EFFECT OF ORGANIC BASED NUTRIENTS ON PHYSICAL, CHEMICAL AND BIOLOGICAL PROPERTIES IN THREE TYPES OF SOILS OF MULBERRY GARDENS

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ABSTRACT

Field trials were conducted to know the effect of organic based nutrients on physical, chemical and biological properties in three types of soils (sandy clay loam, clay and red loamy) in established mulberry (V-1) gardens of Challakere, Hiriyur and Molakalmur taluks of Chitradurga district of Karnataka state, respectively during monsoon, winter and summer seasons of 2013-14 and 2014-15. The physical, chemical and biological properties of soils of mulberry garden were statistically analyzed at $p \leq 0.05$ and $p \leq 0.01$. The results of the current study revealed that, the soil texture (sand, silt and clay) did not show variation when organic based nutrients are applied to three types of soils in three locations of Chitradurga district of Karnataka during three seasons of experimentation. Low bulk density with high water holding capacity were recorded in mulberry plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+ 200N+ 110P+ 140K) (T_6) in clay soil (Hiriyur) during winter. Low pH with high electrical conductivity and more available organic carbon content were recorded in soils of mulberry garden that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+ 200N+ 110P+140K) (T_6) in red loamy soil (Molakalmur) during summer. Available nitrogen, phosphorous and potassium were low in soils of mulberry garden that were supplied with vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+ 200N+ 110P+140K) (T_6) in clay soil (Hiriyur) during monsoon and these were high in recommended FYM (20 MT/ha/yr) + 350N+ 140P+140K kg/ha/yr (control-T_0). Microbial biomass carbon and dehydrogenase activity in soils of mulberry garden were higher in the mulberry plot which received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+ 200N+110P+140K) (T_6) in red loamy soil (Molakalmur) during monsoon. Combined application of Vermicompost and FYM enhanced the microbial biomass and enzyme activities.

Key words: Mulberry, organic based nutrients, seasons, soil types, soil properties.

INTRODUCTION

The mulberry leaf yield and quality depends on the soil type, varieties and available plant nutrients in soil, agronomical practices and agro-climatic conditions. Hence, native soil fertility alone cannot be relied upon for quantity and quality of mulberry leaf productivity, unless the soil is replenished with external sources through manures and fertilizers. Therefore, package of practices for application of manures and fertilizer schedule plays a vital role for obtaining higher leaf yield wirh quality (Anonymous, 2002). The organic farming systems are guided by the philosophy "feed the soil to feed the plant". Addition of organic materials such as green manures, oil cakes, compost and biofertilizers to cultivated soils build-up organic matter content in soil. As soil organic matter increases, the ability of soil to supply nutrients to plant also increases. Therefore, the ultimate goal is to obtain healthy, fertile, biologically active soil with improved structure and enhanced nutrient availability to plants (Singh *et al*., 2006).

Use of chemicals not only disturb the soil structure but also affects the population of beneficial soil microorganisms which, inturn, alter the soil health apart from reducing the productivity potential of soil. The intensive use of chemical inputs in agriculture has not only polluted the soil, water and environment but also affected the human being. The available farm residues and other wastes are to be properly utilized for making nutrient rich organic manure (Babu and Dandin, 2009).

Soil organic matter status appears to be the function of climate and soil management. It improves water holding capacity of light textured soils, makes the soil more fragile, easier to work, more porous, permit better aeration and also reduces encrustation, thus facilitating better establishment of plant.. Organic matter adsorps calcium, magnesium and potassium on its colloidal surfaces and releases them gradually through cation exchange. Maintenance of optimum amount of organic matter in soils is necessary for sustenance of productivity in all crop systems (Patnaik, 1997). According to Masilamani *et al*. (2007), application of organic manures to soil improves the physico-chemical properties of soil, besides serves as a store house of nutrients.

Some beneficial microorganisms are capable of fixing nitrogen and solubilizing P to promote soil fertility and plant growth. Application of biofertilizer (*Azospirillum*) stimulates mulberry

growth, increases the number, length and weight of roots and enhances the number of leaves and leaf weight besides bud development. Further, enhancement in the population of PSB/fungi and VAM make P available to mulberry plants when inoculated. Besides, VAM increases root length and improve photosynthesis (Jayaraj *et al*., 2006).

According to Mahesh (2014), among soil properties, lowest bulk density (1.45 g/cc), maximum water holding capacity (35.79 %), ideal soil pH (7.95), lowest electrical conductivity (0.24 dS/m), highest organic carbon (0.71%), available nitrogen (283.42 kg/ha), phosphorus (49.85 kg/ha) and potassium (186.14 kg/ha) were recorded in V_1 mulberry garden treated with 5.88 tonnes of vermicompost/ha/year + recommended N, P & K @ 350: 140: 140 kg/ha/year through chemical fertilizers over control. Mary *et al*. (2015) reported that irrigated mulberry plots supplied with vermicompost had a significant role in enhancing the soil fertility in terms of macro and secondary nutrients and microbial population. Further, the microbial population in soil helps in improving the health of soil.

Organic farming is an eco-friendly approach and has been realized to a greater extent in the mulberry production using organic manures, green manures, dual-purpose legumes, non-edible oilcakes and vermicompost. Due to large scale harvest of foliage, mulberry is responsible for rapid nutrient mining from soil reserves, yield as well as quality of leaf and eventually the cocoon yield are equally important for economic viability. Hence, production and use of various organic manures should be improved, not only for enhancing the crop productivity but, also reducing cost of cultivation to protect environment and avoid pest and disease outbreaks (Jayaraj *et al*., 2006). As far as possible, it would be better to maximize the use of naturally available organic resources and minimize the application of chemical fertilizers so that good soil health and physico-chemical properties of soils are ensured. In the backdrop of above, the current investigation has been undertaken to know the effect of organic based nutrients on physical, chemical and biological properties of soil.

MATERIALS AND METHODS

Field experiments were conducted in three farmers' fields of Challakere, Hiriyur and Molakalmur taluks of Chitradurga district, Karnataka, consisting three types of soils *viz.,* sandy clay loam, clay and red loamy, respectively during the years 2013-14 and 2014-15 for three seasons *viz.,* monsoon (June-September), winter (October-January) and summer (February-May) in order to know the effect of physical, chemical and biological properties of soils of established mulberry garden raised through the application of organic based nutrients

(FYM, compost, vermicompost, sheep manure and biofertilizers) in established irrigated mulberry (V_1) with a spacing of (150 + 90 cm) x 60 cm. The experimental plots were situated in the Central Dry Zone (Zone-IV) of Karnataka and lies between 13° 34' to 15° 02' North latitude and 75° 37' to 77° 01'East longitude and having temperature of 37°C (Max.) and 15°C (Min.). The experiments were laid out in Randomized Block Design consisting of eight treatments with three replications. Treatments were imposed to irrigated mulberry gardens based on the recommended FYM @ 20 MT/ha/yr. However, compost, vermicompost and sheep manures were applied based on the recommended quantity of FYM (MT/ha/yr). The N biofertilizers (*Azospirillum brasilense*) (@ 23 kg/ha/yr) and P biofertilizer (*Aspergillus awamori*) (@ 5 kg/ha/yr) and chemical fertilizers (NPK) were applied in kg/ha/yr. The cultivation practices were followed as per the recommended package developed for mulberry cultivation under irrigated condition (Dandin and Giridhar, 2010).

