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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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 NH₄OAc) extractable K was used as important parameter for rating the soils under low, medium and high categories. Extractants like 1N HNO₃, 0.2M NaBH₄, 0.01M CaCl₂, 1.38N H₂SO₄ 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 NH₄OAc 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 NH₄OAc and concentration ratio of potassium in the saturation extract of soils i.e., BC⁴ 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

Keywords: Saturation extract; concentration ratio of potassium in the saturation extract of the soil (CR⁵); buffering capacity (BC⁶) and Unified Soil Quantity Intensity factor (USQI factor); ammonium acetate extractable K (Kₑₐₓ).
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.

![Map of Ranga Reddy District]

**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 P₂O₅ 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 NH₄OAc 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 HNO₃ extractable potassium [13].

e) Mineral potassium: The mineral or structural potassium was obtained by deducting the 1N HNO₃ 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 NH₄OAc (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 (CRₕₑ)ₜₑ

It was calculated by using the formula,

\[ CRₕₑ = \frac{C_K}{\sqrt{C_{Ca+Mg}}} \]

\( C_K \) = 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 (BCₕₑ)ₜₑ

\[ BCₕₑ = \frac{K_{am}}{CRₕₑ} \]

\( BCₕₑ \) = (me 100g⁻¹) / (me 1 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].

\[ USQI \text{ factor} = \sqrt{K_{am} \times \tilde{p} \times CRₕₑ} \]

\( \tilde{p} = -\text{ve log of } CRₕₑ \)
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 (P₂O₅) 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 (K₂O) 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 NH₄OAc 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).
| S. No | Mandal     | Village Name      | pH  | EC  (dS m⁻¹) | CEC (cmol kg⁻¹) | OC (g kg⁻¹) | Available N (kg ha⁻¹) | Available P (kg P₂O₅ ha⁻¹) | Available K (kg K₂O ha⁻¹) | sand (%) | silt (%) | clay (%) | Textural class |
|-------|------------|-------------------|-----|--------------|-----------------|-------------|------------------------|----------------------------|----------------------------|-----------|-----------|-----------|----------------|
| 1     | Monabad    | Kolireddypalli    | 7.1 | 0.118        | 4.8             | 9           | 138.0                  | 10.8                      | 322.6                     | 92        | 94        | 4         | Sand          |
| 2     | Chevella   | Chenzelli         | 8.2 | 0.170        | 27.7            | 13          | 200.7                  | 24.4                      | 505.3                     | 63        | 24        | 13        | Sandy loam    |
| 3     | Chevella   | Lakshmi guda      | 8.0 | 0.253        | 21.3            | 10          | 188.2                  | 26.4                      | 732.5                     | 74        | 16        | 10        | Sandy loam    |
| 4     | Pudur      | Puthi guda guda   | 8.4 | 0.237        | 32.6            | 9           | 175.6                  | 11.5                      | 1116.9                    | 74        | 20        | 6         | Sandy loam    |
| 5     | Pudur      | Changamul         | 8.0 | 0.150        | 18.0            | 9           | 200.7                  | 12.8                      | 829.2                     | 65        | 24        | 11        | Sandy loam    |
| 6     | Parigi     | Narayananpur      | 7.6 | 0.135        | 31.0            | 6           | 163.1                  | 11.0                      | 426.7                     | 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       | Wootapally        | 6.3 | 0.086        | 4.2             | 7           | 175.6                  | 10.3                      | 224.4                     | 86        | 4         | 10        | Loamy sand    |
| 9     | Doma       | Sivareddy pally   | 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  | Girigipalli       | 6.9 | 0.397        | 18.0            | 10          | 250.9                  | 43.1                      | 295.7                     | 72        | 20        | 8         | Sandy loam    |
| 16    | Shabad     | Anthalaram        | 7.5 | 0.202        | 15.8            | 11          | 213.2                  | 54.9                      | 595.4                     | 69        | 18        | 13        | Sandy loam    |
| 17    | Shabad     | Kakku luru        | 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    | Masireddy pally   | 6.1 | 0.054        | 8.9             | 13          | 163.1                  | 10.0                      | 182.8                     | 86        | 4         | 10        | Loamy sand    |
| 20    | Shamerpet  | 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    | Anutla            | 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 | Malikaram         | 7.4 | 0.225        | 14.1            | 10          | 200.7                  | 40.0                      | 934.1                     | 82        | 10        | 8         | Loamy sand    |
| 31    | Monabad    | Venkatapalu       | 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 kg\(^{-1}\) | OC (g kg\(^{-1}\)) | Available N (kg ha\(^{-1}\)) | Available P (kg P\(_2\)O\(_5\) ha\(^{-1}\)) | P (kg K\(_2\)O ha\(^{-1}\)) | Available K (kg K\(_2\)O ha\(^{-1}\)) | sand (%) | silt (%) | clay (%) | Textural class |
|-------|--------------|----------------|-------|---------------------|---------------------|----------------|-----------------------------|---------------------------------|----------------|---------------------------------|-----------|---------|---------|----------------|
| Mean  |              |                | 7.5   | 0.18                | 17.92               | 4.2            | 191.0                       | 31.5                            | 193.1                       | 31.5                            | 193.1        | 31.5     | 193.1    |                |
| 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      | 14 - 17  | 10       |                |

