INFLUENCE OF VERMICOMPOST ON THE PHYSICO-CHEMICAL AND BIOLOGICAL PROPERTIES IN DIFFERENT TYPES OF SOIL ALONG WITH YIELD AND QUALITY OF THE PULSE CROP–BLACKGRAM

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ABSTRACT

Field experiments were conducted during 2002-2003 on clay loam, sandy loam and red loam soil at Sivapuri, Chidambaram, Tamil Nadu, to evaluate the efficacy of vermicompost on the physico-chemical and biological characteristics of the soils and on the yield and nutrient content of blackgram - *Vigna mungo*, in comparison to inorganic fertilizers nitrogen, phosphorous, potassium. Vermicompost had increased the pore space, reduced particle and bulk density, increased water holding capacity, cation exchange capacity, reduced pH and electrical conductivity, increased organic carbon content, available nitrogen, phosphorous, potassium and microbial population and activity in all the soil types, particularly clay loam. The yield and quality (protein and sugar content in seed) of blackgram was enhanced in soils, particularly clay loam soil. On the contrary, the application of inorganic fertilizers has resulted in reduced porosity, compaction of soil, reduced carbon and reduced microbial activity.

Key words: Clay loam, sandy loam, red soil, physico-chemico-biological properties, vermicompost, blackgram

INTRODUCTION

Long-term application of inorganic fertilizers like high doses of ammonium sulfate and sulfur coated urea has led to soil acidification (Ma *et al*., 1990), decrease in soil aggregate stability (Estevez *et al*., 1996) decrease in soil respiration (Sharma 2003), pollution of underground water and decrease in earthworm populations (Edwards and Bohlen 1996). Vermicompost has been shown to have high levels of total and available nitrogen, phosphorous, potassium (NPK) and micro nutrients, microbial and enzyme activities and growth regulators (Parthasarathi and Ranganathan 1999; Chaoui *et al*., 2003) and continuous and adequate use with proper management can increase soil organic carbon, soil water retention and transmission and improvement in other physical properties of soil like bulk density, penetration resistance and aggregation (Zebarth *et al*., 1999) as well as beneficial effect on the growth of a variety of plants (Atiyeh *et al*., 2002). Most of these studies are restricted to specific soil type and/or to temperate plants and to greenhouse experiments. Effects of application of vermicompost on different types of soils and the nutritional analysis of plants, particularly in field crops like pulses raised on different tropical soils have not been studied so far. The objectives of the present investigation, therefore, were to monitor the effects of application of vermicompost, produced from the sugar mill wastes (pressmud, trash and bagasse) on a range of physical, chemical and biological properties of clay loam, sandy loam and red loam soil and the yield and nutritional quality of blackgram-*Vigna mungo*.

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MATERIALS AND METHODS

Preparation of vermicompost from sugar mill wastes

One month old pressmud (p), dried and chopped sugarcane trash (t) (12-18cm) and fine bagasse (b) (0.2-0.5cm) were obtained from E.I.D Parry (I) Sugar Factory, Nellikuppam, Cuddalore district of Tamil Nadu, India. To 10Kg of 8:1:1 mixture (w/w) of ptb in cement tanks of dimension 50×35×35 cm, about 100 adult *Eudrilus eugeniae* were introduced and maintained for 50 days, maintaining 65-67% moisture in the mixture at 30±2ºC and 65-70% RH. After 50 days fresh vermicompost was collected by hand from the surface and used for experiments.

Experimental site and design

A microplot ($2m^2$) field experiment was conducted for two consecutive years (2002 and 2003) at Sivapuri, Chidambaram, Tamil Nadu. Experiment was laid out in randomized block design with three replications. Altogether there were 36 plots, four replicate in each for clay loam soil (CLS), sandy loam soil (SLS) and red loam soil (RLS). Blackgram (*Vigna mungo*-Var. ADT-3) was grown as test crop. Treatments consisted of T_1 - control (without application of inorganic NPK or vermicompost); T_2-100% recommended dose of NPK (50:25:0kg/ha); T_3-100% recommended dose of vermicompost (5t/ha) and T_4-50% vermicompost supplemented with 50% NPK (W/W). Inorganic NPK was applied through urea, single super phosphate (SSP) and muriate of potash (MOP). Inorganic NPK and vermicompost were applied to the soil by basal application at the time of sowing of black gram.

