Materials and methods
The selected study site was the agricultural farm of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA & RI), Tamil Nadu Agricultural University, Karaikal constituting a total area of 225 acres. The experimental site lies between 10° 49' and 11° 00' N Latitude and between 78° 43' and 79° 52' E longitude with an average elevation of 4 m above mean sea level. The mean maximum and mean minimum temperature of the region are 31.95°C and 25.52°C with a mean annual rainfall of 1506.87 mm. The farm area is subdivided into two units i.e. the eastern farm (having four blocks, namely A, B, C, D) occupying an area of 63.85 acres and the western farm (having six blocks, namely A, B, C, D, E, F) occupying an area of 24.40 acres. Soils of this farm have been reported to be *Fluventic Haplustept, Typic* and *Pudmailic Hapludalf* respectively.
Non–exchangeable K
In the entire farm, the non-exchangeable–K content of profile soil samples ranged from 122 to 2346 mg kg⁻¹. It ranged from 122 to 1890 mg kg⁻¹ and 123 to 2346 mg kg⁻¹ in the eastern and western farm soils respectively. Concerning the simple correlation analysis, the non-exchangeable–K content was observed to be having significant positive correlations with constant–K, CEC, exchangeable Mg and clay content but negative correlations with the fine sand content of soil profiles. The linear multiple regression analysis to quantify the contribution of different soil separates to that of non-exchangeable K had indicated a trend, wherein 85.2 percent of variations in non-exchangeable K could be attributed to the different sized soil particles, with a significant contribution from the clay content. It is quite expected that the exchangeable and non-exchangeable K content could be closely linked with the clay content as K being a cation is held on the exchange complex and as well as gets locked up in the exchangeable sites of clay which are specific to potassium (Parfitt, 1992) [10].

Step – K
The step – K content of the profile soil samples ranged from 38 to 747 mg kg⁻¹ in the entire farm soils. In the case of the eastern farm, it ranged from 38 to 538 mg kg⁻¹ and that in the case of the western farm, it ranged from 47 mg kg⁻¹ to 747 mg kg⁻¹. The simple correlation analysis confirmed a significant positive relationship of step–K with the solution–K (r=0.839**), exchangeable–K (r=0.892**), constant–K (r = 0.214*), organic carbon (r =0.379**) and clay content (r=0.249*).

Constant–K
The constant–K content, which represents the steady rate of K release after the labile pool is extracted, ranged from 1 to 15 mg kg⁻¹ in the farm soils. It ranged from 1 to 15 mg kg⁻¹ and 2 to 15 mg kg⁻¹ in the eastern and western farms respectively. Further analysis by simple correlation studies revealed that the constant–K was having significant positive correlations with exchangeable–K (r=0.214*), non-exchangeable K (r=0.847**), step–K (r=0.214*), CEC (r =0.290**), exchangeable–Mg (r=0.214*) and clay content (r=0.902**), but negatively correlated to fine sand content (r =-0.436**). The above result was further supported by the multiple regression analysis, wherein 83 percent of the variations in the constant–K release could be explained by the different soil separates with significant contribution from the clay content. It is quite evident that these two fractions are closely related to the K fractions since the release either by repetitive extraction is due to the release of K from the exchangeable complex when the solution K level declines. A significant and positive correlation of step and constant–K with different fractions had confirmed the above statement.
Available–K content

The available–K content of the soil samples as extracted by neutral normal ammonium acetate ranged from 21 to 415 mg kg⁻¹ (Table 2). The available–K content ranged from 21-299 mg kg⁻¹ in the eastern farm and that in the western farm ranged from 26-415 mg kg⁻¹. In the eastern farm the available–K was ranging from 21 to 299 mg kg⁻¹ and in the western farm, the corresponding values were 26 to 415 mg kg⁻¹. From the multiple regression analysis, it was computed that 57.5 percent of the variation in the available–K content could be due to the K-fractions and that of 56.2 percent by the exchangeable cations.

