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# MOISTURE RETENTION CHARACTERISTICS OF RED AND FOREST SOILS OF KERALA*

Reena Mathew and R. Vikraman Nair

*Department of Agronomy,*
*College of Horticulture, Vellanikkara. Trichur*

Information on the capacity of soils to retain water in the plant available form can be had only when water content is related to soil moisture tension. This relation, usually represented through soil moisture characteristic curves, shows wide variation between soils. Much of the soil-to-soil difference in moisture content-tension relation is often accountable as due to differences in texture and organic matter content. The two most important soil moisture constants in deciding plant avaifable water, i.e., field capacity and wilting coefficient, also show high degree of dependence on fineness of soil, as defined by texture and organic matter content. The present study was aimed at working out some of the above relationships in the red and forest soils of Kerala.

## Materials and Methods

The soils taken up for the study included red and forest soil groups of Kerala. Three established soil series were selected for each group. Within a series, soil samples were collected from three profiles at different locations from five depths, viz., 0-30 cm, 30-60 cm, 60-90 cm, 90-120cm, and 120-150 cm. Separate samples were collected from each depth for bulk density determination using core samplers of 10 cm length and 4.4 cm diameter. The sampled depths varied in the case of forest soil according to the depth possible and none of the profiles was deeper than 120 cm.

Moisture retention studies were attempted at six different pressures of 0.3, 1, 3, 5, 10 and 15 bar using the air dried and 2 mm sieved soil. Pressure plate apparatus (Richards, 1947) was employed to study moisture retention and measurements were replicated thrice for each sample. Mechanical analysis was done by International Pipette Method (Piper, 1942) and organic carbon by Walkley and Black titration method (Jackson, 1958). Correlation studies were made between the moisture retention of the sieved soil at different tensions and organic carbon and textural components. Multiple regression analysis as suggested by Snedecor and Cochran (1967) was used to arrive at suitable prediction models relating moisture content at field capacity and wilting coefficient with organic carbon and texture. Moisture characteristic curves were developed for the two **soils.**

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The gravel contents of forest soil samples were estimated from the oven dried core samples. The more than 2 mm fraction was washed and oven dried and the percentage contents calculated. Moisture retention by gravel was measured at 0.3 and 15 bar and incorporated into the retention values of sieved soil inorder to arrive at retention including gravel. Similarly, textural components of 2 mm sieved fraction were recalculated for including content of gravel also. Separate correlation coefficients and prediction equations were worked out for the data on moisture retention including gravel.

## Results and Discussion

Data on the mean moisture retention by 2 mm sieved soil are presented in Table 1. A decreasing trend was observed for moisture retention with increasing tensions. About 50 per cent of available water was removed when the tension increased from 0. 3 to 1 bar. The extraction was more than 80 per cent as the tension reached 3 bar (Fig. 1 and 2).

The mean available water content in red soil amounted to 3,24 per cent, the field capacity and wilting coefficient being 10.45 percent and 7,21 per cent, respectively. These values nearly tally with the figures reported for red soils of Kasaragod (Haridasan, 1978). Ali *et al*. (1966) reported simitar values for red soils of the same textural class (sandy clay loam). The mean field capacity, wilting coefficient and available water content of forest soil were 24.85, 18.15 and 6.70 per cent, respectively. It was observed that the retention at 0.3 bar was considerably lower than the values established for soils of clayey textural groups, which ranged from 31 to 39 per cent, with a mean of 35 percent (Israelsen and Hansen, 1962). The fact that preparation of soil samples for determination of moisture retention results in total destruction of structure may partly explain the low retention values noted in this study.

Table 1

Moisture retention by sieved fractions of red and forest soils at different tensions (percentage by weight)

| Depth cm | | Soil moisture tension (bar) 0.3 | 1 | 3 | 5 | 10 | 15 | Available water (per cent) |
|---|---|---|---|---|---|---|---|---|
| 0—30 | R | 8.93 | 7.46 | 6.55 | 6.07 | 5.70 | 5.58 | 3.35 |
| | F | 24.52 | 21.07 | 18.79 | 18.17 | 17.99 | 17.96 | 6.56 |
| 30-60 | R | 10.29 | 9,03 | 8.02 | 7.52 | 7.21 | 7.06 | 3.23 |
| | F | 23.75 | 20.44 | 18.48 | 18.16 | 17.23 | 17.27 | 6.48 |
| 60—90 | R | 10,74 | 8.77 | 8.18 | 7.89 | 7.53 | 7.60 | 3.14 |
| | F | 25.56 | 22.43 | 20.64 | 19.44 | 19.50 | 19.09 | 6.47 |
| 120—150 | R | 11.03 | 9.54 | 8,60 | 8.32 | 8.09 | 8.00 | 3.03 |
| Mean | R | 10.45 | 8,86 | 7.98 | 7.60 | 7,28 | 7.21 | 3.24 |
| | F | 24.85 | 21.29 | 19.34 | 18.67 | 18.32 | 18.15 | 6.70 |

