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# Soil Physicochemical Properties as Influenced by Fertilisation of Green Manure Crops Grown during *RABI*

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**ABSTRACT: The quest for increasing food grain production for the ever-increasing population has led to the intensification of agriculture globally resulting in a decrease in soil organic matter leading to soil degradation, loss of soil biological fertility, and biodiversity. Soil health conservation could be done only by recycling plant nutrients and improving soil physicochemical and biological properties. Thus, an experiment was conducted in a strip plot design with seven green manure crops and two fertilization levels and replicated thrice at the College farm, College of Agriculture, Rajendra Nagar during *rabi*, 2020-21 to understand the influence of fertilization of green manure crops on the soil physicochemical properties. The soil physicochemical properties were analyzed before sowing of the crops, just before their incorporation and 40 days after their incorporation. Cultivation of green manures crops for a single season did not bring significant change in the physicochemical properties of the soil except for infiltration rate at the time of incorporation. Sunhemp sown plots registered higher infiltration rate (99 mm $h^{-1}$) at the time of incorporation. The lowest infiltration rate on the other side was noted in pillipesara (58 mm $hr^{-1}$) sown plots. But 40 days after *in situ* incorporation of the green manure crops, a significant change in the infiltration rate (126 mm $h^{-1}$) and organic carbon (0.80-0.83) was noted.**

**Keywords:** Green manure crops, physicochemical properties, infiltration rate and organic carbon.

## INTRODUCTION

Green manuring is a practice of turning into the soil un-decomposed green plant tissue. The benefits of green manuring are multifold. It increases soil organic matter, available nitrogen and reduces N losses through leaching and soil erosion. It concentrates nutrients near the soil surface in the available form (Sultani *et al*., 2007). Green manuring is the most important way to influence topsoil. The soil physical properties that are affected by the incorporation of the green manure include the structure, moisture retention capacity, consistency, and density. Other properties such as porosity, aeration, conductivity, hydraulics, and infiltration are allied to the modifications to the soil structure. Application of green manures can reduce soil erosion (Dapaah and Vyn, 1998), enhance soil nutrient-holding ability (Gaston *et al*., 2003), suppress weed reproduction (Burgos and Talbert, 1996), and reduce crop pest populations (Caswell *et al.*, 1991). Compared to chemical fertilizers, green manure provides more organic substrates and carbon resources for microbial growth, changes soil biomass (Esperschütz *et al*., 2007), and increases microbial activity and diversity (Jangid et al. 2008; van Diepeningen *et al*., 2006). In a series of experiments conducted by Goldhamer *et al*. (1994); Hargrove *et al*. (1989); Islam and Weil (2000); Min *et al.* (2003); Tester (1990); Werner (1977), it was concluded that the green manure crops like dhaincha influenced soil structural properties by enmesh of soil primary particles and micro aggregates into macro aggregation through direct- physicochemical action of roots and production of cementing agents from enhanced microbial activities leading to a reduction in the soil bulk density and increase in porosity with greater water retention and transmission capacities. Therefore, the physicochemical properties of the soil improve. It also influences the soil moisture and temperature dynamics (Sultani *et al*., 2007). The Green manuring and soil fertility transformation are considered synonymous with each other but the success of green manuring is largely dependent upon the quantity of biomass produced and later crops to be grown to exploit upon the elevated soil environment much to the benefit of the crops.

## MATERIAL AND METHODS

The study was conducted during *rabi*, 2020-21 at college farm, College of Agriculture, Rajendra Nagar,

Hyderabad. The experiment was laid out in a strip plot design and replicated thrice on a clay loam soil with seven green manure crops *viz*., green gram, black gram, horse gram, cowpea, sunhemp, dhaincha and pillipesara. The soil of the experimental site was alkaline in reaction with high organic matter and low soil available nitrogen and high soil available phosphorous and potassium. All the crops were sown in the first week of December. The mean weekly maximum temperature during the experiment ranged from 27.1° to 38.1° while the mean weekly minimum temperature ranged from 11.1° to 22.6°. The mean weekly relative humidity during the experiment at 0730 hrs and 1400 hrs fluctuated between 72.9 to 95.7 percent and 22.0 to 53.6 percent, respectively. A total rainfall of 2.3 mm was received during the experiment which did not account to a single rainy day. The mean sunshine hours extended from 5.9 to 14.8 hours day$^{-1}$. The evaporative demand of the atmosphere as reflected by pan evaporimeter (USWB Class A pan) during the crop growth varied from 2.7 to 7.0 mm day$^{-1}$. The wind speed stretched from 2.5 kmph to 5.3 kmph. Recommended dose of fertilizers and seed rate for respective green manure crops are mentioned in the Table 1.

