**ASSESSMENT OF SOIL MAJOR NUTRIENTS IN SCARCE RAINFALL ZONE OF ANDHRA PRADESH**

**Abstract**

Six prominent cropping systems in scarce rainfall zone of Andhra Pradesh *viz*., groundnut-horsegram, cotton-fallow, fallow-bengalgram, groundnut monocropping, paddy-paddy and paddy-groundnut cropping systems were selected to study the chemical properties of soils. Twenty soil samples from each cropping system were collected at 0-15 cm (surface soil) and 15-30 cm (sub-surface soil) depth. The soils processed and analysed for theirchemical properties. The highest available K (216 and 148 mg kg-1), water soluble K (19.94 and 14.25 mg kg-1) and exchangeable K (196 and 133 mg kg-1) was recorded under paddy-paddy cropping system in both surface and sub-surface soils. The highest non-exchangeable K (609 and 441 mg kg-1) was recorded under paddy-groundnut cropping system in both surface and sub-surface soils. However, lattice K (34072 and 25614 mg kg-1) and total K (34666 and 26066 mg kg-1) was recorded highest under groundnut monocropping system in both surface and sub-surface soils.

**Introduction**

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

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

 In scarce rainfall zone, the major constraint for agricultural productivity is soil moisture availability and potassium deficiency during their crop growing season. To combat declining soil fertility and increase food security, there is a need to prioritize study in scarce rainfall zone. Crop fertilisation with potassium in rainfed agriculture in India is not practised, merely on the assumption that Indian soils are rich in potassium and crops do not need external K supply. However, under continuous cropping in scarce rainfall regions, huge crop K removals are reported, up to 150–200 kg/ha annually, depending upon amount and distribution of rainfall and biomass production (Srinivasarao *et al*., 2011). Thus, most of the crops essentially deplete soil K reserves. The present study evaluates the soil K reserves under prominent cropping systems based on different soil K fractions. Therefore, the knowledge about different forms and availability of potassium is must while studying the response of crops to K. Because potassium supply to crop plants is a complex phenomenon involving relationships among various K fractions in soil.

Potassium exists in different forms *viz.,* water soluble, exchangeable, non-exchangeable and lattice potassium. Potassium present in soil solution as soluble cation is termed as water soluble K. The exchangeable potassium is the form of K held in the solid phase of soil, on clay and organic matter in the soil matrix, by electrostatic forces and easily moves into the soil solution as this form can be readily exchanged by other cations and also is readily available to plants.  The exchangeable K is important in replenishing soil solution potassium which is removed by cropping or lost by leaching. Generally, the K held at inter-lattice positions is non-exchangeable K and this form is not exchangeable by NH4OAc. This form of K is not readily available to plants. Lattice K that gets fixed in lattice space of the 2:1 clay minerals and held between adjacent tetrahedral layers of di-octahedral and tri-octahedral wedge zones of weathered micas and vermiculite. A large portion of the total potassium in soil occurs as structural component of soil minerals and is unavailable to plants. The content of total potassium depends on the type of soil fraction, type of primary and secondary minerals and type of parent material.

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

**MATERIALS AND METHODS:**

The present study was carried out in scarce rainfall zone of Andhra Pradesh, India lies in between the northern latitudes of 13040**’** to16018**’** and eastern longitudes of 76047**’** to 79034**’**. The geographical area of scarce rainfall zone 36,788 km2. Out of 40 lakh ha of rainfed area, about 45% area is in scarce rainfall zone of Andhra Pradesh. The scarce rainfall zone of Andhra Pradesh received an average annual rainfall of 201.45 mm during the year 2023-2024. Twenty soil samples at 0-15 cm (surface soil) and 15-30 cm (sub-surface soil) depths were collected from the six prominent cropping systems *viz*., groundnut-horsegram, cotton-fallow, fallow-bengalgram, groundnut monocropping, paddy-paddy and paddy-groundnut cropping systems. The collected soil samples were air dried in shade, ground with a wooden hammer, passed through the 2 mm sieve and used for determination of various soil properties by following standard procedures as detailed in Table 1.