Analysis of physico-chemical and biological properties

Soil samples were collected from each plot from 0-15cm depth in two different periods: Initial (I)-0day (before application of NPK and vermicompost and blackgram sowing) and final (F)-75days (after harvesting of blackgram). Physical properties of the soil like porosity, particle density and bulk density were determined by specific gravity bottle method of Kanwar and Chopra (1980), water holding capacity (WHC) was determined by the procedure of Baruah and Barthakur (1999) and cation exchange capacity (CEC) was estimated by ammonium saturation method of Jackson (1973). Chemical parameters like pH and electrical conductivity (EC) were determined by ISI Bulletin (1982) by using digital pH and conductivity meters, organic carbon (OC) was estimated by following the procedure of Walkley and Black (1934), available nitrogen, phosphorus and potassium were estimated respectively by alkaline potassium permanganate method of Subbiah and Asija (1956), Olsen *et al*., (1954) and neutral normal ammonium acetate method of Standford and English (1949). Total microbial population was estimated according to the method of Baron *et al*., (1994) and expressed as $CFU\times10^6/g$ and microbial activity in terms of dehydrogenase activity was estimated adopting the procedure of Stevenson (1959) and expressed as µl H/5g substrate. The harvested seeds of blackgram were analysed for protein by the procedure of Lowry *et al*., (1951) and sugar using the procedure of Nelson (1944). The results were statistically analyzed at $P<0.05$ level using Analysis of Variance with interaction effect (ANOVA-RBD).

RESULTS

The effect of application of NPK (T_2) and ptb vermicompost (T_3) and 50% ptb vermicompost supplemented with 50% NPK on the physical, chemical and biological properties of CLS, SLS and RLS, before sowing (initial soil) and post harvest of blackgram were represented in the Figures-1a-e, 2a-f and 3a and b. The porosity, WHC and CEC of CLS, SLS and RLS were significantly increased in soils treated with 100 % ptb vermicompost (T_3), followed by soil treated with 50 % ptb vermicompost supplemented with 50 % NPK (T4) when compared to control (T_1) (Figures-1a,d,e). On the contrary, porosity, WHC and CEC of all soil types which had decreased significantly in soils treated only with 100% NPK (T_2) when compared to control (T_1). Further, the decreased in particle and bulk density were very significant in all soil types treated with ptb vermicompost (T_3) and ptb vermicompost plus NPK (T_4) when compared to soils treated with NPK alone (T_2) (Figs. 1b and c).

The pH in all soil types had been slightly increased due to the application of NPK (T_2). However, a very slight decrease in pH was observed in all soil types treated with ptb vermicompost (T_3) (Fig. 2a). Application of ptb vermicompost (T_3) revealed that EC had been reduced in CLS than the control (T_1) but EC in SLS and RLS did not get affected significantly due to any of these treatments (Fig. 2b). Organic carbon had been phenomenally