**Table 1: Seed rate (kg ha$^{-1}$) and RDF for the green manure crops.**

| Green manure crops | N – $P_2O_5$ – $K_2O$ (kg ha$^{-1}$) | Seed rate (kg ha$^{-1}$) |
|---|---|---|
| **Greengram** | 20-40-0 | 30 |
| **Black Gram** | 25-50-0 | 20 |
| **Horsegram** | 25-40-20 | 25 |
| **Cowpea** | 25-40-20 | 25 |
| **Sunhemp** | 12.5–40-0 | 50 |
| **Dhaincha** | 0–30-0 | 50 |
| **Pillipesara** | 30-60-0 | 20 |

**Physicochemical properties of the soil of the experimental site.** The soil samples were collected at random from 30 cm depth and were examined for their physicochemical properties by following certain standard procedures. The results of the analysis are given out in Table 2.

**Table 2: Initial Physicochemical properties of the experimental soil.**

| Sr. No. | Particulars | Values | Method of analysis |
|---|---|---|---|
| **I** | **Physical properties** | | |
| | Particle size distribution | | |
| | Sand (%) | **29.9** | Bouyoucos hydrometer method (Piper, 1966) |
| | Silt (%) | **34.8** | |
| | Clay (%) | **35.30** | |
| | Textural class | **Clay loam** | |
| **II** | **Chemical properties** | | |
| | Soil reaction (pH) | **7.85** | Digital pH meter DI 707 (Jackson, 1973) |
| | Electrical conductivity (dS m$^{-1}$) | **0.98** | Digital EC meter (Jackson, 1973) |
| | Organic carbon (%) | **0.75** | Walkley and Black method (Jackson, 1967) |

The data on soil physicochemical properties indicated that the soil was clay loam in texture, highly alkaline (8.62) in reaction, high in organic carbon (0.75 %) whereas, the salt content in the soil was below the critical limit and optimal for the arable crop.

**Moisture holding properties of the experimental soil.** The moisture retention at field capacity (-0.03 MPa) and permanent wilting point (-1.5 MPa) and bulk density were estimated for 0-15 cm soil depth before the initiation of the experiment, at the time of incorporation of green manure crops and after 40 days of incorporation by adopting procedures of Dastane (1967) and Saxton and Rawls (2006). The data characterizing the soil moisture retention properties at the time of incorporation and 40 DAI are collected and analyzed. The soil samples for soil moisture estimation was collected at the time of incorporation and during decomposition at 10 days interval up to 40 DAI. The soil moisture content was estimated by gravimetric method by drying the soil samples in the oven at 105°C temperature until a constant weight of the sample was observed. From this, the soil moisture content is calculated as. The results of the analysis are given out in Table 3.

$$Soil\ moisture\ content\ (\%) = \frac{Weight\ of\ moist\ soil - Weight\ of\ oven\ dried\ soil}{Weight\ of\ oven\ dried\ soil}$$

**Table 3: Moisture retention characteristics of the soil at the experimental site.**

| Particulars | Moisture at | | Bulk density (g $cm^{-3}$) | Available soil moisture (mm) | Porosity (%) | Infiltration rate (mm $h^{-1}$) |
|---|---|---|---|---|---|---|
| | Field capacity at 0.33 bar (%) | Permanent wilting point at 15 bars (%) | | | | |
| Before the initiation of the experiment | 25.4 | 13.2 | 1.17 | 21.4 | 44.2 | 56 |

## RESULTS AND DISCUSSION

The soil physicochemical parameters were studied in the terms of soil pH, electrical conductivity, organic carbon content, bulk density, field capacity, permanent wilting point, available moisture, porosity, and infiltration rate. Cultivation of green manures crops for a single season did not bring significant change in the physicochemical properties of the soil except for infiltration rate. Considering the mean values, soil pH ranged from 7.57 to 7.66, EC from 0.92 to 1.04 dS $m^{-1}$, OC from 0.75 to 0.79 percent and bulk density from 1.07 to 1.15 g $cc^{-1}$. The parameters designating soil water status ranged as - field capacity from 25.6 to 28.0 percent, the permanent wilting point from 14.8 to 16.3 percent, and available soil moisture content from 18.55 to 18.93 percent at the time of incorporation. The soil physical characteristics characterizing water movement in the soil viz., porosity and infiltration rate ranged from 41.3 to 46.3 percent and 58 to 99 mm $h^{-1}$, respectively. Significant increase of infiltration rate (99.0 mm $h^{-1}$) in the sunhemp sown plots may be due to the mining by the extensive root system developed in the crop which can be confirmed from higher root dry weight at harvest. This was followed by cowpea and dhaincha with an infiltration rate of 87 mm $h^{-1}$. The lowest infiltration rate on the other side was noted in pillipesara (58 mm $hr^{-1}$) sown plots implying its poor root growth (Table 4).