Organic carbon content

The organic carbon content of the soil samples of the PAJANCOA & RI farm is presented in Table 2. The organic carbon content ranged from 0.896 to 7.642 mg g⁻¹ with a coefficient of variation of 46.52 percent. The range of organic carbon content was from 1.237 mg g⁻¹ to 6.975 mg g⁻¹ and 0.896 to 7.642 mg g⁻¹ in the eastern and western farm respectively. It was further observed from the simple correlation analysis that the organic carbon content of the profile soils was having significant positive correlations with the solution–K (r=0.413**), exchangeable–K (r=0.379**), step–K (r=0.379**) and exchangeable–Mg (r=0.233*). From simple regression analysis, it was inferred that the organic carbon content could significantly predict the available–K content (R²=0.060*), solution–K, (R²=0.170**) exchangeable–K (R²=0.143**), non-exchangeable–K and step–K (R²=0.143**).

Cation exchange capacity

The cation exchange capacity of the soil samples collected from the different horizons of the profiles of PAJANCOA & RI is furnished in table 2. The CEC of the study area ranged from 8.65 to 42.65 cmol (p+) kg⁻¹ with a coefficient of variation of 34.38 percent. It ranged from 12.44 to 38.48 cmol (p+) kg⁻¹ and from 8.65 to 42.65 cmol (p+) kg⁻¹ in the eastern and western farms respectively. From the simple correlation analysis, it was inferred that the CEC was positively and significantly correlated with exchangeable–K (r=0.305**), constant–K (r=0.290**), solution–Ca (r=0.620**), Mg (r=0.645**) and Na (r=0.462**) and the percent clay content (r=0.394**). However, it was found to be negatively correlated to the percent fine sand content of the soil (r=-0.206*). The simple regression analysis also suggested that the CEC could significantly contribute to non–exchangeable–K (R²=0.305**).

Exchangeable cations

Exchangeable Calcium

The exchangeable calcium content of the soil samples of the profile soils ranged from 4.25 to 29.25 cmol (p+) kg⁻¹ at the farm level (Table 3). For the eastern farm soils, the minimum exchangeable-Ca content was 4.50 cmol (p+) kg⁻¹ and the maximum was 29.25 cmol (p+) kg⁻¹. The corresponding values for the western farm soils were 4.25 and 25.25 cmol (p+) kg⁻¹ respectively. The simple correlation studies had shown significant positive relationships of exchangeable–Ca with CEC (r=0.620**) and exchangeable–Na (r=0.307**).

Exchangeable Magnesium

The content of exchangeable–Mg in the profile soil samples ranged from 0.98 to 11.40 cmol (p+) kg⁻¹ (Table 3). The minimum and maximum values in the eastern farm soils were 1.25 to 11.40 cmol (p+) kg⁻¹ and that of western farm soils

Table 1: Content of K fractions, step K and constant K of the soil profiles

|          | Solution - K | Exchangeable – K | Non Exchangeable-K | Step-K | constant - K |
|----------|--------------|-----------------|-------------------|--------|-------------|
| Overall farm soils |
| Mean     | 17           | 190             | 641               | 228    | 6           |
| S.D      | 9.50         | 111.83          | 485.08            | 134.20 | 3.44        |
| Minimum  | 4            | 32              | 122               | 38     | 1           |
| Maximum  | 45           | 623             | 2346              | 747    | 15          |
| C.V (%)  | 54.35        | 58.66           | 75.64             | 58.66  | 55.77       |
| Eastern farm soils |
| Mean     | 18           | 188             | 620               | 225    | 5           |
| S.D      | 8.588        | 78.69           | 387.20            | 94.43  | 2.837       |
| Minimum  | 4            | 32              | 122               | 38     | 1           |
| Maximum  | 44           | 449             | 1890              | 538.2  | 15          |
| C.V (%)  | 45.41        | 41.99           | 62.39             | 41.99  | 48.89       |
| Western farm soils |
| Mean     | 15           | 196             | 673               | 235    | 6           |
| S.D      | 10.50        | 150.80          | 611.93            | 180.9  | 4.197       |
| Minimum  | 5            | 39              | 123               | 47     | 2           |
| Maximum  | 45           | 625             | 2346              | 747    | 15          |
| C.V (%)  | 68.88        | 77.07           | 90.88             | 77.07  | 62.18       |