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\(^{+}\)) | OC (g kg\(^{-1}\)) | Available N (kg ha\(^{-1}\)) | Available P (kg P\(_2\)O\(_5\) ha\(^{-1}\)) | Available K (kg K\(_2\)O 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       | Sandy loam    |
| 2     | Kothur       | Kodicherla     | 7.7   | 0.102               | 10.5                | 4              | 188.2                       | 52.1                            | 172.0                          | 86      | 4       | 10      | Sandy loam    |
| 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      | Sandy loam    |
| 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    | Chinha Revali  | 7.7   | 0.059               | 10.3                | 4              | 250.9                       | 15.1                            | 71.2                           | 85      | 4       | 11      | Sandy loam    |
| 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       | Sand loam      |
| 13    | Veldanda     | Kotra          | 7.1   | 0.037               | 7.1                 | 3              | 200.7                       | 11.5                            | 104.8                          | 90      | 2       | 8       | Sandy loam    |
| 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    | Bijnapalle   | Bijnapalle     | 8.5   | 0.117               | 16.2                | 12             | 276.0                       | 10.3                            | 380.4                          | 73      | 14      | 13      | Sandy loam    |
| 21    | Bijnapalle   | Mahadevnpet    | 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   | Jilledinime    | 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    |

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| 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$_2$O$_5$ ha$^{-1}$) | Available K (kg K$_2$O 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    | Baimoor   | Kandanagula      | 8.1 | 0.094            | 7.3                         | 10              | 138.0                      | 10.0                                | 176.1                              | 84     | 4      | 12    | Sandy loam     |
| 31    | Baimoor   | Ghattuthumen     | 8.2 | 0.108            | 11.8                        | 10              | 150.5                      | 13.3                                | 375.0                              | 85     | 4      | 11    | Sandy loam     |
| 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    | Uppunatala| Uppunatala       | 8.3 | 0.128            | 13.6                        | 11              | 200.7                      | 43.1                                | 655.9                              | 68     | 10     | 22    | Sandy clay loam|
| 35    | Uppunatala| 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    | Bomraspet | Yenkepalli       | 8.4 | 0.168            | 14.9                        | 9               | 213.3                      | 10.3                                | 255.4                              | 89     | 4      | 7     | Sand           |
| 38    | Bomraspet | 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    | Woopally             | 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 NH₄OAC extractable K of Ranga Reddy district

| S.No | Village Name    | Composition of the saturation extract | CR^K (me l⁻¹)₀.⁵ | Kₑ in me 100g⁻¹ | Bc^K (me100g⁻¹)/(me l⁻¹)₀.⁵ | USQI Factor (me 100g⁻¹)₀.⁵ ×(me l⁻¹)₀.⁵ |
|------|-----------------|---------------------------------------|-----------------|-----------------|----------------------|----------------------------------------|
| 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   | Raviryalala     | 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 NH₄OAC extractable K of Mahaboobnagar district

| S. No | Village Name       | Composition of the saturation extract | CR^Kₑ (me l⁻¹)⁻⁰.³ | Kₘₑ in me 100g⁻¹ | BC^Kₑ (me100g⁻¹)/(me l⁻¹)⁻⁰.₅ | USQI Factor (me 100g⁻¹)⁻⁰.₅×(me l⁻¹)⁻⁰.₅ |
|-------|--------------------|----------------------------------------|--------------------|------------------|-------------------------------|------------------------------------------|
| 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    | Jilledinne         | 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 K 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. Different parameters viz., CR$^{K}$, BC$^{K}$ and USQI factor were derived and the values were given in Tables 5 and 6.

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

CR$^{K}$ values varied from 0.081 to 0.378 (me /l)$^{0.5}$ in Ranga Reddy soils and from 0.67 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 (BC$^{K}$)

BC$^{K}$ 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 NH$_4$OAc

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), Ravirylala (1.07) and Pothireddyguda (1.06) of Ranga Reddy, Jilledinne (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, Jilledinne (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 BC$^{K}$ 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 BC$^{K}$ 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 BC$^{K}$ values. [20].
Significant and positive correlation of OC with $K_{am}$ ($r = 0.531^{**}$), $BC_{5e}^{K}$ ($r = 0.534^{**}$) 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 $K_{am}$, $BC_{5e}^{K}$ and USQI. Suresh (1978) observed that the parameters derived from K extracted by NH$_4$OAc and concentration ratio of K in the saturation extract of soil i.e. $BC_{5e}^{K}$ 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 $BC_{5e}^{K}$ 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 ($BC_{5e}^{K}$) 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.

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