The experiments were conducted in established irrigated V_1 mulberry gardens with spacing of (150 + 90 cm) x 60 cm, gross plot size of 5 x 5 m and net plot size of 4.2 x 4.2 m and organic based nutrients (FYM, compost, vermicompost, sheep manure and biofertilizers) were applied to the mulberry gardens in order to record the growth, yield and quality parameters of mulberry. The experiments were laid out in Randomized Block Design consisting of eight treatments with three replications. The treatment details are as follows:

Treatments

T_0 Recommended FYM (20MT/ha/yr)+350N+140P+140K kg/ha/yr (Control)

T_1 Rec. FYM+N-biofertilizer+P-biofertilizer+200N+110P+140K

T_2 Compost (Equivalent to 50 % of Rec. FYM)+FYM (50% of Rec. FYM) + 350N+140P+140K

T_3 Vermicompost (Equivalent to 50 % of Rec. FYM) + FYM (50 % of Rec. FYM) + 350N+140P+140K

T_4 Sheep manure (Equivalent to 50 % of Rec. FYM) + FYM (50 % of Rec. FYM) +350N+140P+140K

T_5 Compost (Equivalent to 50 % of Rec. FYM)+FYM(50% of Rec. FYM)+N-biofertilizer+P-biofertilizer +200N+110P+140K

T_6 Vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K

T_7 Sheep manure (Equivalent to 50% of Rec. FYM) +FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+200N+110P+140K

The soils of the experimental plots were drawn from a depth of 0 to 45cm before imposing the treatments and during the experimentation in monsoon (June-September), winter (October-January) and summer seasons (February-May) for two years. The soils were analyzed for physical and chemical properties as well as biological activity following the standard procedures.

Physical properties of soil	
Mechanical analysis (Sand, Silt and Clay) (%)	Piper (1966)
Bulk density (g/cc)	Core sampler method by Black (1965)
Maximum water holding capacity (%)	Keen-Raczkowaski cup method by Piper (1966)
Chemical properties of soil	
pH, electrical conductivity (ds/m), available organic carbon (%), available nitrogen (kg/ha), available phosphorus (kg/ha) and available potassium (kg/ha)	Jackson (1973)
Biological properties of soil	
Microbial biomass carbon (MBC) and Dehydrogenase activity (microbial activity)	Jenkinson and Ladd (1981) and Casida *et al.* (1964)

Statistical analysis of the data

The data obtained in the current investigation was subjected to three-way analysis of variance ($p \leq 0.05$ and $p \leq 0.01$) (Sundarraj *et al.*, 1972) through SPSS for Windows version 21.0.

RESULTS AND DISCUSSION

Physical properties of soil

Sand

Proportion of sand did not differ significantly due to the application of different organic based nutrients to mulberry gardens. Among three types of soils (locations), proportion of sand was significantly higher in sandy clay loam soil (Challakere) (54.38%) as compared to red loamy soil (Molakalmur) (34.75%) and clay soil (Hiriyur) (10.10%). Among seasons, proportion of sand was significantly more during winter (35.67%) compared to summer (32.22%) and monsoon (31.36%). In the interaction of treatments x locations, proportion of sand did not differ significantly. However, in the interaction of treatments x seasons, the proportion of sand was significantly less in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K (T_6) during monsoon (29.17%), while, it was more in

recommended FYM (20MT/ha/yr)+350N+140P+140K kg/ha/yr (control-T_0) during winter (38.67%). Similarly, in locations x seasons, proportion of sand showed significantly more in sandy clay loam soil (Challakere) during winter (54.82%), while it was less in clay soil (Hiriyur) during monsoon (6.691%). However, the interaction of treatments x locations x seasons did not show significant difference (Table 1).

Silt

Proportion of silt did not vary significantly due to the application of different organic based nutrients to mulberry gardens. Among three types of soils (locations), proportion of silt was significantly more in red loamy soil (Molakalmur) (42.22%) compared to clay soil (Hiriyur) (29.14%) and sandy clay loam soil (Challakere) (18.78%). Among three seasons, proportion of silt was significantly high during summer (30.85%) compared to monsoon (30.31%) and winter (28.98%). In the interaction of treatments x locations, proportion of silt did not show significant variation, while in treatments x seasons, the proportion of silt was significantly more in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K (T_6) during summer (32.08%), while it was less during monsoon (29.14%). Similarly, in the interaction of locations x seasons, the proportion of silt was significantly higher in red loamy soil (Molakalmur) during summer (42.40%). Further, the interaction of treatments x locations x seasons did not yield significant results (Table 2).

Clay

Proportion of clay did not differ significantly due to the application of different organic based nutrients to soils of mulberry gardens. Among three types of soils (locations), proportion of clay was significantly high in clay soil (Hiriyur) (60.75%) compared to sandy clay loam soil (Challakere) (26.84%) and red loamy soil (Molakalmur) (23.03%), whereas in seasons, proportion of clay was significantly more during monsoon (38.33%) followed by summer (36.94%) and winter (35.35%). In the interaction of treatments x locations, proportion of clay did not show significant result, while, in the interaction of treatments x seasons, the proportion of clay was significantly high in plot received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K (T_6) during summer (39.70%) and it was low in T_0 during winter (33.54%). Similarly, in locations x seasons, the proportion of clay increased

significantly in clay soil (Hiriyur) during monsoon (62.82%), however, it was less in red loamy soil (Molakalmur) during summer (22.43%). Further, in the interaction of treatments x locations x seasons, the proportion of clay did not show significant difference (Table 3).

Bulk density

Bulk density of the soil did not differ significantly due to the application of different organic based nutrients to mulberry. Among three types of soils (locations) bulk density was significantly low in clay soil (Hiriyur) (1.163 g/cc) as compared to red loamy soil (Molakalmur) (1.224 g/cc) and sandy clay loam soil (Challakere) (1.305 g/cc). Bulk density did not vary significantly among three seasons. In the interaction of treatments x locations, treatments x seasons and locations x seasons, the bulk density did not show significant results. However, in the interaction of treatments x locations x seasons, bulk density was significantly low in the treatment that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer + 200N + 110P + 140K (T_6) in clay soil (Hiriyur) (1.120 g/cc) during summer (Table 4).

Maximum water holding capacity

Maximum water holding capacity of the soil in mulberry gardens differed significantly due to the application of different types of organic based nutrients. Maximum water holding capacity was noticed in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K (T_6) (52.90%) followed by sheep manure (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+ 110P+ 140K (T_7) (52.12%) and it was less in plot that received recommended FYM (20MT/ha/yr)+ 350N+ 140P+ 140K kg/ha/yr (control-T_0)(48.22%). Among three types of soils (locations), significantly maximum water holding capacity was found in clay soil (Hiriyur) (63.77%) and it was low in sandy clay loam soil (Challakere) (37.05%). Maximum water holding capacity did not show significant variation in seasons, interaction of treatments x locations, treatments x seasons, treatments x locations x seasons. However, in the interaction of locations x seasons, significantly maximum water holding capacity was recorded in clay soil (Hiriyur) (64.33%) during monsoon, while it was minimum in sandy clay loam soil (Challakere) during summer (36.53%) (Table 5).