R = Red soil F = Forest soil

Fig. 1 Moisture characteristic curve for the 2 mm sieved fraction in red soil

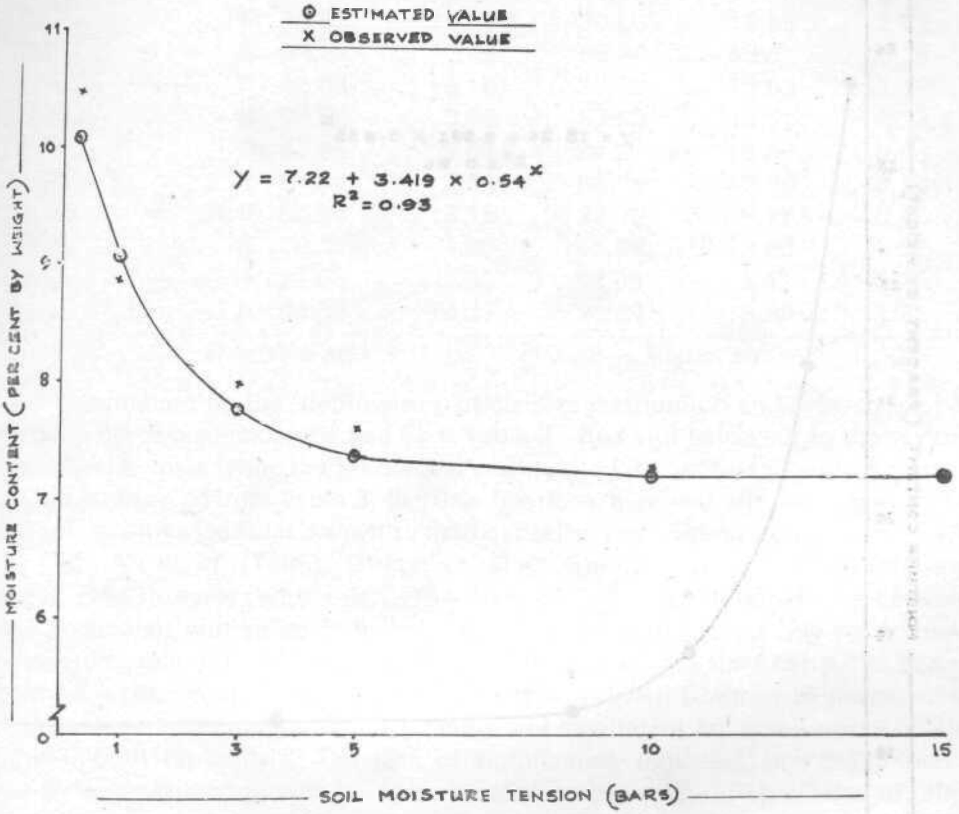

Fig. 2 Moisture characteristic curve for the 2mm sieved fraction in forest soil

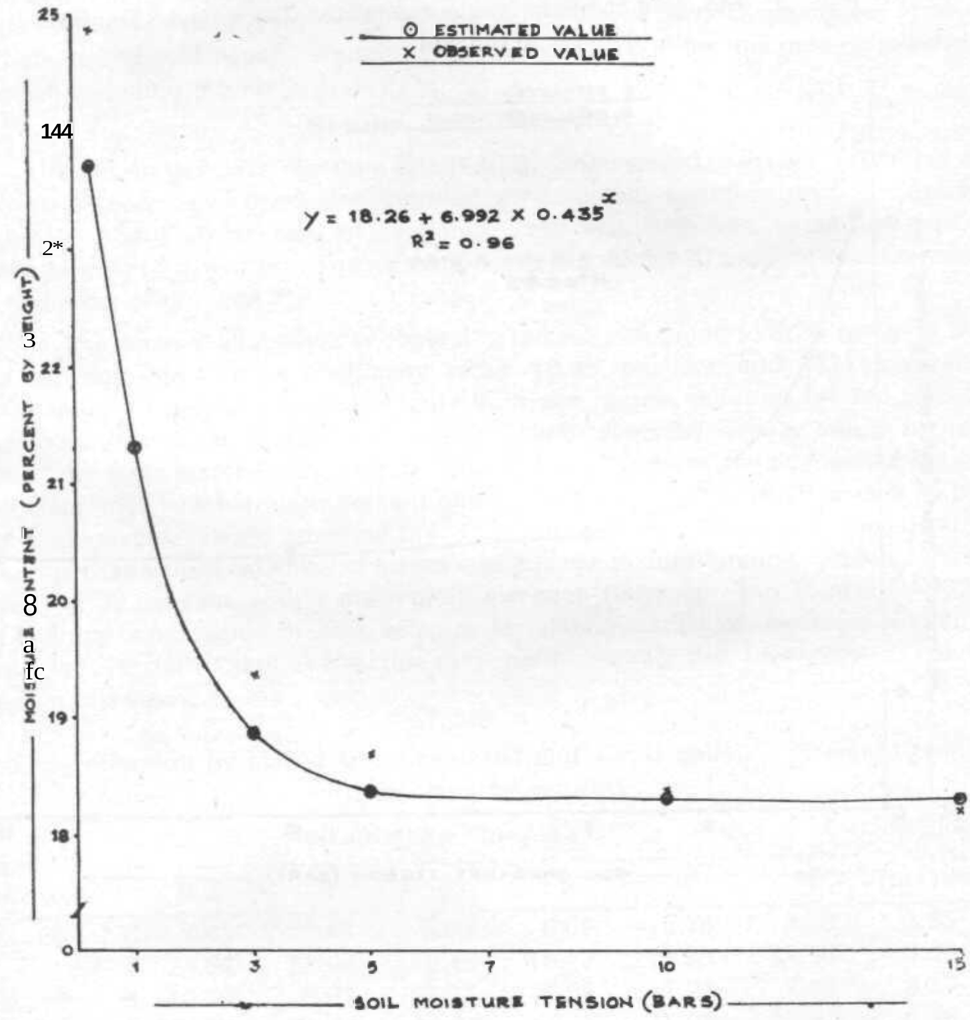

Table 2

Textural composition and organic carbon contents of 2 mm sieved fractions of red and forest soils (percentage)

| Depth (cm) | | Clay | Silt | Fine sand | Coarse sand | Organic carbon |
|---|---|---|---|---|---|---|
| 0—30 | R | 18.66 | 4.82 | 61.57 | 14.95 | 0.38 |
| | F | 35.83 | 15.69 | 30.80 | 17.68 | 2.72 |
| 30-60 | R | 24.31 | 3.98 | 58.90 | 12.81 | 0.29 |
| | F | 42.00 | 15.18 | 27.19 | 15.63 | 1.19 |
| 60—90 | R | 24.96 | 3.58 | 57.95 | 13.51 | 0.23 |
| | F | 47.84 | 9.05 | 24.25 | 18.86 | 0.63 |
| 90—120 | R | 26.34 | 2.64 | 58,28 | 12,74 | 0.18 |
| | F | 50.34 | 17.16 | 22.73 | 9.77 | 0.84 |
| 120—150 | R | 26.13 | 4.80 | 55.98 | 13,09 | 0.20 |
| Mean | R | 24.08 | 3.96 | 58.58 | 13.42 | 0.26 |
| | F | 44.00 | 14.27 | 26.24 | 15.49 | 1.35 |

R = Red soil F = Forest soil

Information on the depthwise particle size distribution and organic carbon contents of the two soils can be had from Table 2. Red soil belonged to the textural class sandy clay loam while the predominant textural class of forest soil was clay. As could be observed from Tabte 3, the fine fractions, clay and silt, produced highly significant positive correlation with field capacity and wilting coefficient. The results of AH *et al*. (1966), Ghazy *et al* (1931), Thulasidharan (1983) and Prameela (1983) agree with this. The lack of a significant correlation between silt and permanent wilting point in red soil can be attributed to the low silt content. The negative relation of fine sand with these soil moisture constants is well established. (Rivers and Shipp, 1978; Talha *et al*. (1979). Contrary to the expected trend, organic carbon content failed to show any significant influence on moisture retention in both the soils. The lack of significance indicates that the influence exerted by organic carbon was being dominated by the over riding effects of clay. Such results were noted and similar conclusions drawn by Thulasidharan (1983) and Prameela (1983). Rajagopal (1967) working on Tamil Nadu soils observed that organic carbon had no bearing on the soil moisture constants.

