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# QUANTITY-INTENSITY RELATIONSHIP OF POTASSIUM IN FCV TOBACCO SOILS OF PRAKASAM AND NELLORE DISTRICTS OF ANDHRA PRADESH

**C. CHANDRASEKHARA RAO, V. KRISHNAMURTHY AND P.R.S. REDDY**

ICAR-Central Tobacco Research Institute, Rajahmundry-533 105, Andhra Pradesh, India

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**Quantity-Intensity parameters of potassium were studied in Flue–cured Virginia tobacco soils by analyzing twenty eight soil samples (0-9") collected from Southern Light Soils (SLS) and Southern Black Soils (SBS) areas of Prakasam and Nellore districts. Textural variation in black soils was silty clay loam to clay whereas in light soils it was sandy loam to clay loam. Soils from SLS and SBS were neutral in soil reaction and low in EC, chlorides and organic carbon. Southern black soils have higher pH, EC, chlorides and organic carbon compared to SLS. Water soluble-K was more in SLS whereas exchangeable K, non-exchangeable-K, total-K and lattice-K were high in SBS which was due to higher clay content and potassium bearing minerals in black soils compared to light soils of Prakasam and Nellore districts. Equilibrium activity ratio $AR^K_o$ values were high in SLS compared to SBS hence SLS area have more readily available potassium. The ranges for $PBC^K$ in SBS and SLS were 80.3 - 200 and 7.3 – 126.4 c mol ($p^+$)/kg, respectively. $PBC^K$ values were more in SBS compared to SLS because of more clay content in SBS (23.8 to 47.4%) compared to SLS (9.43 to 35.64%), which shows that they have more replenishing capacity. Potassium on specific sites ($K_X$) and on non-specific sites ($K_O$) were high in soils of SBS area compared to SLS which is a measure of quantity parameter. Equilibrium activity ratio ($AR^K_o$) values were positively correlated with sand, whereas significant positive correlation was observed between $PBC^K$, $K_O$, $K_X$, and $K_L$ and silt and clay contents. Water soluble-K showed significant positive correlation with $AR^K_o$, whereas, exchangeable-K showed significant positive correlation with $PBC^K$, $K_O$, $K_X$, and $K_L$.**

**Key words:** Potasium, Quantity-intensity, Tobacco soils

## INTRODCTION

Tobacco is a low volume and high value cash crop contributing Rs.17415 crores of excise revenue and Rs. 4100 crores of foreign exchange (Anonymous, 2011). It is grown in an area of 0.45 million ha producing about 750 million kg of tobacco leaf. Of this, flue-cured Virginia (FCV) tobacco is about 270 million kg from an area of 0.23 million ha which is mainly used for cigarette purposes. India has the added advantage in producing FCV leaf of different styles ranging from the coloury, neutral filler to the highly flavouraful leaf to cater the requirements of different importing countries. FCV tobacco is grown in different agro-ecological zones in India *viz.*, Northern Black Soils of Andhra Pradesh comprising Vertisols of East Godavari, West Godavari and Khammam districts (NBS), Central Black Soils of Andhra Pradesh comprising the Vertisols of Krishna and Guntur districts (CBS), Northern Light Soils of Andhra Pradesh comprising the light soils of East Godavari, West Godavari and Khammam districts (NLS), Southern Light Soils of Andhra Pradesh comprising the Alfisols of Prakasam and Nellore districts (SLS), Southern Black Soils comprising the Vertisols of Prakasam and Nellore districts (SBS) and Light Soils of Karnataka comprising the Alfisols of Mysore district (KLS). Among these zones, FCV tobacco is cultivated to an extent of 63,000 ha in light soils and 33,000 ha in heavy soils of Prakasam and Nellore districts.

Among the major nutrients of importance to FCV tobacco, potassium plays an important role in improvement of yield and leaf quality. It improves the color, body, texture, leaf burn *etc.* Quantity (Q), Intensity (I) and buffering capacity parameters determine the K supplying power of the soils (Beckett, 1964) for assessing its availability to the growing plants. In this approach, immediate availability of the potassium is related to intensity factor, reserve of non-exchangeable potassium to the quantity factor and the replenishment capacity to the potassium buffering capacity. Considering the importance of potassium in tobacco production and quality improvement, an attempt was made to study the Quantity-

Intensity parameters of potassium in the FCV tobacco growing soils of Prakasam and Nellore districts of Andhra Pradesh for rational potassium fertilization.