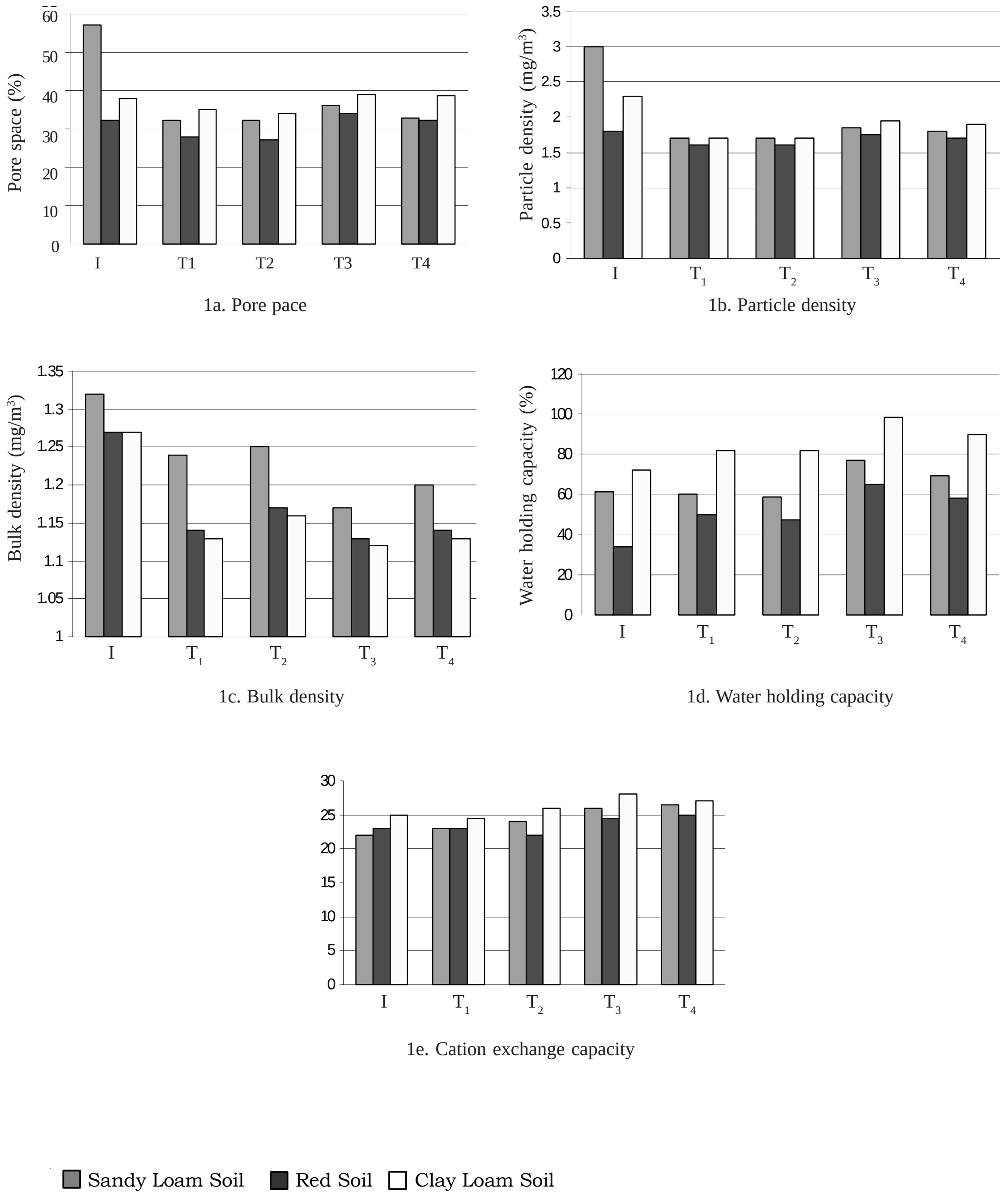


Fig. 1: Effect of vermicompost and inorganic NPK on the physical parameters of soils before sowing (I) and after harvesting of blackgram

I–Initial soils (0 day)–before sowing blackgram; T1–Control soils – after harvesting of blackgram; T2–100% recommended dose of NPK; T3–100% recommended dose of vermicompost; T4–50% vermicompost + 50% NPK

