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Response of tillage and organic nutrient management on yield and physico-chemical and biological properties of soil under finger millet-French bean cropping system

Sulochna, Md Parwaiz Alam, CS Singh, Arvind Kumar Singh, Md Naiyar Ali and Arvind Kumar

Sulochna
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Md Parwaiz Alam
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

CS Singh
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Arvind Kumar Singh
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Md Naiyar Ali
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Arvind kumar
Department of Soil Science and Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Corresponding Author:
Sulochna
Department of Agronomy, Agricultural Chemistry
Birsa Agricultural University, Ranchi, Jharkhand, India

Abstract
A field experiment on ‘Response of tillage and organic nutrient management on yield and physico-chemical and biological properties of soil under finger millet-French bean cropping system’ conducted at Agronomical Research Farm, Birsa Agricultural University, Kanke, Ranchi, and Jharkhand during 2020-21 and 2021-22. The experiment laid out in a split-plot design with three replication. The experiment consisted of four main plot treatments *viz.*, conventional tillage – conventional tillage (CT – CT), conventional tillage – zero tillage (CT – ZT), zero tillage – conventional tillage (ZT – CT) and zero tillage – zero tillage (ZT - ZT) and subplot has four treatments with different sources of organic nutrient management *viz.*, 100% N through FYM, 100% N through vermicompost, 50% N through FYM + 50% N through vermicompost and 75% N through FYM + 25% N through vermicompost. Yield of finger millet, green French bean and system were significantly found maximum in conventional tillage-conventional tillage. In case of organic nutrient 100% N through VC gave significant maximum value. Mechanical, physical, chemical and biological properties of soil were not affected by tillage and organic nutrient management. Maximum sand percent, bulk density, field capacity, electrical conductivity (EC), organic carbon (OC), available NPK and microbial (bacteria, fungi and actinomycetes) count were found maximum in zero tillage – zero tillage (ZT- ZT) practice. In the subplot, 100% N through FYM recorded a higher sand percent, bulk density, field capacity, electrical conductivity (EC), organic carbon (OC), available NPK and microbial population (bacteria, fungi and actinomycetes) after completion of the experiment. The holistic approaches of zero tillage – zero tillage practice and application of 100% N through FYM can be recommended as best practice to the farmers.

Keywords: Tillage, organic nutrient management, yield, physico-chemical, biological properties

Introduction
Soil of Jharkhand is suitable for the cultivation of crop like Finger millet (*Eleusine coracana* (L.) Gaertn). It is generally grown as a rain-fed crop during rainy season. It can be grown in areas with both low as well as high rainfall. It has early maturity, low input requirements, free from major insects & diseases and can tolerate stress condition. Finger millet has high content of calcium (0.38%), protein (6-13%), dietary fiber (18%), carbohydrate (65-75%), minerals (2.5-3.5%) and others that has beneficial effect on health (Devi *et al*., 2014) [6]. It is cultivated in an area of 1.14 Mha with total production of 1.82 MT and an average productivity of 1601 kg/ha. Jharkhand state has good agro-ecological condition for finger millet production. It is grown over an area of 14.3 thousand ha with an annual production of 9.2 thousand tonne and an average productivity of 644 kg/ha (Annual Progress Report: 2017-18, ICAR-AICRP on Small Millets; 2015-16) [1]. In recent decades, emphasis has been shifted from individual crop to cropping system because responses in component crops are influenced by the nutrient application to preceding crops by leaving substantial effect on the succeeding crops as carry over benefit. Inclusion of French bean (*Phaseolus vulgaris* L.) in crop sequence is agronomically very significant. It is a good predecessor to other crops and grown as a *rabi* vegetable. It is a rich source of protein and closely compared with meat. Edible protein is 94% of the pods and per 100 g of edible protein contains: moisture 91.4 g, protein 1.7 g, fat 0.1 g, carbohydrate 4.5 g, fiber 1.8 g, minerals 0.5 g, vitamin A 221 I.U., thiamine 0.08 mg, vitamin C 14 mg, calcium 50 mg, phosphorus 28 mg, iron 1.70 mg, potassium 120 mg, sulphur 37 mg, sodium 4.3 mg copper 0.21 mg (Prasad, 2005) [12]. In India French bean is grown in an area of 228 thousand ha along with production of 2277 thousand tonne and productivity of 9.98 tonne/ha.