Table 2: The organic carbon, available K, and CEC of the soil profile samples

|          | OC (mg g⁻¹) | NH₄OAC-K (kg ha⁻¹) | CEC (cmol (p⁺) kg⁻¹) |
|----------|-------------|--------------------|----------------------|
| Overall farm soil |
| Mean     | 3.122       | 127                | 21.53                |
| SD       | 1.444       | 75                 | 7.40                 |
| Minimum  | 0.896       | 21                 | 8.65                 |
| Maximum  | 7.642       | 415                | 42.65                |
| C.V (%)  | 46.25       | 58.67              | 34.38                |
| Eastern farm soil |
| Mean     | 3.244       | 125                | 22.34                |
| SD       | 1.504       | 52                 | 5.21                 |
| Minimum  | 1.237       | 21                 | 12.44                |
| Maximum  | 6.957       | 299                | 38.48                |
| C.V (%)  | 46.38       | 41.99              | 23.33                |
| Western farm soil |
| Mean     | 2.933       | 130                | 20.27                |
| SD       | 1.344       | 101                | 9.85                 |
| Minimum  | 0.896       | 26                 | 8.65                 |
| Maximum  | 7.642       | 415                | 42.65                |
were 0.98 and 11.26 cmol (p+) kg⁻¹. The simple correlation studies revealed the significant relationship of this parameter with the non-exchangeable K (r=0.293**), constant K (r=0.214*), CEC (r=0.645***), exchangeable Na (r=0.213*), organic carbon (r=0.233*), and clay content (r=0.321**).

Exchangeable Sodium

The exchangeable sodium content of the soil samples was found to range from 0.59 to 12.88 cmol (p+) kg⁻¹ in the entire farm (Table 3). In the eastern farm soils, it was found to range from 0.77 to 10.23 cmol (p+) kg⁻¹ and in the western farm, the corresponding values were 0.59 to 12.88 cmol (p+) kg⁻¹. The simple correlation studies had further revealed that the exchangeable sodium content of the soil was positively correlated with CEC (r=0.462**), exchangeable-Ca (r=0.307**) and exchangeable-Mg (r=0.213*) content and percent clay (r=0.216*) content.

| Particulars               | Exchangeable cations [cmol (p+) kg⁻¹] |
|---------------------------|--------------------------------------|
|                           | Ca²⁺ | Mg²⁺ | Na⁺ | K⁺ |
| **Overall farm soil**     |      |      |     |    |
| Mean                      | 11.34| 4.99 | 3.18| 0.258|
| SD                        | 5.01 | 2.84 | 2.34| 0.227|
| Minimum                   | 4.25 | 0.98 | 0.59| 0.038|
| Maximum                   | 29.25| 11.40|12.88| 1.692|
| C.V (%)                   | 44.13| 57.02|73.66| 87.71|
| **Eastern farm soil**     |      |      |     |    |
| Mean                      | 12.31| 5.39 | 3.28| 0.230|
| SD                        | 5.05 | 2.49 | 2.15| 0.113|
| Minimum                   | 4.50 | 1.25 | 0.77| 0.038|
| Maximum                   | 29.25| 11.40|10.23| 0.660|
| C.V (%)                   | 40.98| 46.20|65.51| 49.08|
| **Western farm soil**     |      |      |     |    |
| Mean                      | 9.84 | 4.37 | 3.02| 0.303|
| SD                        | 4.62 | 3.27 | 2.63| 0.332|
| Minimum                   | 4.25 | 0.98 | 0.59| 0.038|
| Maximum                   | 25.25| 11.26|12.88| 1.692|
| C.V (%)                   | 46.92| 74.70|87.31| 109.49|

Exchangeable potassium

The exchangeable-K content of the soil samples in the profiles ranged from 0.038 to 1.692 cmol (p+) kg⁻¹ (Table 3). It ranged from 0.038 to 0.660 cmol (p+) kg⁻¹ in the eastern farm and from 0.038 to 1.692 cmol (p+) kg⁻¹ in the western farm. From the correlation studies it was inferred that the exchangeable K content was found to be positively and significantly related to the solution–K (r=0.627**) and exchangeable–K fractions (r=0.710**), step–K (r=0.249*), constant–K (r=0.902**), CEC (r=0.394**), exchangeable–Mg (r=0.321**) and exchangeable–Na (r=0.216*). However, it was negatively correlated with fine sand content (r=-0.369**). It was further observed by multiple regression analysis that the clay content could significantly contribute to the solution–K, non-exchangeable–K, and constant–K along with other soil fractions, though their contribution was not marked.

| Particulars | Mechanical composition (%) | Descriptive statistics |
|-------------|----------------------------|------------------------|
| **Fine sand**| 32.73 | 26.86 | 27.44 | 6.31 |
| **Coarse sand**| 20.64 | 19.43 | 12.80 | 5.15 |
| **Clay**    | Minimum                   | 2.92 | 4.11 | 6.20 | 0.75 |
| **Silt**    | Maximum                   | 70.11 | 75.12 | 60.12 | 24.00 |
| C.V (%)     | 63.06 | 72.35 | 46.63 | 81.59 |

Relative proportion of soil separates

The mechanical analysis of the soil samples revealed the relative proportion of the different soil separates which is presented in table 4. The distribution of the different sized particles is described in the following sections.