## MATERIALS AND METHODS

Twenty eight soil samples (0-9") were collected from eleven tobacco auction platforms of Southern Light Soils (SLS) and Southern Black Soil (SBS) of Prakasam and Nellore districts of Andhra Pradesh. Among the twenty eight samples, 9 samples were from SBS area and 19 samples were from SLS area. These soils samples were processed and analysed for soil separates, pH, EC, and various forms of potassium *viz.*, water soluble-K, exchangeable-K, non-exchangeable-K and total-K following the standard methods (Jackson, 1973; Page *et al.*, 1982; Piper, 1950). Quantity and intensity parameters of soil potassium was measured (Beckett, 1964) in the surface soil samples. Five grams of each soil was equilibrated with 50 ml of 0.01M $CaCl_2$ solution containing graded concentrations (0, 5, 10, 20, 40, 80, 100, 150, 200, 250, 400, 600, 800 and 1000 ppm) of potassium. The soil suspension was shaken on a horizontal shaker for one hour and allowed to stand overnight. The suspension was filtered, the equilibrium solution and also the original solution was analyzed for potassium, calcium and magnesium following the standard methods. The loss or the gain of potassium (D K) in the equilibrated samples was obtained from the difference between K added and extracted, concentrations of the K gained or lost were plotted against activity ratio (AR) which was calculated from the equation given below.

$AR^{K} = a_{K} / Öa_{(Ca + Mg)}$

Where all the concentrations are expressed as mol/L in the equilibrium solution. The $AR^K$ values for all the solution K concentrations of each soil was plotted against ± D K to obtain the Q/I curve.

$K_O$ (cmol/kg): Obtained by drawing a tangent on Q/I curve from the point of $AR^K$ where “ K = 0.

$K_L$ (cmol/kg): labile K, by extrapolating Q/I curve where it intercepts on the X axis.

$K_X$ (cmol/kg): The difference between $K_L$ - $K_O$ which is specifically adsorbed K

$AR^K_O$ is Where K is neither gained nor lost. *i.e.* D K = 0

$PBC^K$ (cmol/kg): Potential buffering capacity was computed from the slope of the linear portion of the curve: $K_O / AR^K_o$

## RESULTS AND DISCUSSION

### Soil properties

Results revealed that the textural variation in SBS is in between silty clay loam to clay and the clay content varied between 23.8 to 47.4% (Table 1). The textural variation in light soils of Prakasam and Nellore districts was from sandy loam to sandy clay loam. The clay content of these soils varied between 9.43 and 35.64 % (Table 3). Soils from SLS and SBS areas were neutral in soil reaction and low in EC, chlorides and organic carbon (OC). SBS have higher pH, EC, chlorides and OC values compared to SLS (Tables 1, 3 & 5). The range of soil pH, EC, Cl and OC in top soils of SBS was 7.4-7.7, 0.19-0.32 dS/m, 12-40 mg/kg, 0.15-0.35%, respectively. In soils from SLS area, the ranges of pH, EC, Cl and OC were 6.7-7.6, 0.15 – 0.26 dS/m, 4-44 mg/kg and 0.10-0.30%, respectively.

### Potassium fractions

Potassium fractions showed wide variation in Prakasam and Nellore districts. Water soluble-K was more in SLS compared to SBS whereas exchangeable-K, non-exchangeable-K, total-K and lattice-K was more in SBS compared to SLS (Tables 2, 4 & 5). The ranges for water soluble-K, exchangeable-K, non-exchangeable-K, lattice-K and total-K in top soils of SBS were 17-36, 243-464, 840 -1720, 7160 -14360 and 8000 -15800 mg/kg. In case of soils from SLS area, the ranges were 14-64, 56-273, 520-1800, 3480-11760 and 4000-12800 mg/kg. Higher amount of total-K and non-exchangeable-K in SBS was due to higher clay content and potassium bearing minerals in black soils compared to light soils in Prakasam and Nellore districts.