As soil texture is the inherent property of the soil which cannot be changed suddenly due to the application of organic based nutrients/residues. Furthermore, organic matter will be

destroyed while determining the texture of soil; hence not much variation existed in soil texture. Sarkar *et al*. (2003) reported that the application of organic manures increased organic carbon, aggregate stability and moisture retention capacity and infiltration rate of the surface soil by reducing the bulk density. The current results are in conformity with the findings of Jayaraj *et al*. (2006); Easwaran *et al.* (2003); Senapati *et al*. (2005) and Manjunatha *et al*. (2006), who are of the opinion that vermicompost is known to influence physical, chemical and biological properties of soil which support the growth of plants. Masilamani *et al*. (2007) who observed that the application of organic manures to soil improves the physico-chemical properties, besides serves as a store house of nutrients. Organic matter not only improves bulk density, water holding capacity, porosity, aggregate stability and biological activity of the soil but also serves as a reservoir for organic acids and plant nutrients such as nitrogen.

Chemical properties of soil

pH

The pH in soil of mulberry gardens was significantly lower in sandy clay loam soil (Challakere) and clay soil (Hiriyur) due to the application of different organic based nutrients, but it was higher in red loamy soil (Molakalmur) as compared to initial status. Among different organic based nutrients, pH was significantly low (7.89) in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+110P+140K (T_6). Among three types of soils (locations), pH was significantly low in red loamy soil (Molakalmur) (7.85) compared to sandy clay loam soil (Challakere) (8.03) and clay soil (Hiriyur) (8.29). Further, among three seasons, pH was significantly low in summer (7.94) as compared to winter (7.98) and monsoon (8.25). In the interaction of treatments x locations, treatments x seasons and treatments x locations x seasons, pH did not differ significantly. However, in the interaction of locations x seasons, pH was significantly less in red loamy soil (Molakalmur) (7.76) during monsoon and it was higher in clay soil (Hiriyur) (8.64) during monsoon (Table 6).

Electrical conductivity

Electrical conductivity (EC) in soil of mulberry gardens varied significantly due to the application of different organic based nutrients. Among different treatments, EC was significantly high in plot that received vermicompost (Equivalent to 50 % of Rec. FYM)

+FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+ 110P+ 140K (T_6) (0.316dS/m). Among three types of soils (locations), EC was significantly high in sandy clay loam soil (Challakare) (0.295dS/m) compared to red loamy soil (Molakalmur) (0.289dS/m) and clay soil (Hiriyur) (0.223dS/m). Among the seasons, EC was significantly higher in summer (0.289dS/m) as compared to winter (0.265dS/m) and monsoon (0.253dS/m). The interaction of treatments x seasons did not register significant difference for EC. In the interaction of treatments x locations, EC was significantly higher (0.372dS/m) in T_6 with sandy clay loam soil (Challakare) and it was lower (0.205 dS/m) in T_0 with clay (Hiriyur). In the interaction of locations x seasons, EC was significantly higher (0.306 dS/m) in sandy clay loam soil (Challakere) during summer and it was lower (0.189dS/m) in clay (Hiriyur) during monsoon. However, in the interaction of treatments x locations x seasons, EC was significantly maximum in T_6 with sandy clay loam soil (Challakare) during summer (0.406dS/m) and it was minimum in T_0 with clay soil (Hiriyur) during monsoon (0.160 dS/m) (Table 7).

Available organic carbon

Available organic carbon (OC) content in soil of mulberry gardens increased significantly due to the application of different organic based nutrients. Among the treatments, maximum available OC (0.903%)was recorded in T_6which received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+ 110P+140K (T_6) followed by sheep manure (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+200N+ 110P+ 140K (T_7) (0.848 %). Among three types of soils (locations), available OC was significantly higher (0.874 %) in red loamy soil (Molakalmur) compared to sandy clay loam soil (Challakere) (0.817%) and clay soil (Hiriyur) (0.636%). Among the seasons, available OC was significantly high in summer (0.815%) as compared to winter (0.765%) and monsoon (0.748%). In the interactions of treatments x locations and locations x seasons, available OC was significantly high in T_6 with red loamy soil (Molakalmur) (0.976%), whereas in the interaction of locations x seasons, available OC was significantly more (0.894%) in red loamy soil (Molakalmur) during summer. However, available OC did not show significant variation in the interaction of treatments x seasons and treatments x locations x seasons (Table 8).

Available nitrogen

Available nitrogen in soils of mulberry garden varied due to the application of different organic based nutrients. Among the treatments, the available nitrogen was significantly low inplot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+110P+140K (T_6) (338.8 kg/ha) followed by sheep manure (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+110P+140K (T_7) (339.1 kg/ha) and it was more in recommended FYM (20MT/ha/yr)+350N+140P+140K kg/ha/yr (control-T_0) (424.2 kg/ha). Among three types of soils (locations), available nitrogen was significantly more (417.8 kg/ha) in red loamy soil (Molakalmur) compared to sandy clay loam soil (Challakere) (404.6 kg/ha) and clay soil (Hiriyur) (302.4 kg/ha). Among the seasons, available nitrogen was significantly high in summer (398.2 kg/ha) as compared to winter (365.5 kg/ha) and monsoon (361.3 kg/ha). In the interaction of treatments x seasons, available nitrogen was significantly low in T_6 during monsoon (313.9 kg/ha), whereas, in the interaction of locations x seasons, available nitrogen was significantly high in red loamy soil (Molakalmur) during summer (438.3 kg/ha). However, in the interaction of treatments x locations x seasons, available nitrogen was significantly less (222.9 kg/ha) in T_6 with sandy clay loam soil (Challakere) during monsoon and it was more in T_0 with red loamy soil (Molakalmur) during summer (475.2 kg/ha) (Table 9).

Available phosphorus

Available phosphorus in soils of mulberry garden did not vary significantly due to the application of different organic based nutrients. Among three types of soils (locations), available phosphorus was significantly more in sandy clay loam soil (Challakare) (31.92 kg/ha) compared to red loamy soil (Molakalmur) (30.09 kg/ha) and clay soil (Hiriyur) (10.52 kg/ha). Among the seasons, available phosphorus was significantly maximum in summer (29.60 kg/ha) as compared to winter (21.97 kg/ha) and monsoon (20.95 kg/ha). In the interaction of treatments x locations, T_6 recorded significantly less in sandy clay loam soil (Challakare) (34.00 kg/ha), in treatments x seasons, T_6 registered significantly less in monsoon (19.36 kg/ha), in locations x seasons, it was found significantly higher (44.42 kg/ha)in red loamy soil (Molakalmur) during summer. In treatments x locations x seasons, it was significantly more in T_0 with red loamy soil (Molakalmur) during summer (62.09 kg/ha), but it was less in T_6 in clay soil (Hiriyur) during monsoon (8.902 kg/ha) (Table 10).