In case of Jharkhand, it is cultivated over an area of 12.91 thousand ha with production of 191.18 thousand tonne and productivity of 14.81 tonne/ha (Horticultural Statistics at a Glance, 2018) [9]. Finger millet-French bean cropping system under conservation tillage and organic nutrient management may be suitable in upland situation of Jharkhand (Das *et al.*, 2014) [5]. Proper tillage has favorable effect on soil properties and crop performance. The role of conservation tillage practices in conserving soil moisture, with the subsequent effect on crop yields, has also been observed in various parts of the country (Singh *et al*., 2008) [16]. Tillage practices greatly enhance the labour cost in production systems, resulting in lower economic returns. However, conservation tillage (zero tillage) is effective for reducing water loss from shallow depth soils and improves soil moisture regime as soil porosity, soil infiltration and soil structure are greatly affected by tillage (Madejon *et al*., 2007) [19]. On the other hand, increasing awareness of deleterious effects of organic fertilizers and pesticides in agriculture has led to adopt organic crop production as an alternative method for cultivation. Organic sources like FYM and vermicompost *etc.* supply not only organic matter but also increase the fertility status of the soil (Chung *et al*., 2000; Keupper and Gegner, 2004) [4, 10]. The organic manure slowly releases nutrient and has good effect both on instant crop as well as performance of succeeding crops. It also maintains the soil physical, chemical and biological characteristics and improves overall ecological balance of the crop production system. Keeping above points in mind, an investigation entitled, "Tillage and organic nutrient management in finger millet-French bean cropping system" has been planned to carry out at Agronomic Research Farm, Birsa Agricultural University, Kanke, Ranchi, Jharkhand.

Materials and Method

The experiment entitled, "'Response of tillage and organic nutrient management on yield and physico-chemical and biological properties of soil under finger millet-French bean cropping system'" was conducted in Agronomical Research Farm of the Birsa Agricultural University, Kanke, Ranchi (23° 17' N latitude, 85^0 10' E longitude and 625.22 m above mean sea level), Jharkhand during 2020-21 and 2021-22. The experiment was laid out in a split-plot design with three replication. The experiment consisted of four main plot treatments *viz*., conventional tillage–conventional tillage (CT -CT), conventional tillage-zero tillage (CT-ZT), zero tillage -conventional tillage (ZT-CT) and zero tillage-zero tillage (ZT-ZT) and subplot has four treatments with different sources of organic nutrient management *viz*., 100% N through FYM, 100% N through vermicompost, 50% N through FYM + 50% N through vermicompost and 75% N through FYM + 25% N through vermicompost. Finger millet and French bean (for vegetable purpose) variety taken for cultivation were BBM 10 and Swarna Priya respectively. Seed rate for finger millet and French bean were 10 and 80 kg/ha respectively. Recommended dose of nitrogen (RDN) for finger millet and French bean were 40 and 140 kg/ha respectively. The source of organic nutrients were FYM and vermicompost. Sowing of finger millet was done on 26th June 2020 and 18th June 2021 with row-to-row spacing of 30 cm and plant to plant 10 cm spacing was maintained after thinning. Fifteen days prior to sowing of green French bean, the organic nutrients were manually incorporated into the soil. Green French bean was sown on 13th Nov 2020 and 06th Nov 2021 with row-to-row spacing of 40 cm and plant-to-plant spacing of 10 cm. Both crops were sown in east-west direction in both the years.

The texture of soil (0-15 cm of depth) was sandy loam. Mechanical analysis was done by Hydrometer method, bulk density by core sampler method, permanent wilting point and field capacity by pressure plate method, pH and EC by pH and EC meter, organic carbon by Walkley & Black method, available nitrogen by Alkaline permanganate method, available phosphorus by Bray's P_1 method, available potassium by Flame photometer method and microbial count by Pour plate techniques. The soils were acidic, medium in organic carbon, low in available nitrogen, medium in available phosphorous and potassium. The maximum and minimum temperature ranged from 26.8 to 36.8 ºC and from 4.0 to 24.1 ºC respectively during 2020-21. During second season (2021-22) it ranged from 21.0 to 34.2 ºC and from 3.6 to 25.2ºC respectively. Rainfall varied from 0 to 185.8 mm and from 0 to 229.4 mm in first and second season respectively. Agricultural operations and practices were applied as recommended for the crop. The finger millet crop was harvested on 28th Oct 2020 in first year and on 19th Oct 2021 in second year. While in case of French bean it was harvest on 18th Feb 2021 and on 9th Feb 2022 in first and second year respectively. Data on soil parameters were recorded as per normal procedure.