### Quantity-Intensity parameters

Results emanated from the present study revealed that variation existed in different Q/I parameters between SLS and SBS soils (Tables 2, 4 & 6). Equilibrium activity ratio $AR^K_o$ values where, the soil neither gains nor loses the potassium (i.e. “ K=0) were high in SLS compared

**Table 1: Textural composition and soil properties of southern black soils of Prakasam and Nellore districts**

| S. No. | Village | Sand (%) | Silt (%) | Clay (%) | Textural class | pH | EC (dS/m) | Cl (mg/kg) | OC (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Pongulurivaripalem | 43.3 | 17.7 | 39.0 | C | 7.7 | 0.19 | 32 | 0.15 |
| 2 | Naidu palem | 18.4 | 38.8 | 42.8 | Si C | 7.5 | 0.24 | 16 | 0.31 |
| 3 | Throvagunta | 21.9 | 41.4 | 36.7 | Si CL | 7.4 | 0.32 | 24 | 0.23 |
| 4 | Naguluppalapadu | 32.3 | 20.3 | 47.4 | C | 7.7 | 0.20 | 32 | 0.24 |
| 5 | Koresepadu | 48.0 | 20.4 | 31.6 | CL | 7.4 | 0.25 | 20 | 0.35 |
| 6 | Bodduvaripalem | 39.7 | 36.5 | 23.8 | Si L | 7.5 | 0.24 | 16 | 0.26 |
| 7 | Cherukumpalem | 40.0 | 31.9 | 28.1 | Si CL | 7.5 | 0.22 | 40 | 0.21 |
| 8 | Nidamanur | 30.7 | 33.4 | 35.9 | Si CL | 7.5 | 0.24 | 24 | 0.22 |
| 9 | Vennur | 40.7 | 17.0 | 42.2 | C | 7.6 | 0.19 | 12 | 0.26 |

**Table 2: Potassium fractions and Q/I parameters of southern black soils of Prakasam and Nellore districts**

| S. No. | Village | Water soluble-K (mg/kg) | Exchan-geableK (mg/kg) | Non ˘ exchan-geable ˘K (mg/kg) | Lattice-K (mg/kg) | Total-K (mg/kg) | $K_L$ (cmol (p+)/kg) | $K_0$ (cmol (p+)/kg) | $K_x$ (cmol (p+)/kg) | $AR^K_0$ | $PBC^K$ (cmol (p+)kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pongulurivaripalem | 33 | 247 | 840 | 7160 | 8000 | 0.55 | 0.35 | 0.20 | 0.002 | 175 |
| 2 | Naidu palem | 36 | 464 | 1720 | 11280 | 13000 | 1.21 | 0.60 | 0.61 | 0.003 | 200 |
| 3 | Throvagunta | 30 | 390 | 1440 | 14360 | 15800 | 0.757 | 0.485 | 0.272 | 0.0027 | 179.6 |
| 4 | Naguluppalapadu | 32 | 368 | 1000 | 9000 | 10000 | 0.657 | 0.257 | 0.400 | 0.0032 | 80.3 |
| 5 | Koresepadu | 26 | 334 | 880 | 8520 | 9400 | 0.50 | 0.320 | 0.180 | 0.0025 | 128 |
| 6 | Bodduvaripalem | 17 | 243 | 1000 | 7600 | 8600 | 0.40 | 0.257 | 0.143 | 0.0020 | 128.5 |
| 7 | Cherukumpalem | 31 | 349 | 1200 | 8600 | 9800 | 0.83 | 0.530 | 0.300 | 0.0029 | 182.8 |
| 8 | Nidamanur | 23 | 297 | 920 | 8080 | 9000 | 0.685 | 0.40 | 0.285 | 0.0021 | 190.5 |
| 9 | Vennur | 33 | 347 | 1040 | 7560 | 8600 | 0.40 | 0.257 | 0.143 | 0.0021 | 122 |