Available potassium

Available potassium in soils of mulberry garden did not differ significantly due to the application of organic based nutrients. However, available potassium content decreased due to different treatments among different locations as compared to initial status. Among three type of soils (locations), available potassium was significantly higher in red loamy soil (Molakalmur) (191.4 kg/ha) compared to sandy clay loam soil (Challakare) (186.9 kg/ha) and clay soil (Hiriyur) (162.7 kg/ha). Among the seasons, available potassium content was significantly more in winter (187.9 kg/ha) as compared to summer (176.8 kg/ha) and monsoon (176.4 kg/ha). The interaction of treatments x locations and treatments x seasons did not show variation. However, locations x seasons, it was significantly more in red loamy soil (Molakalmur) during winter (208.4 kg/ha), whereas, in treatments x locations x seasons, it was significantly more in T_0 in red loamy soil (Molakalmur) during winter (246.5 kg/ha) and it was less in T_6 with clay soil (Hiriyur) during monsoon (120.3 kg/ha) (Table 11).

As per Setua *et al.* (2003), there was an improvement in available NPK in soils of mulberry garden even after two years of inoculation of soil with biofertilizers. Alemu and Bayu (2005) reported that the application of FYM (10 and 15 t/ha) for four years enhanced the total N, OC, available P, K and Mg in soil as against the plot that received less FYM to the soil depth of 0-20 cm. Similarly, Sori *et al*. (2008) who observed that the mulberry garden treated with bio-inoculants of *Azotobacter* 20 kg/ha) + *A. awamori* (25 kg/ha) + *T. harzianum* (20 kg/ha)+ 75 % recommended N and P each through chemical fertilizers with recommended dose of FYM and K registered more availability of NPK in soil. The current results are in line with the earlier works of Bhogesha *et al*. (2006); Bhaskar *et al.* (2006); Venugopal *et al*. (2008) and Naika (2008). The current results are also in conformity with the work of Mary *et al*. (2015), who observed that irrigated mulberry plots supplied with vermicompost had a significant role in enhancing the soil fertility in terms of macro and secondary nutrients and microbial population. Mallappa *et al*. (2016) also reported that the application of FYM (20 t/ha) + recommended dose of NPK through integrated nutrient management practices recorded significantly higher available nutrients (NPK) in the soil after harvest of mulberry leaf.

Microbial biomass carbon

Microbial biomass carbon in soil of mulberry gardens significantly differs due to the application of different organic based nutrients. Among the treatments, the microbial biomass carbon was maximum (481.5 mg/kg of soil) in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+110P+140K (T_6). Among three types of soils, (locations), microbial biomass carbon was significantly more (451.0 mg/kg of soil) in red loamy soil (Molakalmur) compared to sandy clay loam soil (Challakare) (419.2mg/kg of soil) and clay soil (Hiriyur) (380.7 mg/kg of soil). Among the seasons, microbial biomass carbon was significantly maximumin monsoon (489.5 mg/kg of soil) as compared to winter (403.6 mg/kg of soil) and summer (357.7 mg/kg of soil). In the interaction of treatments x locations, it was significantly more in T_6 with red loamysoil (Molakalmur) (522.1 mg/kg of soil). In treatments x seasons, microbial biomass carbon did not differ significantly. However, in locations x seasons, it was significantly higher in red loamy soil (Molakalmur) during monsoon (546.4 mg/kg of soil) and in treatments x locations x seasons, it was significantly higher in $T_6$with red loamy soil (Molakalmur) during monsoon (618.5 mg/kg of soil). However, it was less in T_0 with clay soil (Hiriyur) during summer (256.0 mg/kg of soil) (Table 12).

Dehydrogenase activity

Dehydrogenase activity in soils of mulberry gardens varied significantly due to the application of different organic based nutrients. Among the treatments, the dehydrogenase activity was significantly maximum in plot that received vermicompost (Equivalent to 50 % of Rec. FYM) +FYM (50 % of Rec. FYM) +N-biofertilizer+P-biofertilizer+ 200N+110P+140K (T_6) (4.631 µg/TPF/g/ha), but it was minmum in recommended FYM (20MT/ha/yr)+350N+140 P+140K kg/ha/yr (control-T_0) (2.435 µg/TPF/g/ha). Among threetypes of soils (locations), dehydrogenase activity was significantly more (3.737 µg/TPF/g/ha) in red loamy soil (Molakalmur) as compared tosandy clay loam soil (Challakare) (3.369 µg/TPF/g/ha) and clay soil (Hiriyur) (3.361 µg/TPF/g/ha). Among seasons, it was significantly more in monsoon (3.800 µg/TPF/g/ha) as compared to winter (3.423 µg/TPF/g/ha) and summer (3.244 µg/TPF/g/ha). In the interaction of treatments x locations, dehydrogenase activity was higher in T_6 with red loamy (Molakalmur) (4.974 µg/TPF/g/ha). In treatments x seasons, it was significantly more in T_6 during monsoon (4.960 µg/TPF/g/ha). Further, in locations x seasons, it was significantly maximum in red loamy soil

(Molakalmur) during monsoon (4.096 µg/TPF/g/ha). In the interaction of treatments x locations x seasons, it was highest in T_6in red loamy soil (Molakalmur) during monsoon (5.538 µg/TPF/g/ha), whereas it was lowest in T_0 in clay (Hiriyur) during summer (2.185 µg/TPF/g/ha) (Table 13).

These results are in conformity with the earlier findings of Rao *et. al* (2011), who observed that the microbial biomass carbon and enzyme activities were increased due to the combined effect of organic and inorganic nutrients and combined application of vermicompost and FYM. Chandrakumar *et al*. (2008) reported that the organic based treatments [vermicompost + biofertilizer (Silica solubilizing bacteria, *Azotobacter* and *Arbuscular mycorrhiza* fungi) + Neemcake] increases bacterial and fungal populations in soil compared to inorganic fertilizers (NPK) applied plots and control. According to Venugopal *et al*. (2008), mulberry plots supplied with green manuring + *Azospirillum* and PSB mixed with FYM + neem cake significantly increased bacterial, fungal and actinomycetes population, organic carbon, available nitrogen, phosphorus and potassium contents in the soil by reducing soil alkalinity and results in enhancement of leaf yield. Mary *et al*. (2015) reported that application of vermicompost to irrigated mulberry plots had a significant role in enhancing the microbial population in soil thus helps in improving the health of soil.

CONCLUSION

The mulberry gardens (V_1) supplied with vermicompost (Equivalent to 50 % of Rec. FYM)+FYM (50 % of Rec. FYM)+N-biofertilizer+P-biofertilizer+200N+110P+140K found better in improving soil health along with physical and chemical properties of soil during winter season.