The soil physicochemical parameters were analysed 40 DAI to study the impact of green manure residue incorporation as influenced by fertilisation. Soil pH, electrical conductivity, organic carbon content, bulk density, field capacity, permanent wilting point, available moisture, porosity, and infiltration rate were noted at 40 DAI. Incorporation of green manure residues for a single season did not bring significant change in the physicochemical properties of the soil except for soil organic carbon content and infiltration rate. However, considering the mean values all the physico chemical properties of the soil have been moderated favourably for crop growth. The soil pH after 40 DAI ranged from 7.39 to 7.49, EC from 0.82 to 0.87 dS $m^{-1}$, OC from 0.80 to 0.83, bulk density from 1.00 to 1.12 g $cc^{-1}$. The parameters designating soil water status ranged as - field capacity from 27.3 to 32.0 percent, the permanent wilting point from 15.4 to 20.6 percent, and available soil moisture content from 17.1 to 20.1 percent at 40 DAI. The soil physical parameters characterizing water movement in the soil *viz*., porosity and infiltration rate ranged from 45.4 to 49.1 percent and 80 to 126 mm $h^{-1}$, respectively. A significant increase of infiltration rate in the sunhemp sown plots (126 mm $h^{-1}$) was noted due to the moderated soil physicochemical properties *viz*., reduced bulk density and increased porosity. This was followed by dhaincha, cowpea with an infiltration rate of 117 mm $h^{-1}$. The lowest infiltration rate on the other side was noted in pillipesara sown plots (80 mm $h^{-1}$) implying its poor root growth (Table 5).

**Table 4: Soil physicochemical properties at the time of green manure crops incorporation.**

| Treatment | pH | EC (dS $m^{-1}$) | OC (%) | Bulk density (g $cc^{-1}$) | Field capacity (%) | PWP (%) | ASM (mm) | Porosity (%) | Infiltration rate (mm $h^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| **Vertical strip (Green manure crops): A** | | | | | | | | | |
| **$M_1$:** Green gram | 7.57 | 1.04 | 0.75 | 1.12 | 26.3 | 15.2 | 18.70 | 45.1 | 69.0 |
| **$M_2$:** Black gram | 7.60 | 0.97 | 0.76 | 1.13 | 25.9 | 15.0 | 18.68 | 44.1 | 61.5 |
| **$M_3$:** Horse gram | 7.63 | 0.92 | 0.77 | 1.14 | 25.8 | 14.9 | 18.65 | 42.0 | 60.5 |
| **$M_4$:** Cowpea | 7.64 | 0.99 | 0.79 | 1.10 | 27.1 | 15.8 | 18.80 | 46.2 | 87.0 |
| **$M_5$:** Sunhemp | 7.66 | 0.98 | 0.78 | 1.07 | 28.0 | 16.3 | 18.93 | 46.3 | 99.0 |
| **$M_6$:** Dhaincha | 7.64 | 0.96 | 0.76 | 1.11 | 26.7 | 15.4 | 18.75 | 44.4 | 87.0 |
| **$M_7$:** Pillipesara | 7.63 | 0.95 | 0.75 | 1.15 | 25.6 | 14.8 | 18.55 | 41.3 | 58.0 |
| **SEm±** | **0.14** | **0.04** | **0.030** | **0.04** | **0.54** | **0.65** | **0.20** | **1.47** | **1.60** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **3.49** |
| **Horizontal strip (Fertilisation): B** | | | | | | | | | |
| **$S_1$**-Fertilised | 7.56 | 0.94 | 0.72 | 1.11 | 26.7 | 15.4 | 18.7 | 44.8 | 77.1 |
| **$S_2$**-Unfertilised | 7.69 | 1.00 | 0.80 | 1.12 | 26.4 | 15.2 | 18.8 | 43.5 | 72.0 |
| **SEm±** | **0.13** | **0.03** | **0.034** | **0.01** | **0.28** | **0.19** | **0.05** | **1.09** | **0.50** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **2.13** |
| **Interaction (A ×B) at same vertical strip** | | | | | | | | | |
| **SEm±** | **0.15** | **0.04** | **0.06** | **0.03** | **0.97** | **0.62** | **0.06** | **2.00** | **0.94** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **Interaction (A × B) at different horizontal strips** | | | | | | | | | |
| **SEm±** | **0.64** | **0.11** | **0.20** | **4.34** | **2.34** | **1.56** | **0.13** | **4.82** | **0.02** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