to SBS which shows that SLS have more readily available potassium compared to SBS. The ranges of $AR^K_o$ values in soils from SBS and SLS areas were 0.002 – 0.0032 and 0.0016 – 0.0323, respectively. Higher values of $AR^K_o$ in soils from SLS were due light textured nature of these soils (sandy loams to clay loams) compared to SBS which are heavy textured (silty clay loams to clay) having high clay and CEC. These soils may have higher cation retentive power and have small amounts of K in soil solution. Significant correlation of silt with $AR^K_o$ values is reported by Joshi (1992). Higher $AR^K_o$ values in light textured soils is due to higher ionic activity of potassium in comparison to calcium and magnesium in soil solution (Sharma and Mishra, 1989). Similar results were reported by Subba Rao *et al.* (1984), Srinivas and Seshaiah (1993) and Tamuli and Baruah (2000). The highest $AR^K_o$ value was observed in soils of CTRI Kandukur farm of SLS area whereas in SBS the highest $AR^K_o$ value was observed in Naguluppalapadu village. Potential buffering capacity ($PBC^K$) denotes the rate of change of quantity with intensity and is represented by the gradient of the curve. The ranges for $PBC^K$ in SBS and SLS were 80.3 - 200 and 7.3 – 126.4 cmol($p^+$)/kg, respectively (Table 6). The highest $PBC^K$ value was observed in Naidupalem in SBS area and Krishnareddypalem in SLS area. $PBC^K$ values were more in southern black soils compared to southern light soils because of more clay content in soils from SBS area (23.8 to 47.4) compared to SLS area (9.43 to 35.64), which shows that SBS have more replenishing capacity compared to SLS. Similar results were also reported (Sailakshmiswari *et al.*,

**Table 3: Textural composition and soil properties of southern light soils of Prakasam and Nellore districts**

| S. No. | Village | Sand (%) | Silt (%) | Clay (%) | Textural class | pH | EC (dS/m) | Cl (mg/kg) | OC (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Korrapativaripalem | 63.70 | 20.40 | 15.90 | L | 7.5 | 0.26 | 16 | 0.18 |
| 2 | Doddavaram | 79.26 | 6.81 | 13.94 | SL | 7.5 | 0.25 | 16 | 0.19 |
| 3 | Chinarikatla I | 80.08 | 2.80 | 17.12 | SL | 7.0 | 0.19 | 24 | 0.16 |
| 4 | Chinarikatla II | 89.59 | 0.93 | 9.43 | SL | 7.1 | 0.17 | 12 | 0.11 |
| 5 | Gulla Samudram | 68.36 | 11.30 | 20.34 | L | 7.5 | 0.20 | 12 | 0.25 |
| 6 | Machavaram | 71.58 | 4.88 | 23.54 | SCL | 6.8 | 0.20 | 8 | 0.26 |
| 7 | Srirangapuram | 80.16 | 3.97 | 15.87 | SL | 6.8 | 0.18 | 8 | 0.14 |
| 8 | Juvvigunta | 66.11 | 13.48 | 20.41 | L | 7.6 | 0.18 | 16 | 0.30 |
| 9 | Petlur | 66.02 | 8.41 | 25.57 | CL | 7.3 | 0.25 | 20 | 0.21 |
| 10 | Oletivaripalem | 68.59 | 7.56 | 23.85 | SCL | 7.2 | 0.22 | 20 | 0.18 |
| 11 | CTRI Kandukur F3 | 77.46 | 5.14 | 17.39 | SL | 6.9 | 0.20 | 4 | 0.10 |
| 12 | CTRI Kandukur 10 | 81.49 | 3.86 | 14.65 | SL | 6.7 | 0.15 | 16 | 0.10 |
| 13 | Ponnalur | 52.03 | 17.68 | 30.29 | CL | 7.4 | 0.22 | 24 | 0.26 |
| 14 | Uppalapadu | 41.13 | 23.23 | 35.64 | CL | 7.4 | 0.24 | 8 | 0.19 |
| 15 | Chundi | 77.51 | 3.40 | 19.09 | SCL | 7.6 | 0.20 | 40 | 0.25 |
| 16 | Varikuntapadu | 68.13 | 5.45 | 26.42 | SCL | 7.3 | 0.20 | 44 | 0.18 |
| 17 | Duttalur | 51.80 | 22.22 | 25.98 | CL | 7.4 | 0.22 | 16 | 0.22 |
| 18 | Vinjamur | 77.27 | 3.93 | 18.80 | SCL | 6.9 | 0.21 | 12 | 0.14 |
| 19 | KrishnaReddy palem | 48.09 | 22.94 | 28.97 | CL | 7.4 | 0.25 | 12 | 0.25 |