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Table 1: Proportion of sand (%) in soil of mulberry gardens as influenced by the application of organic based nutrientsto three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	34.32	**L1**	54.38	**S1**	31.36	**T0**	56.22	10.05	36.68	**T0**	29.87	38.67	35.12	**L1**	53.55	54.82	54.77	**T0**	51.70	58.34	58.62	5.517	17.51	7.133	30.28	40.16	39.60
T1	33.87	**L2**	10.10	**S2**	35.67	**T1**	55.62	10.04	35.97	**T1**	29.96	37.58	34.08	**L2**	6.691	16.64	6.984	**T1**	52.31	57.11	57.43	5.933	17.27	6.913	31.63	38.36	37.90
T2	33.15	**L3**	34.75	**S3**	32.22	**T2**	54.34	9.967	35.16	**T2**	30.37	36.30	32.79	**L3**	33.53	35.55	35.19	**T2**	52.73	55.15	55.13	6.417	16.75	6.733	31.97	37.00	36.50
T3	33.36					**T3**	54.05	11.06	34.97	**T3**	32.07	35.70	32.31					**T3**	53.29	54.49	54.35	10.26	16.35	6.583	32.67	36.26	35.98
T4	32.54					**T4**	53.72	9.908	33.72	**T4**	31.20	34.83	31.59					**T4**	53.10	54.54	54.35	6.150	16.71	6.867	34.35	33.26	33.55
T5	32.62					**T5**	54.00	9.921	34.43	**T5**	31.40	35.13	31.33					**T5**	53.70	53.80	53.05	6.517	16.60	6.650	33.98	35.00	34.30
T6	32.35					**T6**	53.52	9.940	33.72	**T6**	29.17	33.94	33.44					**T6**	56.53	52.23	52.00	7.750	15.82	6.250	37.55	32.26	31.35
T7	32.42					**T7**	53.59	9.944	33.40	**T7**	32.73	33.67	30.65					**T7**	55.04	52.86	53.25	7.333	16.10	6.400	35.83	32.06	32.30
F-value	0.468^{NS}		8643**		11.63**		0.716^{NS}				5.626**				37.93**				0.570^{NS}									

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 2: Proportion of silt (%) in soil of mulberry gardens as influenced by the application of organic based nutrientsto three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	29.46	**L1**	18.78	**S1**	30.31	**T0**	18.40	29.03	40.94	**T0**	31.13	27.79	29.44	**L1**	18.35	18.99	19.00	**T0**	19.48	18.03	17.70	30.70	25.85	30.53	43.23	39.50	40.10
T1	29.67	**L2**	29.14	**S2**	28.98	**T1**	18.32	28.99	41.71	**T1**	30.86	28.20	29.96	**L2**	30.19	26.08	31.16	**T1**	19.02	18.04	17.90	30.55	25.64	30.79	43.00	40.92	41.20
T2	29.97	**L3**	42.22	**S3**	30.85	**T2**	18.72	29.16	42.05	**T2**	30.66	28.69	30.58	**L3**	42.39	41.88	42.40	**T2**	18.67	18.63	18.85	30.35	25.93	31.18	42.95	41.50	41.70
T3	30.03					**T3**	18.65	29.18	42.27	**T3**	30.31	29.00	30.79					**T3**	18.47	18.78	18.70	29.95	26.21	31.38	42.52	42.00	42.30
T4	30.20					**T4**	18.58	29.33	42.70	**T4**	30.36	29.30	30.96					**T4**	18.42	18.67	18.65	30.45	26.58	30.97	42.20	42.64	43.25
T5	30.31					**T5**	19.22	29.15	42.55	**T5**	30.27	29.34	31.32					**T5**	18.22	19.59	19.85	30.25	25.91	31.30	42.35	42.50	42.80
T6	30.38					**T6**	19.25	29.12	42.68	**T6**	29.14	29.82	32.08					**T6**	16.63	20.51	20.60	29.55	26.21	31.60	41.25	42.74	44.05
T7	30.35					**T7**	19.10	29.17	42.87	**T7**	29.78	29.72	31.65					**T7**	17.91	19.64	19.75	29.75	26.26	31.50	41.67	43.24	43.70
F-value	0.493^{NS}		9935^{**}		11.27^{**}		1.383^{NS}				8.241**				79.28**				0.081^{NS}									

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 3: Proportion of clay (%) in soil of mulberry gardens as influenced by the application of organic based nutrientsto three types of soils in different seasons

T		L		S		T x L			T x S			L x S			T x L x S								
						L1	L2	L3	S1	S2	S3	S1	S2	S3	L1			L2			L3		
															S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	36.23	L1	26.84	S1	38.33	T0 25.38	60.92	22.38	T0 38.05	33.54	35.44	L1 28.10	26.20	26.23	T0 28.82	23.63	23.68	63.78	56.64	62.33	26.50	20.34	20.30
T1	36.45	L2	60.75	S2	35.35	T1 26.07	60.97	22.33	T1 39.19	34.22	35.96	L2 62.82	57.29	62.15	T1 28.68	24.85	24.68	63.52	57.09	62.29	25.37	20.72	20.90
T2	36.87	L3	23.03	S3	36.94	T2 26.95	60.88	22.79	T2 38.97	35.01	36.63	L3 24.07	22.58	22.43	T2 28.60	26.22	26.02	63.23	57.32	62.08	25.08	21.50	21.80
T3	36.61					T3 27.31	59.75	22.76	T3 37.62	35.30	36.90				T3 28.24	26.73	26.95	59.79	57.44	62.03	24.82	21.74	21.72
T4	37.26					T4 27.43	60.76	23.58	T4 38.44	35.87	37.46				T4 28.48	26.79	27.00	63.40	56.71	62.17	23.45	24.10	23.20
T5	37.07					T5 27.26	60.93	23.02	T5 38.33	35.54	37.35				T5 28.08	26.61	27.10	63.23	57.49	62.05	23.67	22.50	22.90
T6	37.27					T6 27.17	60.94	23.60	T6 36.91	36.75	39.70				T6 26.83	27.27	27.40	62.70	57.97	62.15	21.20	25.00	24.60
T7	37.24					T7 27.18	60.88	23.73	T7 37.49	36.61	37.70				T7 27.05	27.49	27.00	62.92	57.63	62.10	22.50	24.70	24.00
F-value	0.432^{NS}		13302^{**}		14.68**	0.755^{NS}			3.519*			17.40**			0.465^{NS}								

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 4: Bulk density (g/cc) in soil of mulberry gardens as influenced by the application of organic based nutrientsto three types of soils in different seasons