Result and Discussion

Yield of finger millet, green French bean and system

Yield of finger millet and green French bean and system were influenced by tillage and organic nutrient management (Table 1). Treatment CT-CT produced maximum grain yield (23.90 q/ha) which was significantly higher than ZT-CT (21.18 q/ha) and ZT-ZT (19.87 q/ha) but at par with CT-ZT (22.95 q/ha). Among organic nutrient management, 100% N through VC produced maximum (24.25 q/ha) grain yield which was comparable to 100% N through FYM (18.72 q/ha) whereas, remain at par with 50% N through FYM + 50% N through VC (22.80 q/ha) and 75% N FYM + 25% N VC (22.14 q/ha). This might be due to conventional tillage favourable physical conditions for seed germination, seedling emergence and stand establishment. Further, the plant growth regulators and humic acid made available through vermicompost also enhanced the growth of plants (Saha *et al*. 2010) [15]. In case of French bean main plot treatment i.e. CT-CT recorded maximum (82.87 q/ha) green pod yield followed by CT-ZT (80.98 q/ha) but comparable to ZT-CT (79.17 q/ha) and ZT-ZT (74.72 q/ha). Sub plot treatment such as 100% N through VC recorded higher (88.91 q/ha) green pod yield than 100% N through FYM (67.14 q/ha) and 75% N through FYM + 25% N through VC (78.92 q/ha) while remain at par with 50% N through FYM + 50% N through VC (82.76 q/ha). This might be due to conventional tillage increases the transmission of air and water and modify soil structure by changing physical properties of the soil. Moreover, superiority of vermicompost over farmyard manure might be due to its nutritional richness, quick mineralization and more availability of nitrogen and other plant nutrients (Mujahid and Gupta, 2010) [14]. System yield was also found significantly maximum (106.77 q/ha) in CT-CT remained at with CT-ZT (103.93 q/ha) and significantly superior to rest of the treatments. Among organic nutrient management 100% N through VC gave significant maximum value (113.16 q/ha) which was comparable to rest of the treatments (Upasani *et al*. 2017) [17].

Mechanical analysis (soil texture)

Sand, silt and clay percent of the soil after two years of experiment, are shown in Table 2. Examination of data revealed non-significant effect of tillage and organic nutrient management on sand percentage of the soil. Initial sand percentage of the soil at the start of the experiment was 60.80%. It varied from 60.80 to 60.75% in main plot and sub plot treatments. Highest sand percentage of the soil was noticed in ZT-ZT (60.80%) and lowest in CT-CT (60.75%). Among organic nutrient management, 100% N through FYM performed best (60.80%) whereas, 100% N through VC gave the minimum (60.75%) sand percent. There was no increase in sand percentage of soil as compared to initial value. The sand percent was less in CT-CT, because repeated ploughing of the soil breaks the sand particles into silt and clay particles. No disturbance to soil and more content of organic matter (*i.e*. application of 100% N through FYM) increased the sand percent in ZT-ZT as compared to CT-CT. Results revealed no significant effect of tillage and organic nutrient management on silt percent of the soil. Initial silt percentage of the soil at the start of the experiment was 22.8%. It varied from 22.82 to 22.80% in main plot and sub plot treatments. Highest silt percentage of the soil was noticed in CT-CT (22.82%) and lowest in ZT-ZT (22.80%). Among organic nutrient management, 100% N through VC performed best (22.82%) whereas, 100% N through FYM gave the minimum (22.80%) silt percentage of soil. Analysis of data with regard to clay percent was found non-significant due to the effect of tillage and organic nutrient management. Initial clay percentage of the soil before the start of the experiment was 16.4%. It varied from 16.43 to 16.40% in tillage and organic nutrient management treatments. Highest clay percentage of the soil was reported in CT-CT (16.43%) and lowest in ZT-ZT (16.40%). In case of organic nutrient management, 100% N through VC gave maximum (16.43%) clay percentage while, 100% N through FYM gave the minimum (16.40%) clay percentage of soil. Silt and clay percent were more in CT-CT and in case of organic source they were found maximum in 100% N through VC, the possible reason behind this was due to physical manipulation of soil through tillage activity in CT-CT and vermicompost was finer than FYM.