**Table 4: Potassium fractions and Q/I parameters of southern light soils of Prakasam and Nellore districts**

| S. No. | Village | Water Soluble-K (mg/kg) | Exchan-geableK (mg/kg) | Non ˘ Exchan-geable ˘K (mg/kg) | Lattice-K (mg/kg) | Total-K (mg/kg) | $K_L$ (cmol ($p^+$)/kg) | $K_0$ (cmol ($p^+$)/kg) | $K_x$ (cmol ($p^+$)/kg) | $AR^K_0$ | $PBC^K$ (cmol ($p^+$)$kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Korrapativaripalem | 22 | 124 | 1080 | 10120 | 11200 | 0.227 | 0.159 | 0.068 | 0.0068 | 23.4 |
| 2 | Doddavaram | 18 | 80 | 1040 | 7960 | 9000 | 0.400 | 0.150 | 0.250 | 0.0025 | 60 |
| 3 | Chinarikatla I | 33 | 119 | 1000 | 6400 | 7400 | 0.250 | 0.200 | 0.05 | 0.0211 | 9.5 |
| 4 | Chinarikatla II | 30 | 86 | 520 | 3480 | 4000 | 0.244 | 0.180 | 0.064 | 0.0245 | 7.3 |
| 5 | Gulla Samudram | 31 | 137 | 1800 | 11000 | 12800 | 0.300 | 0.200 | 0.100 | 0.006 | 33.3 |
| 6 | Machavaram | 23 | 127 | 1480 | 8520 | 10000 | 0.313 | 0.188 | 0.125 | 0.0025 | 75.2 |
| 7 | Srirangapuram | 38 | 56 | 560 | 9040 | 9600 | 0.280 | 0.120 | 0.160 | 0.0025 | 48.0 |
| 8 | Juvvigunta | 14 | 96 | 1120 | 7880 | 9000 | 0.400 | 0.200 | 0.200 | 0.0016 | 125 |
| 9 | Petlur | 15 | 99 | 1080 | 7520 | 8600 | 0.400 | 0.216 | 0.184 | 0.0030 | 72 |
| 10 | Oletivaripalem | 22 | 148 | 960 | 6840 | 7800 | 0.404 | 0.269 | 0.135 | 0.0036 | 74.7 |
| 11 | CTRI Kandukur F3 | 46 | 132 | 880 | 8320 | 9200 | 0.466 | 0.330 | 0.136 | 0.015 | 22.0 |
| 12 | CTRI Kandukur 10 | 64 | 78 | 840 | 11760 | 12600 | 0.450 | 0.300 | 0.150 | 0.0323 | 9.29 |
| 13 | Ponnalur | 47 | 273 | 1640 | 5960 | 7600 | 0.400 | 0.243 | 0.173 | 0.0030 | 81 |
| 14 | Uppalapadu | 21 | 259 | 720 | 5680 | 6400 | 0.293 | 0.186 | 0.107 | 0.0031 | 60.0 |
| 15 | Chundi | 49 | 113 | 1040 | 7160 | 8200 | 0.316 | 0.233 | 0.083 | 0.010 | 23.3 |
| 16 | Varikuntapadu | 33 | 143 | 960 | 7640 | 8600 | 0.494 | 0.40 | 0.094 | 0.0124 | 32.3 |
| 17 | Duttalur | 22 | 238 | 920 | 5480 | 6400 | 0.646 | 0.369 | 0.277 | 0.0035 | 105 |
| 18 | Vinjamur | 43 | 217 | 880 | 4320 | 5200 | 0.640 | 0.500 | 0.140 | 0.0218 | 22.9 |
| 19 | Krishna Reddy palem | 17 | 141 | 640 | 5160 | 5800 | 0.486 | 0.316 | 0.170 | 0.0025 | 126.4 |

1986; Beckett, 1964; Subbarao *et al.*, 1984; Srinivas and Seshaiah, 1983). $PBC^K$, delta G and K potential were higher in sub-surface soils compared to surface soils (Kumar and Kumaraswamy, 2001).

The $K_O$ values indicate the quantity of K held at the non-specific sites and the values ranged from 0.257 – 0.60 cmol($p^+$)/kg in SBS and 0.12 – 0.50 cmol($p^+$)/kg in SLS. The labile form of K ($K_L$) is the K being exchanged by the cations from the colloidal surface. The values varied from 0.4-1.21 cmol($p^+$)/kg in SBS and 0.227 – 0.646 cmol($p^+$)/kg in SLS. $K_X$ is the content of the exchangeable K associated with specific sites. The values ranged from 0.143 – 0.61 cmol($p^+$)/kg in SBS and 0.05 – 0.277 cmol($p^+$)/kg in SLS. The labile form of potassium ($K_L$), potassium on specific sites ($K_X$) and potassium on non specific sites ($K_O$) were high in soils of SBS compared to soils of SLS, which is a measure of quantity parameter.