T		L		S		T x L			T x S			L x S			T x L x S								
						L1	L2	L3	S1	S2	S3	S1	S2	S3	L1			L2			L3		
															S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	1.254	L1	1.305	S1	1.232	T0 1.344	1.182	1.237	T0 1.267	1.275	1.221	L1 1.306	1.314	1.294	T0 1.333	1.375	1.323	1.185	1.186	1.175	1.282	1.265	1.163
T1	1.270	L2	1.163	S2	1.234	T1 1.328	1.249	1.232	T1 1.256	1.258	1.295	L2 1.150	1.158	1.180	T1 1.325	1.345	1.313	1.175	1.174	1.397	1.267	1.255	1.175
T2	1.234	L3	1.224	S3	1.226	T2 1.314	1.157	1.231	T2 1.239	1.245	1.218	L3 1.239	1.229	1.204	T2 1.311	1.325	1.305	1.155	1.160	1.155	1.250	1.249	1.195
T3	1.223					T3 1.301	1.142	1.224	T3 1.227	1.228	1.213				T3 1.303	1.305	1.295	1.135	1.147	1.145	1.242	1.231	1.200
T4	1.226					T4 1.308	1.152	1.219	T4 1.219	1.232	1.227				T4 1.308	1.315	1.300	1.130	1.164	1.161	1.220	1.217	1.220
T5	1.222					T5 1.294	1.150	1.221	T5 1.226	1.225	1.215				T5 1.303	1.295	1.285	1.145	1.155	1.150	1.230	1.224	1.210
T6	1.200					T6 1.266	1.127	1.208	T6 1.201	1.196	1.203				T6 1.277	1.265	1.255	1.125	1.135	1.120	1.205	1.188	1.230
T7	1.215					T7 1.282	1.145	1.217	T7 1.219	1.210	1.215				T7 1.287	1.285	1.275	1.155	1.145	1.135	1.217	1.200	1.235
F-value	9.390^{NS}		118.8**		0.547^{NS}	0.834^{NS}			0.551^{NS}			2.049^{NS}			3.270**								

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 5: Maximum water holding capacity (%) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S	T x L			T x S			L x S			T x L x S								
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3	
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	48.22	**L1**	37.05	**S1**	50.69	**T0**	35.06	60.01	49.57	**T0**	49.08	46.77	48.80	**L1**	37.22	37.42	36.53	**T0**	36.29	34.65	34.25	62.52	55.38	62.15	48.43	50.28	50.00
T1	49.82	**L2**	63.77	**S2**	51.29	**T1**	36.18	62.87	50.36	**T1**	49.57	50.17	49.70	**L2**	64.33	63.44	63.42	**T1**	36.12	36.52	35.90	62.73	63.35	62.60	49.87	50.65	50.60
T2	50.46	**L3**	51.64	**S3**	50.48	**T2**	36.59	63.69	51.09	**T2**	50.32	51.01	50.05	**L3**	50.52	53.02	51.38	**T2**	36.30	37.33	36.15	64.15	63.83	63.10	50.52	51.87	50.90
T3	51.07					**T3**	37.34	64.26	51.62	**T3**	51.10	51.61	50.51					**T3**	37.45	37.72	36.85	65.20	64.37	63.22	50.65	52.75	51.45
T4	50.90					**T4**	37.03	63.39	52.29	**T4**	50.58	51.71	50.42					**T4**	37.33	37.37	36.40	63.58	63.63	62.95	50.83	54.13	51.90
T5	51.09					**T5**	37.52	63.81	51.94	**T5**	50.91	51.73	50.63					**T5**	37.67	37.98	36.90	64.24	63.99	63.20	50.81	53.24	51.78
T6	52.90					**T6**	38.53	66.66	53.51	**T6**	52.13	54.28	52.29					**T6**	38.45	39.15	38.00	66.23	67.25	66.40	51.71	56.45	52.37
T7	52.12					**T7**	38.18	65.42	52.75	**T7**	51.85	53.06	51.44					**T7**	38.15	38.64	37.75	66.02	65.75	64.50	51.37	54.79	52.08
F-value	10.39**		4726.6**		2.638^{NS}		1.150^{NS}				2.054^{NS}				7.757**				0.268^{NS}								

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 6: pH in soil of mulberry gardens as influenced by the application of organic based nutrientsto three types of soils in different seasons

	T		L		S	T x L			T x S			L x S			T x L x S								
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3	
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	8.232	**L1**	8.039	**S1**	8.251	**T0**	8.246	8.376	8.074	**T0**	8.378	8.140	8.178	**L1**	8.342	7.924	7.850	**T0**	8.537	8.140	8.060	8.717	8.240	8.170	7.880	8.040	8.303
T1	8.189	**L2**	8.292	**S2**	7.989	**T1**	8.176	8.346	8.047	**T1**	8.336	8.111	8.121	**L2**	8.645	8.146	8.086	**T1**	8.457	8.122	7.951	8.695	8.203	8.141	7.853	8.013	8.273
T2	8.099	**L3**	7.850	**S3**	7.942	**T2**	8.114	8.323	7.863	**T2**	8.330	8.044	7.923	**L3**	7.766	7.896	7.888	**T2**	8.483	8.001	7.854	8.680	8.180	8.113	7.827	7.952	7.810
T3	8.048					**T3**	8.016	8.290	7.837	**T3**	8.245	8.011	7.887					**T3**	8.297	7.943	7.813	8.654	8.157	8.062	7.785	7.937	7.794
T4	8.045					**T4**	8.014	8.328	7.792	**T4**	8.239	7.994	7.900					**T4**	8.324	7.900	7.820	8.673	8.190	8.121	7.722	7.893	7.762
T5	8.018					**T5**	7.958	8.292	7.803	**T5**	8.230	7.940	7.883					**T5**	8.295	7.792	7.792	8.636	8.154	8.090	7.760	7.881	7.773
T6	7.891					**T6**	7.884	8.136	7.654	**T6**	8.084	7.790	7.800					**T6**	8.162	7.743	7.754	8.477	7.952	7.983	7.613	7.680	7.671
T7	7.961					**T7**	7.904	8.248	7.732	**T7**	8.166	7.878	7.840					**T7**	8.181	7.764	7.770	8.623	8.100	8.024	7.692	7.773	7.730
F-value	13.03**		145.9**		133.9**		1.846^{NS}				1.138^{NS}				78.79**				0.645^{NS}								

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 7: Electrical conductivity (dS/m) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

T		L		S		T x L			T x S			L x S			T x L x S								
						L1	L2	L3	S1	S2	S3	S1	S2	S3	L1			L2			L3		
															S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	0.231	L1	0.295	S1	0.253	T0	0.231	0.205	0.255	T0	0.220	0.228	0.244	L1	0.283	0.295	0.306	T0	0.215	0.224	0.252	0.160	0.223	0.235	0.285	0.234	0.246
T1	0.234	L2	0.223	S2	0.265	T1	0.232	0.207	0.267	T1	0.232	0.225	0.247	L2	0.189	0.217	0.263	T1	0.234	0.223	0.235	0.171	0.204	0.240	0.292	0.243	0.268
T2	0.248	L3	0.289	S3	0.289	T2	0.263	0.208	0.273	T2	0.239	0.238	0.267	L3	0.286	0.284	0.297	T2	0.253	0.264	0.270	0.172	0.195	0.253	0.290	0.255	0.274
T3	0.273					T3	0.305	0.233	0.282	T3	0.258	0.268	0.293					T3	0.292	0.302	0.314	0.204	0.226	0.275	0.283	0.272	0.290
T4	0.267					T4	0.288	0.209	0.303	T4	0.246	0.266	0.288					T4	0.271	0.285	0.305	0.173	0.207	0.243	0.292	0.304	0.313
T5	0.279					T5	0.316	0.225	0.293	T5	0.262	0.275	0.299					T5	0.314	0.313	0.323	0.190	0.214	0.270	0.284	0.296	0.302
T6	0.316					T6	0.372	0.256	0.322	T6	0.282	0.318	0.348					T6	0.325	0.382	0.406	0.237	0.235	0.296	0.285	0.332	0.344
T7	0.302					T7	0.348	0.240	0.317	T7	0.281	0.303	0.322					T7	0.346	0.355	0.345	0.206	0.229	0.285	0.291	0.325	0.335
F-value	7.431*		32.43**		36.47**		4.333**			0.808^{NS}			8.417**						1.604*							

