (1.027) of Mahaboobnagar (Table 6).

Correlation between soil physico chemical properties and forms of K indicated that CR^{K} was positively and significantly correlated with water soluble K (r = 0.585**), exchangeable K (r = 0.407*) and Mineral K(r = 0.495**). Similarly $\mathrm{BC}^{\mathrm{K}}_{\mathrm{Se}}$and USQI factor positively and significantly correlated with exchangeable K (r = 0.787**) and non-exchangeable K (r = 0.619**). These parameters also showed significant positive correlation with silt (r = 0.470**) indicating that silt fraction contributed to the intensity factor of K in the saturation extract. Similarly $\mathrm{BC}^{\mathrm{K}}_{\mathrm{Se}}$and K_{am} showed a strong positive correlation with CEC (r = 0.775**) suggesting that the existence of competitive relationship between K and Ca + Mg in the saturation extract. As the concentration of Ca + Mg in the saturation extract increased the release of K into soil solution decrease and the adsorption of K increases resulting in higher $\mathrm{BC}^{\mathrm{K}}_{\mathrm{Se}}$values. [20] .

Significant and positive correlation of OC with K_{am} (r = 0.531**), BC^{K}_{Se} (r = 0.534**) and USQI (r = 0.607**) indicate that the OC could play a major role in release of K which can be explained by the fact that the organic matter during decomposition release organic acids which tend to dissolve K from minerals present in silt fractions leading to an increase in the parameters K_{am}, BC^{K}_{Se} and USQI. Suresh (1978) observed that the parameters derived from K extracted by NN NH_4OAc and concentration ratio of K in the saturation extract of soil *i.e.* BC^{K}_{Se} and USQI factor served as better indices for assessing the K supplying status of soils than K extracted by different chemical methods. From the above discussion it is clear that these parameters provide a better overview of dynamics of K in soil. This approach will result in assessment of K dynamics in soils and help in making significant practical contribution to operational K management in vegetable growing soils of Ranga Reddy and Mahaboobnagar districts.

4. CONCLUSION

The parameters of the saturation extract namely, K_{am} and BC^{K}_{Se} were significantly correlated with exchangeable and non exchangeable forms of K and also with soil characteristics clearly indicate that the quantity factor K_{am}, K_L and intensity factors Potassium Buffering Capacity in Saturation Extract (BC^{K}_{Se}) are important to assess available K status. It is clear that saturation extract parameters provide a better overview of dynamics of K in soil. This approach will result in assessment of K dynamics in soils and help in making significant practical contribution to operational K management in vegetable growing soils.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bidari BI, Hebsur NS. Potassium in relation to yield and quality of selected vegetable crops Karnataka Journal Agricultural Sciences. *2011;*24(1):55-59.
2. Beckett PHT. Studies on soil potassium II. The immediate Q/I relation of labile potassium in the soil. Journal of Soil Science. 1964;15:9-23.
3. Prasada Rao A. Studies on the physico-chemical and mineralogical properties of soils occurring in Toposequence, faculty of P.G School. Indian Agricultural Research Institute, New Delhi; 1977.
4. Suresh V. Relative utility of different methods for estimating the available potassium in soils. M.Sc. (Ag) thesis, Andhra Pradesh Agricultural University, Hyderabad, India; 1978.
5. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay; 1966.
6. Jackson ML. Soil chemical analysis. Prentice hall of India Private Limited, New Delhi. India; 1973.
7. Walkley A, Black CA. Estimation of organic carbon by chromic acid titration method. Soil Science. 1934;37:29-38.
8. Bower CA, Reitemeir RF, Fireman M. Exchangeable cation analysis of saline and alkaline soils. Soil Science. 1952;73:251-261.
9. Richards LA, Allison LE, Borhestein. Diagnosis and improvement of saline and alkali soils. Oxford and IBH Publishing Company Private Limited; 1954.
10. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Current Science. 1956;25:259-260.
11. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soil by extracting wiyh sodium bicarbonate. USDA Circ. 939, Washington. In Soil Chemical Analysis (ed. M. L. Jackson) Prentice Hall of Indian Private Limited, New Delhi; 1954.
12. Hanway J, Heidal HC. Soil analysis methods as used in Iowa State College Soil Testing laboratory. Iowa State College Agricultural bulletin No. 1952;57:1-31.
13. Wood LK, DeTurk EE. The absorption of potassium in soils in non replaceable

forms. Proceedings of soil science society of America. 1941;5:152-16.
14. Page AL, Miller RH, Keeney DR. Methods of soil analysis part 2. American Society of Agronomy. Inc.Madison, Wisconsin, USA; 1982.
15. Richards LA. Diagnosis and improvement of saline and alkali soils. USDA Handbook No.60, Oxford and IBH Publishing Company Private Limited; 1968.
16. Black CA. Methods of Soil analysis part-II. American Society of Agronomy and American Society for Testing and materials; 1965.
17. Kalyani K. Potassium status of cauliflower (*Brassica oleracea*. var. Botrytis) growing soils of Rangareddy district in relation to the short term and long term availability. M.Sc.(Ag.) Thesis, Acharya N G Ranga Agricultural University, Hyderabad, India; 2012.
18. Sharma A, Jalali VK, Vivak M. Arya, Pradeep R. Distribution of various forms of Potassium in soils representing intermediate zone of Jammu region. Journal of Indian Society of Soil Science. 2009;57(2):205-207.
19. Grimme H. Soils factors of potassium availability. Bull.No.10. Indian Society of Soil Science, I.A.R.I. New Delhi. 1976;144-163.
20. Kareem MA. Nature, distribution and plant availability of potassium in Alfisols and Vertisols of Andhra Pradesh. Ph.D. thesis, Andhra Pradesh Agricultural University, Hyderabad. India; 1990.

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