Physical analysis

Critical study of the data related to bulk density (Table 3) showed no significant difference on bulk density of soil due to the effect of tillage and organic nutrient management. It ranged from 1.41 to 1.40 Mg/m^2 both in main and sub plot treatments. ZT-ZT recorded maximum bulk density (1.41 Mg/m^2) while, minimum value was noticed in CT-CT (1.40 Mg/m2). In case of organic nutrient management, 100% N through FYM gave maximum (1.41 Mg/m^2) bulk density and minimum was observed in 100% N through VC (1.40 Mg/m^2). Summary of the data related to field capacity exhibited no significant difference on field capacity of soil due to the effect of tillage and organic nutrient management. It varied from 21.37 to 21.34 at 0.03 M Pa in both tillage and organic nutrient management treatments. ZT-ZT recorded maximum field capacity (21.37 at 0.03 M Pa) while, minimum value was noticed in CT-CT (21.34 at 0.03 M Pa). In case of organic nutrient management, 100% N through FYM gave maximum (21.37 at 0.03 M Pa) bulk density and minimum was observed in 100% N through VC (21.34 at 0.03 M Pa). The ploughing and subsequent inter-cultivations in conventional tillage had reduced the bulk density and field capacity as a result of loosened soil particles. Whereas, zero tillage was ascribed to increased soil compaction as a result of no soil disturbance, ploughing and soil crusting. These outcomes corroborated with the findings of Hatti *et al*., (2018) [8]. Higher bulk density was observed in some studies in zero tilled soil than conventionally tilled by Bhattacharyya *et al*., 2006a [2] and Hatti *et al*., (2018) [8]. Findings on permanent wilting point reflected no significant difference on permanent wilting point of soil due to the effect of tillage and organic nutrient management. It ranged from 7.22 to 7.20 at 1.5 M Pa due to these two factors. Maximum permanent wilting point was observed in CT-CT (7.22 at 1.5 M Pa) while, minimum value of permanent wilting point was noticed in ZT-ZT (7.20 at 1.5 M Pa). In case of organic nutrient management, 100% N through VC showed maximum (7.23 at 1.5 M Pa) permanent wilting point and minimum permanent wilting point was observed in 100% N through FYM (7.20 at 1.5 M Pa). Due to conductance of tillage operation in CT-CT and less bulky matter content in 100% N through VC in comparison to FYM increased the permanent wilting point.

Chemical analysis

A close observation of data in Table 4 revealed that soil pH was not affected by tillage and organic nutrient management and showed non-significant variation. Soil pH varied from 5.82 to 5.76 among tillage treatments while, it varied from 5.84 to 5.75 among organic nutrient management treatments. Higher pH of soil was observed in CT-CT (5.82) by using organic nutrient like 100% N through VC (5.84) than other tillage and organic nutrient treatments. Lowest value of soil pH was obtained in ZT-ZT treatment and with respect to organic nutrient 100% N through FYM (5.74 and 5.75 respectively) reported with minimum value. Initial soil pH value was 5.56. These results were similar to the findings of Brady and Weil (2008). It is evident from data regarding soil electrical conductivity that the effect of tillage and organic nutrient management was found to be non-significant. Maximum electrical conductivity (0.043 dS/m) was registered with ZT-ZT and minimum was registered with CT-CT (0.041 dS/m). Among organic nutrient management, electrical conductivity was found highest in 100% N through FYM (0.044 dS/m) and lowest in 100% N through VC (0.041 dS/m). At the beginning of the experiment electrical conductivity was 0.03 dS/m. The level of soil organic carbon is an indicator of the soil health and its production potential. It is one of the most important parameters in soil fertility that determines the quality of soil. Data on soil organic carbon (g/kg) has been presented in Table 4. Perusal of the data revealed that different treatments of tillage and organic nutrient management had no significant effect on organic carbon content of soil. Soil organic carbon varied from 6.38 g/kg to 6.31 g/kg in tillage treatments whereas, it varied from 6.41 g/kg to 6.30 g/kg in organic nutrient management treatments. Highest (6.38 g/kg) value of organic carbon content was observed with ZT-ZT treatment and lowest (6.31 g/kg) in CT-CT treatment. Among nutrient management, 100% N through FYM reported with maximum (6.41 g/kg) soil organic carbon and minimum in 100% N through VC