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 8: Available organic carbon (%) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

T		L		S		T x L			T x S			L x S			T x L x S								
						L1	L2	L3	S1	S2	S3	S1	S2	S3	L1			L2			L3		
															S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	0.663	L1	0.817	S1	0.748	T0	0.745	0.496	0.749	T0	0.650	0.645	0.695	L1	0.873	0.855	0.844	T0	0.740	0.720	0.775	0.470	0.478	0.540	0.740	0.737	0.770
T1	0.696	L2	0.636	S2	0.765	T1	0.785	0.542	0.760	T1	0.667	0.685	0.735	L2	0.572	0.630	0.706	T1	0.770	0.770	0.815	0.480	0.535	0.610	0.750	0.750	0.780
T2	0.741	L3	0.874	S3	0.815	T2	0.822	0.627	0.776	T2	0.693	0.739	0.792	L3	0.799	0.809	0.894	T2	0.800	0.810	0.855	0.520	0.640	0.720	0.760	0.767	0.800
T3	0.793					T3	0.908	0.683	0.787	T3	0.767	0.780	0.832					T3	0.920	0.880	0.925	0.610	0.680	0.760	0.770	0.780	0.810
T4	0.760					T4	0.878	0.570	0.831	T4	0.723	0.751	0.805					T4	0.890	0.850	0.895	0.490	0.570	0.650	0.790	0.833	0.870
T5	0.802					T5	0.933	0.671	0.803	T5	0.772	0.790	0.844					T5	0.940	0.910	0.948	0.597	0.670	0.745	0.780	0.790	0.840
T6	0.903					T6	0.939	0.794	0.976	T6	0.888	0.892	0.929					T6	0.975	0.970	0.963	0.770	0.773	0.840	0.920	0.933	0.983
T7	0.848					T7	0.945	0.703	0.894	T7	0.823	0.834	0.885					T7	0.950	0.930	0.955	0.640	0.690	0.780	0.880	0.883	0.920
F-value	15.40**		105.1**		93.87**		13.49**			1.172^{NS}			27.90**						1.293^{NS}							

T: Treatments (T0 to T7) L = Locations L1 = Challakere (Sandy clay loam soil) L2 = Hiriyur (Clay soil) L3 = Molakalmur (Red loamy soil)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 9: Available nitrogen (kg/ha) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	424.2	**L1**	404.6	**S1**	361.3	**T0**	455.1	356.6	460.9	**T0**	398.6	426.1	447.8	**L1**	405.5	404.4	403.8	**T0**	433.0	461.3	471.0	287.6	370.4	411.7	461.0	446.7	475.2
T1	393.1	**L2**	302.4	**S2**	365.5	**T1**	435.7	318.4	425.0	**T1**	353.3	391.9	434.1	**L2**	255.9	299.3	352.5	**T1**	419.1	431.7	456.3	234.5	321.8	399.4	406.3	422.2	446.7
T2	394.9	**L3**	417.8	**S3**	398.2	**T2**	433.9	310.3	440.5	**T2**	385.6	396.7	402.2	**L3**	422.5	392.6	438.3	**T2**	429.5	449.4	422.6	275.9	313.3	341.6	451.5	427.8	442.0
T3	375.7					**T3**	409.6	294.8	422.6	**T3**	375.8	366.6	384.5					**T3**	427.5	411.5	389.7	272.5	284.0	328.3	427.8	404.3	435.6
T4	380.1					**T4**	407.5	322.9	409.8	**T4**	365.1	376.3	398.9					**T4**	405.2	408.7	408.8	281.2	320.8	366.6	408.6	399.4	458.7
T5	353.9					**T5**	380.6	286.6	394.7	**T5**	349.2	336.2	376.4					**T5**	409.6	361.3	370.6	233.6	295.1	331.0	404.4	352.2	427.4
T6	338.8					**T6**	354.8	257.0	405.5	**T6**	313.9	315.6	374.5					**T6**	348.3	342.3	347.0	222.9	230.2	317.8	402.2	333.0	413.5
T7	339.1					**T7**	359.5	273.7	383.3	**T7**	335.6	323.9	367.0					**T7**	371.8	369.0	364.3	231.4	266.3	323.3	403.5	355.7	421.5
F-value	9.581**		209.5**		14.93**		1.636^{NS}				2.358*				23.75**				6.749**									

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$)NS = Non-significant

Table 10: Available phosphorus (kg/ha) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	26.18	**L1**	31.92	**S1**	20.95	**T0**	31.58	10.26	33.52	**T0**	22.82	21.96	35.24	**L1**	30.58	32.15	33.03	**T0**	26.67	30.56	37.50	9.975	9.740	12.13	22.50	25.58	62.09
T1	25.36	**L2**	10.52	**S2**	21.97	**T1**	30.66	11.04	33.02	**T1**	20.18	21.43	34.47	**L2**	9.50	10.70	11.34	**T1**	27.50	28.14	36.33	9.771	11.57	11.77	23.24	24.57	55.29
T2	25.11	**L3**	30.09	**S3**	29.60	**T2**	31.88	10.50	32.96	**T2**	20.30	22.14	32.90	**L3**	22.76	23.05	44.42	**T2**	28.67	31.73	35.25	9.356	10.93	11.20	22.87	23.74	52.25
T3	25.07					**T3**	33.46	10.43	31.31	**T3**	21.23	22.83	31.16					**T3**	31.83	34.50	34.10	9.178	10.74	11.37	22.65	23.25	48.00
T4	23.78					**T4**	33.12	10.71	27.52	**T4**	22.12	22.55	26.67					**T4**	33.00	34.21	32.17	9.262	11.18	11.68	24.10	22.23	36.17
T5	22.83					**T5**	28.54	10.58	29.36	**T5**	21.74	22.75	28.08					**T5**	27.83	28.05	29.73	9.738	10.84	11.15	22.00	22.75	43.33
T6	22.50					**T6**	34.00	10.24	23.40	**T6**	19.36	20.46	22.04					**T6**	36.17	37.09	28.74	8.902	10.19	10.69	22.48	21.00	26.68
T7	22.54					**T7**	32.10	10.39	25.08	**T7**	19.86	21.54	24.27					**T7**	33.00	32.95	30.35	9.827	10.45	10.74	22.23	21.28	31.73
F-value	0.361^{NS}		123.4**		15.37**		2.572*				3.279*				33.78**				8.981**									