Prediction equations developed to estimate moisture contents at 0.3 and 15 bar in red soil aregiven below. The coefficients of determination were high indicating that the difference in the quality of soil organic matter and fine fractions in the red soil are not substantial.

(a) Moisture percentage at 0,3 bar ($Y_1$)

$$Y_1 = 1.9228 + 0.2920\, x_1 + 0.3171\, x_2 + 0.0020\, x_3 - 0.0185\, x_4 + 1.3930\, x_5 \quad (R^2 = 0.87)$$

(b) Moisture percentage at 15 bar ($Y_2$)

$$Y_2 = 19.8026 + 0.0552\,x_1 + 0.0352\,x_2 + 0.1938\,x_3 - 0.2064\,x_4 + 0.1635\,x_5 \quad (R^2 = 0.90)$$

where $x_1$ = clay per cent;
$x_2$ = silt per cent;
$x_3$ = fine sand percent;
$x_4$ = coarse sand per cent; and
$x_5$ = organic carbon percent.

Table 3

Correlation coefficients of moisture contents at 0.3 and 15 bar with textural components and organic carbon

| Tension in bar | | Clay | Silt | Fine sand | Coarse sand | Organic carbon |
|---|---|---|---|---|---|---|
| 0.3 | R | 0.8599** | 0.3252* | -0.7332** | -0.0352 | 0.1839 |
| | F | 0.4547* | 0.4255* | -0.8063** | -0.1153 | 0.1849 |
| 15 | R | 0.9023** | 0.2807 | -0.7499** | -0.0431 | 0.1124 |
| | F | 0.5120** | 0.4215* | -0.8205** | -0.1798 | 0.2063 |

R = Red soil F = Forest soil ** Significant at 1 per cent level
* Significant at 5 per cent level

Table 4

Moisture retention by gravel (percentage by weight)

| Depth (cm) | Moisture content 0.3 bar | Moisture content 15 bar | Available water | Gravel content (per cent) |
|---|---|---|---|---|
| 0— 30 | 9.14 | 9.44 | -0.30 | 17.80 |
| 30- 60 | 10.00 | 9.13 | 0.87 | 28.69 |
| 60— 90 | 11.25 | 8.49 | 2.76 | 36.08 |
| 90-120 | 12.80 | 10.76 | 2.04 | 36.95 |
| Mean | 10.80 | 9.46 | 1.34 | 29.88 |

Moisture retention by gravel in the forest soil at 0.3 and 15 bar was considerably less than that of 2 mm sieved soil (Table 4). These values were incorporated into the retention by 2 mm sieved fraction according to the proportion of gravel in each sample. The calculated overall mean moisture retention including gravel are furnished in Table 5. Correlation studies were attempted relating moisture retention including gravel with textural separates including gravel and organic carbon. Gravel content indicated a significant negative relation with moisture content at 0.3 bar. The correlation coefficients in the case of the other variables were simitar to that of 2 mm sieved soil. The values are presented in

Table 6. It is suggested that field capacity and wilting coefficient could be accurately estimated from the values on textural separates including gravel and organic carbon. The prediction models are given here under:

(a) Moisture percentage ot 0.3 bar($Y_1$)

$$Y_1 = -10.7186 + 0.4584\ x_1 + 0.5927\ x_2 + 0.0394\ x_3 + 0.3251\ x_4 + 0.2031\ x_5 + 0.7594\ x_6\ (R^2 = 0.84)$$

(b) Moisture percentage at 15 bar ($Y_2$)

$$Y_2 = -27.780 + 0.5820\ x_1 + 0.6201\ x_2 + 0.1789\ x_3 + 0.3483\ x_4 + 0.3563\ x_5 + 1.1699\ x_6\ (R^2 = 0.93)$$

where $x_1$ = clay per cent;
$x_2$ = silt per cent;
$x_3$ = fine sand per cent;
$x_4$ = coarse sand per cent;
$x_5$ = gravel percent, and
$x_6$ = organic carbon per cent.