(6.30 g/kg). It is noticed that there was increase in soil organic carbon as compared to initial value (6.08 g/kg). These outcomes corroborated with the findings of Hatti *et al*., (2018) [8] and Liu *et al*. (2013) [11]. Data on available nitrogen after two years of experiment, has been shown in Table 5. Critical examination of data revealed non-significant effect of tillage and organic nutrient management on available nitrogen of soil. Initial available nitrogen of soil at the start of the experiment in 2020 was 230.63 kg/ha. Available nitrogen of soil varied from 247.05 kg/ha to 234.95 kg/ha in main plot treatments but in case of sub plot treatments it ranged from 249.39 kg/ha to 231.74 kg/ha. Highest available nitrogen of soil was noticed in ZT-ZT (247.05 kg/ha) and lowest in CT-CT (234.95 kg/ha). Among organic nutrient management, 100% N through FYM performed best (249.39 kg/ha) whereas, 100% N through VC gave the minimum (231.74 kg/ha) available nitrogen of soil. There was increase in available nitrogen of soil as compared to initial value. A close observation of data in Table 5 revealed that available phosphorus of soil after two cropping system (finger millet – French bean cropping system) showed no significant variation under the influence of tillage and organic nutrient management. Available phosphorus of soil before the start of the experiment was 16.92 kg/ha. Available phosphorus of soil varied from 18.14 kg/ha to 17.67 kg/ha in main plot treatments but in case of sub plot treatments it ranged from 18.18 kg/ha to 17.53 kg/ha. Application of balanced organic nutrient increased available phosphorus of soil. Maximum value of available P of soil was recorded under ZT-ZT (18.14 kg/ha) and minimum under CT-CT (17.67 kg/ha). On the other hand, application of 100% N through FYM gave highest (18.18 kg/ha) available phosphorus of soil and lowest (17.53 kg/ha) was observed in 100% N through VC. Available potassium after completion of the experiment is explained in the Table 5. No significant effect of tillage and organic nutrient management on available potassium of soil was observed. Initial value of available potassium of soil prior to the execution of the experiment in 2020 was 186.32 kg/ha. Available potassium of soil varied from 197.86 kg/ha to 191.38 kg/ha due to tillage effect whereas, it ranged from 198.92 kg/ha to 190.52 kg/ha due to organic nutrient effect. Highest (197.86 kg/ha) available potassium of soil was noticed under ZT-ZT but lowest under CT-CT (191.38 kg/ha). However, 100% N through FYM produced maximum (198.92 kg/ha) available potassium and minimum with the application of 100% N through VC. There was addition of available potassium in soil as compared to initial value. This may be due to lower uptake of nutrients and lower yield, which leads to lower utilization of nutrients present in soil and makes more availability to the next subsequent crop. The soil application with recommended organic manure application will improve the soil fertility and availability of nutrients through slow mineralization and slow release of nutrients which in turn results in availability of nutrients throughout the growing period of the crop. These results are conformity with Dhawan *et al*., (1992) [7] and Upasani *et al*., (2017) [17].