**Table 5: Soil physicochemical properties at 40 days after incorporation of green manure crops.**

| Treatment | pH | EC (dS $m^{-1}$) | OC (%) | Bulk density (g $cc^{-1}$) | Field capacity (%) | PWP (%) | ASM (mm) | Porosity (%) | Infiltration rate (mm $h^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| **Vertical strip (Green manure crops): A** | | | | | | | | | |
| **$M_1$:** Green gram | 7.39 | 0.85 | 0.80 | 1.07 | 29.3 | 16.9 | 19.6 | 47.6 | 92.0 |
| **$M_2$:** Black gram | 7.42 | 0.85 | 0.81 | 1.08 | 28.6 | 16.3 | 19.4 | 46.8 | 83.0 |
| **$M_3$:** Horse gram | 7.45 | 0.82 | 0.82 | 1.09 | 28.2 | 16.2 | 19.1 | 46.1 | 83.0 |
| **$M_4$:** Cowpea | 7.46 | 0.87 | 0.83 | 1.04 | 30.2 | 18.0 | 19.9 | 48.3 | 117 |
| **$M_5$:** Sunhemp | 7.48 | 0.87 | 0.82 | 1.00 | 32.0 | 20.6 | 20.1 | 49.1 | 126 |
| **$M_6$:** Dhaincha | 7.46 | 0.84 | 0.81 | 1.06 | 29.3 | 17.1 | 19.7 | 48.4 | 117 |
| **$M_7$:** Pillipesara | 7.49 | 0.84 | 0.80 | 1.12 | 27.3 | 15.4 | 17.1 | 45.4 | 80.0 |
| **SEm±** | **0.14** | **0.01** | **0.06** | **0.06** | **1.50** | **2.65** | **1.50** | **1.29** | **2.24** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **4.87** |
| **Horizontal strip (Fertilisation): B** | | | | | | | | | |
| **$S_1$-** Fertilised | 7.39 | 0.84 | 0.71 | 1.05 | 30.3 | 17.9 | 19.5 | 49.7 | 103 |
| **$S_2$-**Unfertilised | 7.51 | 0.86 | 0.91 | 1.08 | 28.2 | 16.5 | 19.0 | 45.0 | 96.3 |
| **SEm±** | **0.11** | **0.01** | **0.09** | **0.02** | **0.86** | **0.47** | **0.26** | **1.58** | **1.14** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **3.50** |
| **Interaction (A × B) at same vertical strip** | | | | | | | | | |
| **SEm±** | **0.15** | **0.03** | **0.08** | **0.01** | **1.44** | **1.00** | **1.32** | **1.82** | **1.86** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **Interaction (A × B) at different horizontal strips** | | | | | | | | | |
| **SEm±** | **0.64** | **0.07** | **0.15** | **0.03** | **2.45** | **1.96** | **2.91** | **2.56** | **0.03** |
| **CD (P= 0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

## CONCLUSION

Cultivation of green manures crops for a single season did not bring significant change in the physicochemical properties of the soil except for infiltration rate at the time of incorporation. The application of green manures to the soil produced an improvement in the soil physicochemical properties though non significantly but brought about a significant change in the infiltration rate and organic carbon content 40 days after incorporation.

## FUTURE SCOPE

Green manures can be used as mulch which in turn regulates soil temperature, moisture and weed growth. The green manure crops can be used to reclaim alkaline soils, improve the availability of several critical nutrients, improve nitrogen usage efficiency, soil health and quality, and crop yield. Rice fallows, unoccupied degraded lands, and watershed areas must all be encouraged to grow them. Farmers must be persuaded and encouraged to plant green manure crops for in-situ integration due to several benefits. The ongoing rural job guarantee programmes can be used to encourage the cultivation of green manures.

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