**Table 1. Standard methods of analysis**

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **Parameter** | **Method** | **References** |
| 1. | Available K | Neutral *N* Ammonium acetateextraction | Hanway and Heidel (1952) |
| 2. | Water soluble K | 1:5 Soil water suspension | Jackson (1973) |
| 3. | Exchangeable K | Available K – Water soluble K | Mention reference |
| 4. | Non-exchangeable K | Boiling *1N* Nitric acid extraction | Wood and DeTurk (1941) |
| 5. | Lattice K | Total K – (Water soluble K + Exchangeable K + Non- exchangeable K) | Wiklander (1954) |
| 6. | Total K | HF-HClO4 method | Pratt (1965) |

**RESULTS AND DISCUSSION:**

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

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

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

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

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

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

**Exchangeable K:** The exchangeable potassium content of surface soils varied from 65 mg kg-1 in groundnut monocropping system to 266 mg kg-1 in paddy- paddy cropping system with mean values of 112 and 196 mg kg-1, respectively. In sub-surface soils exchangeable potassium content varied from 52 mg kg-1in groundnut monocropping system to 220 mg kg-1 in paddy- paddy cropping system with mean values of 84 and 133 mg kg-1, respectively.

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

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

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

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

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

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

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

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

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

|  |  |  |  |
| --- | --- | --- | --- |
|

|  |  |  |
| --- | --- | --- |
|

|  |  |
| --- | --- |
|

|  |
| --- |
|  |

 |

 |

 |

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

**Table 2. Distribution of different forms of potassium under groundnut-horsegram cropping system in scarce rainfall zone of Andhra Pradesh**

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

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

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

**Table 4. Distribution of different forms of potassium under fallow-bengalgram cropping system in scarce rainfall zone of Andhra Pradesh**

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

**Table 5. Distribution of different forms of potassium under groundnut monocropping system in scarce rainfall zone of Andhra Pradesh**

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

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

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

**Table 7. Distribution of different forms of potassium under paddy-groundnut system in scarce rainfall zone of Andhra Pradesh**

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

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

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

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

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

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

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

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

**CONCLUSION**

The results of this study indicated that the soils under prominent cropping systems in scarce rainfall zone of Andhra Pradesh were medium to high in available potassium.

The available K, water soluble K and exchangeable K in the prominent cropping systems were in the order of paddy-paddy > paddy-groundnut > fallow-bengalgram > cotton-fallow > groundnut-horsegram > groundnut monocropping.

The non-exchangeable K content in the prominent cropping systems was in the order of paddy-groundnut > paddy-paddy > fallow bengalgram > cotton-fallow > groundnut-horsegram > groundnut monocropping.

The lattice K and total K in the prominent cropping systems were in the order of groundnut monocropping > groundnut-horsegram > fallow bengalgram > cotton-fallow paddy-paddy > paddy-groundnut.

Soil K fractions in all cropping systems were in the order of total K > lattice K > non-exchangeable K > available K > exchangeable K > water soluble K.

**REFERENCES**

Charankumar, G.R and Munaswamy, V. 2022. Forms of Potassium and their Distribution under Prominent Cropping Systems of Chittoor District of Andhra Pradesh, India. *Indian Journal of Ecology*. 49(1): 109-113.

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

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

Hanway, J.J and Heidel, H. 1952. Soil Analysis Methods, as used in Iowa State. College Soil Testing Laboratory, Iowa, Agriculture. 57: 1-31.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Oxford IBH Publishing House, Bombay. 38.

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

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

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

Kundu, M.C., Hazra, G.C., Biswas, P.K., Mondal, S and Ghosh, G.K. 2014. Forms and distribution of potassium in some soils of Hooghly district of West Bengal. *Journal of Crop and Weed.* 10(2): 31-37.

Lalitha, M and Dhakshinamoorthy, M. 2014. Forms of soil potassium-a review. *Agricultural reviews*. 35(1): 64-68.

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

Pratt, P.F. 1965. *Potassium*. In *Methods of Soil Analysis* Part 2 (C.A. Black, Ed.), American Society of Agronomy Inc., Madison, Wisconsin. 1022-1030.

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

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

Ruparna, V.B., Banwasi, R and Bhagat, D. 2022. Soil potassium fractions as influenced by varying level of k mineral in an Inceptisols.

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

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

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