Biological analysis

Table 6 revealed no significant effect of tillage and organic nutrient management on bacterial population of soil sample after the end of the experiment. Treatment ZT-ZT recorded maximum value of bacterial population of soil (14.42 x 10^6 CFU/ g soil). Minimum value of bacterial population was observed under CT-CT (13.49 x 10^6 CFU/g soil). Organic nutrient management like 100% N through FYM was noticed with highest value (14.45 x 10^6 CFU/g soil) of bacterial population in soil and lowest in 100% N through VC (13.38 CFU/g soil). There was an increase in bacterial population after experimentation as compared to initial value (12.24 x 10^6 CFU/g soil). Fungal population was depicted in Table 6 that revealed no significant effect of tillage and organic nutrient management on fungal population of soil after completion of the experiment. Treatment ZT-ZT recorded maximum value of fungal population of soil (33.34 x 10^4 CFU/ g soil). Minimum value of fungal population was observed under CT-CT (30.47 x 10^4 CFU/g soil). Organic nutrient management like 100% N through FYM was noticed with highest value (33.44 x 10^4 CFU/g soil) of fungal population in soil and lowest in 100% N through VC (30.36 x 10^4 CFU/g soil). As compared to the initial value (23.16 x 10^4 CFU/g soil) the population of fungai increased after the experimentation. No significant effect of tillage and organic nutrient management on actinomycetes population of soil sample after the end of the experiment (Table 6) was observed. Tillage practice ZT-ZT recorded maximum value of actinomycetes population of soil (8.44 x 10^6 CFU/ g soil). Minimum value of actinomycetes population was observed under CT-CT (7.74 x 10^6 CFU/g soil). Organic sources like 100% N through FYM was noticed with highest value (8.46 x 10^6 CFU/g soil) of actinomycetes population in soil and lowest in 100% N through VC (7.63 CFU/g soil). The population of actinomycetes enhanced in comparison to initial value (12.24 x 10^6 CFU/g soil) after two years of experimentation. The increase in microbial population under ZT-ZT and by the application of organic source i.e. 100% N through FYM might be due to favourable soil condition for better growth and activities of micro-organisms. The crop roots also release many types of organic acids as an easily available source of food for soil micro-organisms. The addition of organic matters increased the microbial counts might be due to carbon addition and change to congenial physico–chemical conditions in soil. Population of microorganism in soil is character specific of the quality of organic matter and thus, controls storage, recycle and energy level of nutrients as productivity indicator of the soil. Hatti *et al*., (2018) [8] and Vengatsan *et al*., (2021) [18] also advocated the same.

Table 1: Yield of finger millet, green French bean and system as influenced by tillage and organic nutrient management in finger millet – French bean cropping system

A. Tillage Practice	Finger millet yield (q/ha)	Green french bean yield (q/ha)	System yield (q/ha)
CT-CT	23.90	82.87	106.77
CT-ZT	22.95	80.98	103.93
ZT-CT	21.18	79.17	100.34
ZT-ZT	19.87	74.72	94.59
S.Em±	0.33	0.69	0.73
CD (P=0.05)	1.39	2.90	3.06
B. Organic Manure Management			
100% N through FYM	18.72	67.14	85.86
100% N through Vermicompost	24.25	88.91	113.16
50% N FYM + 50% N Vermicompost	22.80	82.76	105.56
75% N FYM + 25% N Vermicompost	22.14	78.92	101.06
S.Em±	0.45	2.13	2.23
CD (P=0.05)	1.51	7.19	7.54
CV%	7.06	9.28	7.62
Interaction (A x B)			
S.Em±	0.84	3.75	3.93
CD (P=0.05)	NS	NS	NS

Table 2: Sand, silt and clay content in soil after two years of experimentation as influenced by tillage and organic nutrient management in finger millet – French bean cropping system

A. Tillage Practice	Sand (%)	Silt (%)	Clay (%)
CT-CT	60.75	22.82	16.43
CT-ZT	60.76	22.82	16.42
ZT-CT	60.77	22.81	16.42
ZT-ZT	60.80	22.80	16.40
S.Em±	0.91	0.78	0.02
CD (P=0.05)	NS	NS	NS
B. Organic Nutrient Management			
100% N through FYM	60.80	22.80	16.40
100% N through Vermicompost	60.75	22.82	16.43
50% N FYM + 50% N Vermicompost	60.76	22.82	16.42
75% N FYM + 25% N Vermicompost	60.78	22.81	16.41
S.Em±	0.86	0.33	0.28
CD (P=0.05)	NS	NS	NS
CV%	4.88	5.03	5.89
Interaction (A x B)			
S.Em±	1.74	0.97	0.48
CD (P=0.05)	NS	NS	NS
Initial Value	60.80	22.80	16.40

Table 3: Bulk density, field capacity and Permanent wilting point of soil after two years of experimentation as influenced by tillage and organic nutrient management in finger millet – French bean cropping system

A. Tillage Practice	Bulk Density (Mg/m^3)	Field Capacity at 0.03 M Pa	Permanent wilting point at 1.5 M Pa
CT-CT	1.40	21.34	**7.22**
CT-ZT	1.40	21.35	7.21
ZT-CT	1.41	21.36	7.21
ZT-ZT	1.41	21.37	7.20
S.Em±	0.02	0.38	0.14
CD (P=0.05)	NS	NS	NS
B. Organic Nutrient Management			
100% N through FYM	1.41	21.37	7.20
100% N through Vermicompost	1.40	21.34	7.23
50% N FYM + 50% N Vermicompost	1.40	21.35	7.22
75% N FYM + 25% N Vermicompost	1.41	21.36	7.21
S.Em±	0.02	0.27	0.11
CD (P=0.05)	NS	NS	NS
CV%	3.91	4.37	5.30
Interaction (A x B)			
S.Em±	0.04	0.61	0.24
CD (P=0.05)	NS	NS	NS
Initial Value	1.41	21.33	7.19