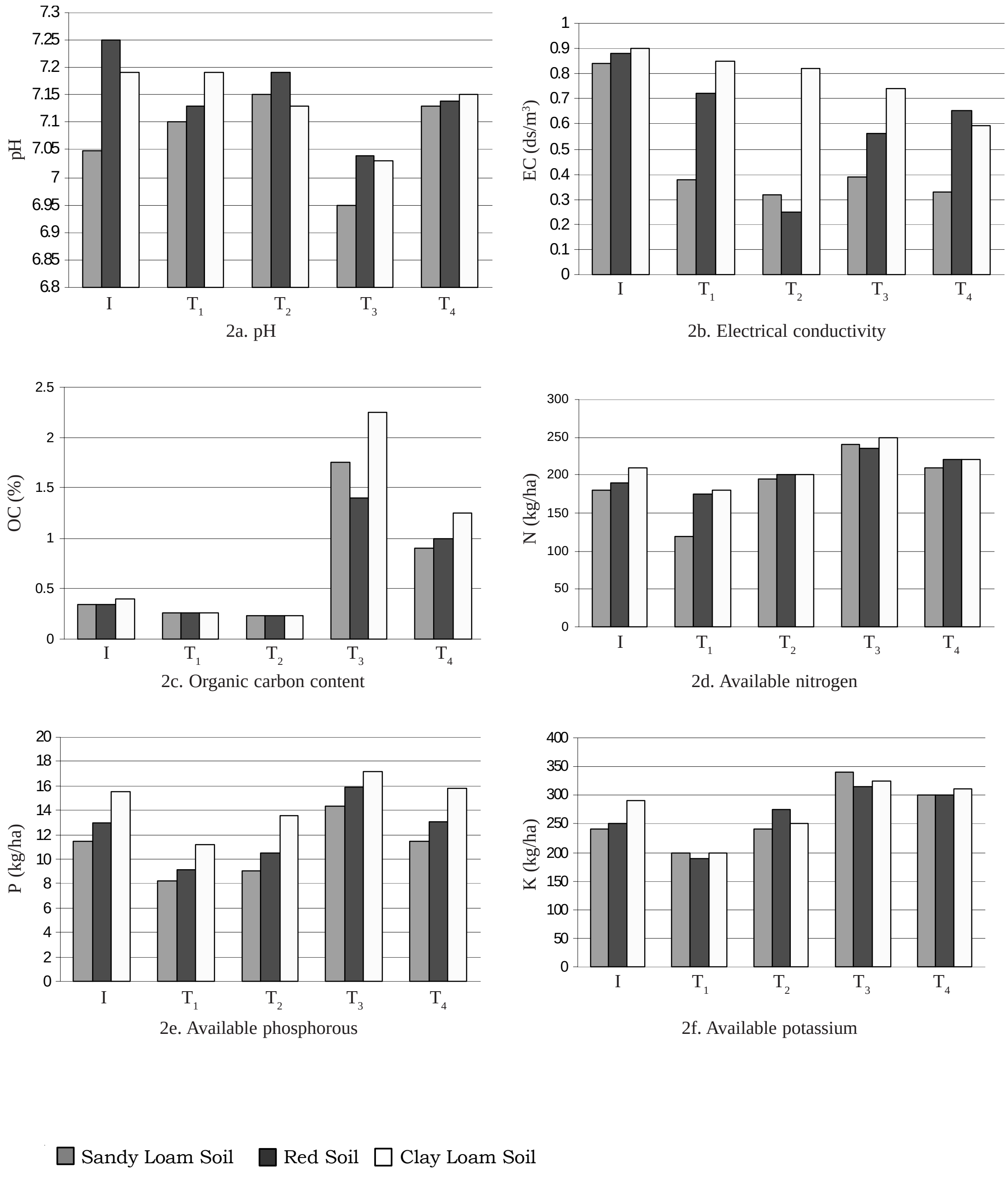
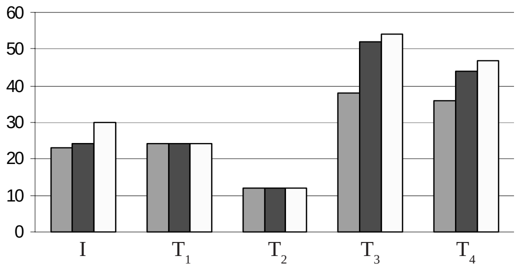
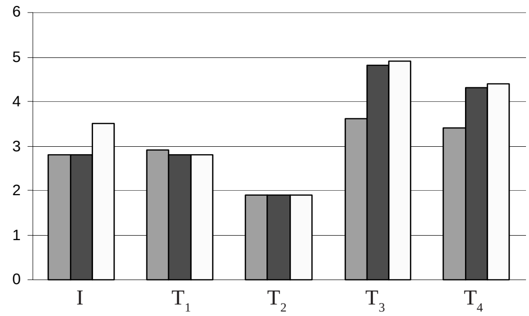


Fig. 2: Effect of vermicompost and inorganic NPK on the chemical parameters of soils before sowing (I) and after harvesting of blackgram

I–Initial soils (0 day)–before sowing blackgram; T_1-Control soils–after harvesting of blackgram; T_2–100% recommended dose of NPK; T_3–100% recommended dose of vermicompost; T_4–50% vermicompost + 50% NPK