Coarse sand content

The coarse sand content in the soil samples of the entire study site ranged from 4.11 to 75.12 percent. In the eastern farm, a minimum of 4.11 percent and a maximum of 65.32 percent of coarse sand content was recorded. The corresponding values for the western farm soils were 5.02 and 75.12 percent respectively. The simple correlation studies had revealed that the coarse sand content was negatively correlated to the solution–K (r=-0.288**).

Fine sand content

The content of fine sand ranged from 2.92 percent to 70.11 percent in the entire farm, while it was 5.11 to 70.11 percent in the eastern farm and 2.92 to 60.82 percent in the western farm. The fine sand content was found to be significantly and negatively related to non-exchangeable–K (r =-0.399**), constant–K (r=-0.436**), CEC (r=-0.206*) and clay content (r=0.369**).

Silt content

The silt content ranged from 0.75 to 24.00 percent in the soil samples of PAJANCOA & RI. In the eastern farm, the minimum silt content was 0.75 percent and the maximum was 21.30 percent. The corresponding values in the western farm soils were 1.11 and 24.00 percent respectively.

Clay content

The clay content of soil samples varied from 6.20 percent to 60.12 percent with a minimum value of 7.90 percent and a maximum of 51.65 percent in the eastern farm. Both the minimum and maximum values at the entire farm level were recorded in the western farm itself. It was further seen that the clay content of profile soil samples had a significant and positive relationship with exchangeable K (r=0.249*), non-exchangeable–K (r=0.918**), step–K (r=0.249*), constant–K (r=0.902**), CEC (r=0.394**), exchangeable–Mg (r=0.321**) and exchangeable–Na (r=0.216*). However, it was negatively correlated with fine sand content (r=-0.369**). It was further observed by multiple regression analysis that the clay content could significantly contribute to the solution–K, non-exchangeable–K, and constant–K along with other soil fractions, though their contribution was not marked.

Conclusion

The analysis of K fractions in the soil profile samples had shown that the content of solution K, exchangeable K, and nonexchangeable K ranged from 4 to 45, 32 to 623 and 122 to
2346 mg kg⁻¹, respectively. The step K content, which is a measure of easily as well as slowly available K ranged between 38 to 747 mg kg⁻¹. The constant K releasing power of the study site ranged between 1 and 15 mg kg⁻¹. The simple correlation studies indicated that solution K was positively correlated to the exchangeable K, step K and organic carbon content of the soils. It was also noticed that the exchangeable K content was positively related to step K, constant K, organic carbon content and the percent clay. Among the soil properties, the constant K, CEC, exchangeable Mg, and percent clay content were positively correlated to the non-exchangeable K content of the soils. The step-K was significantly correlated with solution K, exchangeable K, constant K, organic carbon content and percent clay. Similarly, the constant K content of the soil was positively correlated to exchangeable K, non-exchangeable K, step K, CEC and percent clay content of the soils. The textural analysis of the profile samples indicated that the coarse sand, fine sand silt, and clay content ranged from 4.11 to 75.12, 2.92 to 70.11, 0.75 to 24.00 and 6.20 to 60.12 percent, respectively. The available K content of the profile soil samples ranged from 21 to 415 kg ha⁻¹. The organic carbon content of the profile soil samples ranged between 0.896 and 7.642 mg g⁻¹. The cation exchange capacity was found to vary between 8.65 and 42.65 cmol (p+) kg⁻¹ in the profile soils of the farm. Among the exchangeable cations Ca²⁺ was the dominant one (4.25 to 29.25 cmol (p+) kg⁻¹) followed Mg²⁺ (0.98 to 11.40 cmol (p+) kg⁻¹), Na⁺ (0.59 to 12.88 cmol (p+) kg⁻¹) and K⁺ (0.038 to 1.692 cmol (p+) kg⁻¹).

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