Table 4: Soil pH, electrical conductivity and organic carbon after two years of experimentation as influenced by tillage and organic nutrient management in finger millet – French bean cropping system

A. Tillage Practice	pH	EC (dS/m)	OC (g/kg)
CT-CT	5.82	0.041	6.31
CT-ZT	5.81	0.042	6.34
ZT-CT	5.79	0.042	6.36
ZT-ZT	5.76	0.043	6.38
S.Em±	0.06	0.00	0.06
CD (P=0.05)	NS	NS	NS
B. Organic Nutrient Management			
100% N through FYM	5.75	0.044	6.41
100% N through Vermicompost	5.84	0.041	6.30
50% N FYM + 50% N Vermicompost	5.80	0.042	6.33
75% N FYM + 25% N Vermicompost	5.79	0.043	6.35
S.Em±	0.08	0.00	0.07
CD (P=0.05)	NS	NS	NS
CV%	4.89	5.11	3.95
Interaction (A x B)			
S.Em±	0.16	0.00	0.14
CD (P=0.05)	NS	NS	NS
Initial Value	5.56	0.03	6.08

Table 5: Available NPK in soil after two years of experimentation as influenced by tillage and organic nutrient management in finger millet – French bean cropping system

A. Tillage Practice	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
CT-CT	234.95	17.67	191.38
CT-ZT	238.86	17.74	193.35
ZT-CT	242.30	17.89	196.25
ZT-ZT	247.05	18.14	197.86
S.Em±	4.25	0.40	2.81
CD (P=0.05)	NS	NS	NS
B. Organic Manure Management			
100% N through FYM	249.39	18.18	198.92
100% N through Vermicompost	231.74	17.53	190.52
50% N FYM + 50% N Vermicompost	237.88	17.76	193.43
75% N FYM + 25% N Vermicompost	244.14	17.97	195.96
S.Em±	5.00	0.34	2.95
CD (P=0.05)	NS	NS	NS
CV%	7.19	6.60	5.25
Interaction (A x B)			
S.Em±	9.64	0.71	5.84
CD (P=0.05)	NS	NS	NS
Initial Value	230.63	16.92	186.32

Table 6: Bacteria, Fungi and Actinomycetes in soil after two years of experimentation as influenced by tillage and organic nutrient management in finger millet–French bean cropping system

A. Tillage Practice	Bacteria (x 10^6 CFU/g soil)	Fungi (x 10^4 CFU/g soil)	Actinomycetes (x 10^6 CFU/g soil)
CT-CT	13.49	30.47	7.74
CT-ZT	13.71	31.60	7.92
ZT-CT	14.01	32.27	8.12
ZT-ZT	14.42	33.34	8.44
S.Em±	0.42	0.79	0.17
CD (P=0.05)	NS	NS	NS
B. Organic Nutrient Management			
100% N through FYM	14.45	33.44	8.46
100% N through Vermicompost	13.38	30.36	7.63
50% N FYM + 50% N Vermicompost	13.78	31.75	7.96
75% N FYM + 25% N Vermicompost	14.02	32.13	8.17
S.Em±	0.31	0.75	0.16
CD (P=0.05)	NS	NS	NS
CV%	7.74	8.15	6.98
Interaction (A x B)			
S.Em±	0.68	1.52	0.33
CD (P=0.05)	NS	NS	NS
Initial Value	12.24	23.16	6.83

Conclusion

On the basis of two years experiment, it can be concluded that conventional tillage-conventional tillage practice increased the finger millet yield, green French bean yield and system yield. Among organic nutrients, 100% N through VC increased the finger millet yield, green French bean yield and system yield. Improved soil properties *viz*., bulk density, field capacity, permanent wilting point, soil pH, electrical conductivity, organic carbon, available NPK and microbial (bacteria, fungi and actinomycetes) population were realized under conservation tillage practice (zero tillage). Application of organic sources like 100% N through FYM also increased the physical, chemical and biological properties of the soil.

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