**Correlation between Q/I parameters and soil properties**

Equilibrium activity ratio ($AR^K_o$) values were positively correlated with sand whereas significant positive correlation was observed between $PBC^K$, $K_O$, $K_X$ and $K_L$ and silt and clay contents (Table 7). The parameters pH, EC and organic carbon showed significant positive correlation with $PBC^K$ and significant negative correlation with $AR^K_o$. Water soluble-K showed significant positive correlation with $AR^K_o$ whereas exchangeable–K showed significant positive correlation with $PBC^K$, $K_O$, $K_X$ and $K_L$. Non-exchangeable-K, lattice-K and total-K showed positive correlation with $PBC^K$, $K_O$, $K_X$ and $K_L$ and negative correlation with $AR^K_o$.

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**Table 5: Ranges and mean values of soil chemical properties and potassium fraction of SLS and SBS areas**

| Region | | pH | EC (dS/m) | Cl (mg/kg) | OC (%) | Water soluble-K (mg/kg) | Exchangeable -K (mg/kg) | Non exchaneable - K (mg/kg) | Lattice-K (mg/kg) | Total-K (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| SBS | Mean | 7.5 | 0.23 | 24 | 0.28 | 29 | 338 | 1116 | 9129 | 10244 |
| | Range | 7.4-7.7 | 0.19-0.32 | 12-40 | 0.15-0.35 | 17-36 | 243-464 | 840-1720 | 7160-14360 | 8000-15800 |
| SLS | Mean | 7.2 | 0.21 | 17 | 0.19 | 31 | 140 | 1008 | 7381 | 8389 |
| | Range | 6.7-7.6 | 0.15-0.26 | 4-44 | 0.10-0.30 | 14-64 | 56-273 | 520-1800 | 3480-11760 | 4000-12800 |

**Table 6: Ranges and mean values Quantity –Intensity parameters of potassium in southern light soils and southern black soils**

| Region | | $K_L$ (cmol ($p^+$)/kg) | $K_0$(cmol ($p^+$)/kg) | $K_x$(cmol ($p^+$)/kg) | $AR^K_0$ | $PBC^K$ (cmol($p^+$)/kg) |
|---|---|---|---|---|---|---|
| SBS | Range | 0.4 - 1.21 | 0.257-0.60 | 0.143 – 0.61 | 0.002 – 0.0032 | 80.3 -200 |
| | mean | 0.665 | 0.384 | 0.281 | 0.0025 | 154.1 |
| SLS | Range | 0.227-0.646 | 0.12 – 0.50 | 0.05 – 0.277 | 0.0016 – 0.0323 | 7.3 – 126.4 |
| | mean | 0.390 | 0.250 | 0.140 | 0.0094 | 53.2 |

**Table 7: Correlation coefficients between soil properties and Quantity-Intensity parameters**

| Soil Properties | $K_L$ (cmol ($p^+$)/kg) | $K_0$(cmol ($p^+$)/kg) | $K_x$(cmol ($p^+$)/kg) | $AR^K{}_0$ | $PBC^K$ (cmol ($p^+$)/kg) |
|---|---|---|---|---|---|
| Sand | -0.677** | -0.545** | -0.674** | 0.608** | -0.850** |
| Silt | 0.642** | 0.537** | 0.616** | -0.553** | 0.831** |
| Clay | 0.588** | 0.448* | 0.612** | -0.555** | 0.706** |
| pH | 0.257 | 0.111 | 0.357 | -0.629** | 0.543** |
| EC | 0319 | 0.287 | 0.286 | -0.519** | 0.461* |
| Chlorides | 0.264 | 0.327 | 0.143 | -0.066 | 0.208 |
| OC | 0.281 | 0.124 | 0.391 | -0.659** | 0.553** |
| Water –K | 0.089 | 0.209 | -0.051 | 0.622** | -0.343 |
| Exch.K | 0.754** | 0.669** | 0.685** | -0.402* | 0.730** |
| Non-Exch.K | 0.320 | 0.234 | 0.352 | -0.297 | 0.260 |
| Lattice-K | 0.324 | 0.215 | 0.366 | -0.133 | 0.262 |
| Total-K | 0.342 | 0.230 | 0.384 | -0.161 | 0.276 |

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