Table 5

Moisture retention including gravel on weight basis in forest soil, %

| Depth cm | 0.3 bar | 15 bar | Available water |
|---|---|---|---|
| 0— 30 | 21.65 | 16.29 | 5.36 |
| 30— 60 | 19.98 | 15.16 | 4.82 |
| 60— 90 | 20.25 | 14.65 | 5.60 |
| 90-120 | 21.00 | 16.23 | 4.77 |
| Mean | 20.72 | 15.58 | 5.14 |

Table 6

Correlation coefficients of moisture retention including gravel at 0.3 and 15 bar with textural separates including gravel and organic carbon (forest soil)

| Tension in bar | Clay | Silt | Fine sand | Coarse sand | Gravel | Organic carbon |
|---|---|---|---|---|---|---|
| 0.3 | 0.5782** | 0.5785** | -0.2151 | 0.1631 | -0.4452* | 0.3091 |
| 15 | 0.5494** | 0.5799** | -0.3504 | 0.1765 | -0.3029 | 0.3506 |

** Significant at 1 per cent level
* Significant at 5 percent level

The overall mean available water content on volume basis in red soil amounted to 4.58 per cent It was obtained by multiplying the available water on weight basts with bulk density. In as much as there is no considerable variation between samples on the available water content, it may be reasonable to rely on this overall mean value as a representative of red soils of Kerala. However, in the case of forest soil, it will be more accurate to work out the retention using prediction equations, as the mean moisture retention and bulk density values showed fluctuations in the different locations.


## Summary

Moisture retention studies of red and forest soils were conducted at the College of Horticulture at six different tensions ranging from 0.3 to 15 bar. The results revealed that the clayey textured forest soil retained higher moisture at all the tensions than red soil which is sandy c!ay loam in texture. The field capacity and wilting coefficient values were 24.85 and 18.15 per cent, respectively for forest soil as against 10.45 and 7.21 percent for red soil. About 50 percent of the available water was removed when the tension increased from 0.3 to 1 bar. Significant positive correlations were obtained between moisture contents at different tensions and the contents of clay and silt while the relation with fine sand was significant and negative. Organic carbon failed to show any significant influence on moisture retention but the content of gravel had a depressing effect on moisture percentage especially at 0.3 bar. Regression equations with high predictability have been developed to estimate field capacity and witting coefficient from the contents of organic carbon, textural separates and gravel.



## സംഗ്രഹം

ചെമ്മണ്ണിലും വനമണ്ണിലും ജലാംശം നിലനിർത്തുന്നതിനെക്കുറിച്ചുള്ള ഒരു പഠനം വെള്ളാനിക്കര ഹോർട്ടിക്കൾച്ചറൽ കോളേജിൽ നടത്തുകയുണ്ടായി. അതിനായി 0.3 മുതൽ 15 ബാർ വരെയുള്ള ആറു വ്യത്യസ്ത മർദ്ദങ്ങൾ ഉപയോഗിച്ച് നിരീക്ഷണങ്ങൾ നടത്തി. തൽഫലമായി ചെളിരാശി കലർന്ന വനമണ്ണ്, മണലും ചെളിയും ചേർന്ന ചെമ്മണ്ണിനേക്കാൾ കൂടുതൽ ജലാംശം എല്ലാ മർദ്ദത്തിലും നിലനിർത്തുന്നതായി കണ്ടു. ഫീൽഡ് കപ്പാസിററി വിൽററിംഗ് ഗുണാംങ്കം ഇവയിലെ ജലാംശത്തിന്റെ അളവ് വനമണ്ണിൽ യഥാക്രമം 24.85 ശതമാനവും 18.15 ശതമാനവും ആയിരുന്നപ്പോൾ ചെമ്മണ്ണിലേത് 10.45 ശതമാനവും 7 2t ശതമാനവും ആയിരുന്നു. വിവിധ മർദ്ദങ്ങളിലെ ജലാംശവും ചെളി, എക്കൽ, പൊടിമണ്ണ് എന്നിവയും തമ്മിൽ ബന്ധമുള്ളതായി കണ്ടു. ജൈവ കാർബണും ജലാശം നിലനിർത്തുവാനുള്ള മണ്ണിന്റെ കഴിവും തമ്മിൽ ബന്ധം കാണാൻ കഴിഞ്ഞില്ല. എങ്കിലും 0.3 ബാർ മർദ്ദത്തിൽ മണ്ണിലെ ചരലിന്റെ അംശത്തിന് ജലാംശം കുറയ്ക്കാനുള്ള കഴിവുണ്ടെന്നു തെളിഞ്ഞു. ജൈവ കാർബൺ, മണ്ണിന്റെ രചന, ചരലിന്റെ അംശം എന്നിവയിൽ നിന്നും ഫീൽഡ് കപ്പാസിററി, വിൽററിംഗ് പോയിൻറ് എന്നിവ കണ്ടുപിടിക്കാനുള്ള സമവാക്യങ്ങൾ രൂപപ്പെടുത്തുകയുണ്ടായി.



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