3a. Total microbial population

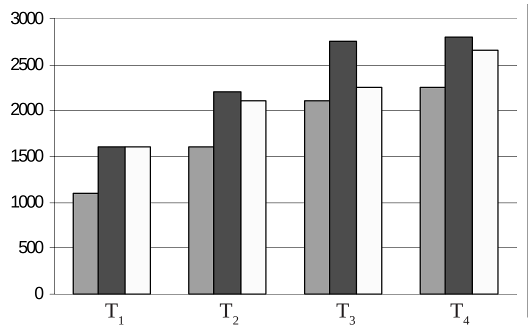


3b. Dehydrogenase activity

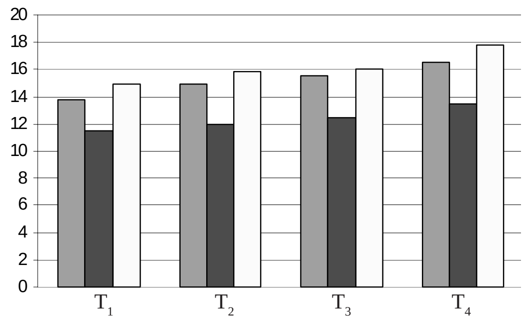
Sandy Loam Soil Red Soil Clay Loam Soil

Fig. 3: Effect of vermicompost and inorganic NPK on the biological parameters of soils before sowing (I) and after harvesting of blackgram

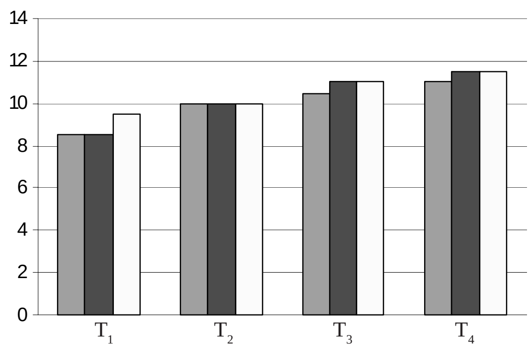
I–Initial soils (0 day)–before sowing blackgram; T_1–Control soils–after harvesting of blackgram; T_2–100% recommended dose of NPK; T_3–100% recommended dose of vermicompost; T_4–50% vermicompost + 50% NPK.



4a. Yield



4b. Protien contents in seeds



4c. Sugar contents in seeds

Sandy Loam Soil Red Soil Clay Loam Soil

Fig. 4: Effect of vermicompost and inorganic NPK on the yield and quality parameters of blackgram

I–Initial soils (0 day)–before sowing blackgram; T_1–Control soils – after harvesting of blackgram; T_2–100% recommended dose of NPK; T_3–100% recommended dose of vermicompost; T_4–50% vermicompost + 50% NPK enhanced in all soil types treated with ptb vermicompost (T_3) and ptb vermicompost plus NPK (T_4) (Fig. 2c). There was a significant increase in available NPK in all soil types post harvest of blackgram, where the vermicompost (T_3) and vermicompost plus NPK (T_4) were applied than the plots treated only with NPK (T_2) (Fig. 2d-f).

The total microbial population and activity had been significantly enhanced in all soil types treated with ptb vermicompost (T_3) and ptb vermicompost was supplemented with NPK (T_4). A very striking feature of the application of NPK (T_2) to soil is the significant reduction in total microbial population and activity and the reduction was even lesser than the values obtained from control field (T_1) (Figs. 3a and b). Conspicuous effects were observed on the grain yield of blackgrams in plots fertilized with 50% vermicompost supplemented with 50% NPK (T_4) (Fig. 4a). Enhanced sugar and protein contents were also observed in the T_4 treatments than plants treated either with vermicompost (T_3) or NPK (T_2) (Figs. 4b and c). Especially these effects were more in CLS than SLS and RLS.

DISCUSSION

The porosity depends upon the texture and aggregation of the soil. Application of sewage sludge compost at rates equivalent to 50 and 150t/ha manure, based on organic carbon content, had been shown to increase the porosity of a sandy loam soil at all times during two years of monitoring (Guidi *et al*., 1983). The increased porosity in vermicompost and vermicompost plus NPK treated plots in the present investigation is probably due to aggregation of the soil particles by the action of microorganisms in the vermicompost which produce polysaccharides providing a cementing action between the soil particles (Six *et al*., 1995) and possibly also by fungal mycelia (Edwards and Bohlen, 1996).

Particle density was significantly reduced in all the soil types and in all the treatments compared to the initial non-cultivated soils. There was also a significant decrease in the bulk density of the soils treated with vermicompost and vermicompost plus NPK compared to those treated with NPK alone; it could be mainly due to the increased porosity. Similar observations were made by Vasanthi and Kumarasamy (1999) who found a significant reduction in the bulk density of soil treated with vermicompost supplemented with NPK. The least reduction in bulk density among the four treatments was observed in soils treated with only NPK.