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$)NS = Non-significant

Table 11: Available potassium (kg/ha) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	203.8	**L1**	186.9	**S1**	176.4	**T0**	207.1	178.9	225.5	**T0**	195.2	210.6	205.7	**L1**	195.4	189.0	176.2	**T0**	202.5	195.3	223.5	170.7	189.8	176.2	212.5	246.5	217.5
T1	195.7	**L2**	162.7	**S2**	187.9	**T1**	210.9	175.1	201.2	**T1**	187.8	198.7	200.6	**L2**	148.9	166.3	173.4	**T1**	213.8	204.8	214.2	159.3	185.6	180.3	190.4	205.6	207.7
T2	182.4	**L3**	191.4	**S3**	176.8	**T2**	190.6	161.4	195.3	**T2**	174.4	182.5	190.4	**L3**	185.0	208.4	180.8	**T2**	184.5	182.3	205.0	151.2	162.3	170.6	187.4	203.0	195.3
T3	172.0					**T3**	172.3	157.3	186.5	**T3**	168.5	176.8	170.9					**T3**	179.2	173.0	164.8	142.5	157.9	171.8	183.7	199.3	176.0
T4	178.4					**T4**	187.8	167.0	180.4	**T4**	174.6	185.0	175.5					**T4**	190.0	185.7	187.7	155.4	171.4	174.2	178.3	198.0	164.6
T5	172.2					**T5**	175.0	157.2	184.6	**T5**	172.9	180.3	163.4					**T5**	190.7	180.8	153.5	147.2	157.2	166.7	181.1	203.2	169.8
T6	167.9					**T6**	175.2	148.9	179.5	**T6**	169.8	186.6	147.2					**T6**	207.8	197.4	127.1	120.3	152.3	167.2	174.5	210.4	154.0
T7	170.6					**T7**	175.8	157.4	178.8	**T7**	168.3	182.6	161.0					**T7**	194.5	192.3	140.8	138.3	153.8	180.3	172.3	201.8	161.7
F-value	13.49^{NS}		47.60**		5.009*			0.569^{NS}				0.972^{NS}				6.688*							28.71**					

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 12: Microbial biomass carbon (mg/kg) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S									
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3			
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	315.1	**L1**	419.2	**S1**	489.5	**T0**	330.1	287.6	327.7	**T0**	375.0	304.7	265.6	**L1**	498.6	401.4	357.4	**T0**	397.7	312.3	280.2	314.3	292.3	256.0	413.0	309.5	260.5
T1	371.7	**L2**	380.7	**S2**	403.6	**T1**	388.8	331.7	394.4	**T1**	438.3	360.3	316.5	**L2**	423.6	375.1	343.5	**T1**	465.0	358.8	342.7	363.2	330.8	301.0	486.7	391.3	305.8
T2	405.3	**L3**	451.0	**S3**	357.7	**T2**	409.2	379.3	427.6	**T2**	476.7	392.9	346.1	**L3**	546.4	434.3	372.3	**T2**	485.5	395.6	346.0	430.5	368.5	339.2	515.0	414.7	353.0
T3	426.4					**T3**	431.7	392.6	454.9	**T3**	502.9	408.8	367.4					**T3**	511.0	411.5	372.3	440.7	384.6	352.4	557.0	430.4	377.2
T4	425.2					**T4**	417.9	365.5	492.3	**T4**	498.4	408.3	369.3					**T4**	494.0	402.2	357.6	407.5	349.2	340.3	593.7	473.5	409.6
T5	445.3					**T5**	442.3	413.4	480.2	**T5**	525.0	428.6	382.1					**T5**	524.8	427.1	375.3	463.0	404.7	372.5	587.2	454.8	398.7
T6	481.5					**T6**	480.6	441.8	522.1	**T6**	561.8	468.8	413.9					**T6**	579.2	459.0	404.0	487.8	440.0	397.2	618.5	507.3	440.4
T7	464.9					**T7**	452.7	433.7	508.4	**T7**	537.5	456.1	401.2					**T7**	531.3	444.5	382.2	481.3	430.8	389.0	599.8	492.8	432.5
F-value	31.46**		39.44**		803.1**			10.78**				1.914^{NS}				68.99**							4.843**					

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer **: Highly significant ($p \leq 0.01$) NS = Non-significant

Table 13: Dehydrogenase activity (µg TPF/g/ha) in soil of mulberry gardens as influenced by the application of organic based nutrients to three types of soils in different seasons

	T		L		S		T x L				T x S				L x S				T x L x S								
							L1	L2	L3		S1	S2	S3		S1	S2	S3		L1			L2			L3		
																			S1	S2	S3	S1	S2	S3	S1	S2	S3
T0	2.435	**L1**	3.369	**S1**	3.800	**T0**	2.339	2.373	2.594	**T0**	2.556	2.364	2.386	**L1**	3.634	3.321	3.127	**T0**	2.466	2.346	2.205	2.496	2.438	2.185	2.706	2.562	2.515
T1	2.885	**L2**	3.361	**S2**	3.423	**T1**	2.742	2.753	3.159	**T1**	3.210	2.763	2.681	**L2**	3.669	3.221	3.215	**T1**	3.038	2.643	2.545	2.983	2.625	2.652	3.609	3.021	2.847
T2	3.194	**L3**	3.737	**S3**	3.244	**T2**	2.929	3.297	3.356	**T2**	3.625	2.999	2.958	**L3**	4.096	3.726	3.388	**T2**	3.135	2.897	2.754	3.856	2.888	3.146	3.883	3.210	2.974
T3	3.404					**T3**	3.175	3.391	3.644	**T3**	3.842	3.236	3.133					**T3**	3.415	3.105	3.006	3.907	3.039	3.227	4.202	3.563	3.167
T4	3.318					**T4**	2.992	3.059	3.902	**T4**	3.540	3.255	3.159					**T4**	3.247	2.928	2.802	3.231	2.937	3.011	4.143	3.901	3.663
T5	3.764					**T5**	3.898	3.597	3.797	**T5**	4.233	3.656	3.403					**T5**	4.486	3.784	3.423	4.037	3.432	3.323	4.177	3.751	3.462
T6	4.631					**T6**	4.529	4.391	4.974	**T6**	4.960	4.757	4.177					**T6**	4.748	4.605	4.233	4.593	4.552	4.029	5.538	5.116	4.268
T7	4.280					**T7**	4.280	4.090	4.468	**T7**	4.432	4.353	4.054					**T7**	4.531	4.262	4.047	4.253	4.112	3.906	4.511	4.686	4.208
F-value	31.60**		11.53*		28.20**		5.361**				3.826*				3.781*				11.05**								

T: Treatments (T0 to T7) L = Locations L1 = Sandy clay loam soil (Challakere) L2 = Clay soil (Hiriyur)L3 = Red loamy soil (Molakalmur)
S : Seasons S1 = Monsoon S2 = Winter S3 = Summer *: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$)