A comparison between a raw, composted, and a worm-worked mixture of primary and secondary kraft paper mill sludge found that the composted and worm-worked sludges increased the available soil moisture of a sandy loam from 10.5% to 54.4 and 31.6%, respectively. WHC was reported to be greater in soils with large amount of organic matter (or) clay particles (Einspahr and Fiscus, 1984). The increased WHC in vermicompost and vermicompost plus NPK treated plots, in the present study, was due to increased porosity and decreased bulk density of the soil due to vermicompost application and these in turn provide greater areation and better drainage.

CEC is greater in soils with greater amount of organic matter and clay. Our present study revealed that CEC had been significantly increased in all the three different soils, particularly in CLS treated with vermicompost and vermicompost supplemented with NPK. The increased CEC in vermicompost and vermicompost plus NPK treated plots in the present study was mainly due to humic substances in the vermicompost. This observation falls in line with Vasanthi and Kumarasamy (1999) who found significant increase in CEC of the soil treated with vermicompost plus NPK. In addition to the presence of higher amount of humus, presence of clay loam soil have helped in boosting the cation exchange capacity.

pH range between 6-7 seems to promote the availability of plant nutrients (Edwards and Bohlen, 1996). In the present study, irrespective of treatments, the pH of the three types of soils had not decreased significantly. Application of NPK or vermicompost supplemented with NPK to SLS had increased the pH. However, the very slight decrease in pH observed in the present study in the other treatments could be due to the acidifying effect of urea and organic acids produced during the course of decomposition of organic amendments. Similarly, decreased pH was observed in the soils treated with enriched compost of industrial wastes, after harvest of ragi and cowpea (Srikanth *et al*., 2000). Application of vermicompost and NPK revealed that among the three soil types, EC was higher in CLS and lowest in SLS; however it was not significant. EC in RLS was greatly reduced due to NPK application. Similarly, low EC was observed in the soil treated with enriched composts, FYM and vermicompost after harvest of ragi and cowpea (Srikanth *et al*., 2000). Decreased EC could be due to the increased permeability leading to leaching of salts. Organic carbon had been enhanced in all types of soil treated with vermicompost and vermicompost plus NPK and was sustained after harvest. On the contrary, in fields where only NPK was applied, percentage of OC content was lower than control fields. Our results are in line with the observation made by Vasanthi and Kumarasamy (1999) and Srikanth *et al*., (2000) where the incorporation of various enriched compost, FYM and vermicompost have been shown to have increased OC content in the soil. Significant increase in the available NPK in all types of soil and in CLS in particular, with vermicompost and vermicompost supplemented with NPK, at harvest of blackgram was observed. Similarly increased available NPK in the soils were observed where the soils were treated, respectively, with enriched compost from different organic wastes, FYM, vermicompost and vermicompost plus NPK after the harvest of rice, ragi and cowpea (Vasanthi and Kumarasamy, 1999; Srikanth *et al*., 2000; Sailajakumari and Ushakumari, 2002; Chaoui *et al*., 2003).

Compared to control, total microbial population and activity had been significantly enhanced in all the three types of soils where vermicompost and vermicompost plus NPK were applied, while it decreased with NPK alone. Manure application is known to stimulate and improve stable soil structure, fungal and bacterial population and biological activity (Chaoui *et al*., 2003). The greater pore volume in earthworm casts and compost amended soils have been shown to increase the availability of both water and nutrients to microorganisms in soils (Scott *et al*., 1996). On the contrary in the present study, application of NPK had resulted in the reduction of microbial population in NPK alone treated plots which is due to reduction of OC content in the soil, compaction, reduced porosity, reduced WHC and reduced micronutrients.

The result showed significantly higher grain yield and sugar and protein contents in the blackgram seed harvested from plots treated with vermicompost supplemented with NPK, followed by plots treated with 100% vermicompost and the plots treated only with NPK. These results are in line with the observations of Vasanthi and Kumarasamy (1999) and Sailajakumari and Ushakumari (2002) who found increased rice yield after treatment with vermicompost plus NPK and enhanced nutrient uptake and yield by cowpea after application of vermicompost enriched with rock phosphate. Vermicompost and vermicompost supplemented with NPK improved porosity, WHC and CEC and reduced bulk density which support better aeration to plant root, drainage of water, facilitation of cations N^+, P^+ and K^+ exchange and thereby the uptake by the plants has resulted in better growth, yield and quality of blackgram. Among the three types of soil, CLS seems to be better than SLS and RLS because CLS has higher WHC, CEC and EC and hence the yield and quality of blackgram was also better in CLS.

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