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Effect of organic manures and crop residue management on physical, chemical and biological properties of soil under pigeonpea based intercropping system

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ABSTRACT

A field experiment was conducted to study the effect of organic manures (FYM and pigeonpea stalk) along with phosphocompost on physico-chemical and biological properties of soil in pigeonpea based intercropping system at Pulses Research Unit, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra during Kharif season of 2013-14 on inceptisol. The results revealed that lower bulk density, pH and electrical conductivity, higher organic carbon and available N, P, K and significantly highest soil microbial biomass carbon (SMBC) and microbial population (fungal, bacterial and actinomycetes) were observed in pigeonpea + blackgram and pigeonpea + greengram intercropping over sole pigeonpea system. Among combined use of organic manure, FYM + phosphocompost and pigeonpea stalk + phosphocompost resulted in improvement of physical, chemical and biological properties of soil over recommended dose of fertilizer (RDF) application.

Keywords: Intercropping; organic manure; microbial count; SMBC

INTRODUCTION

Pigeonpea, *Cajanus cajan* (L) Millsp ranks second in India after chickpea with respect to area and production. In Maharashtra its area is 11.80 lakh ha with production of 9.66 lakh tonnes (Anon 2014). One of the reasons for its low and unstable yield is low or no use of fertilizers. Of late there is a growing interest among the farmers to cultivate crops under organic farming because of the escalating cost of inorganic fertilizers, decreased soil fertility, environmental and health concerns due to pesticide usage and expected premium prices for organically grown crops (Ramesh et al 2005). One of the important aspects of organic farming is the soil fertility

or nutrient management to optimize the crop productivity. The use of manures from livestock and the composts prepared from farm wastes is an important way of recycling nutrients to the soil. The management of manures within a crop rotation can have large effects on yield and crop quality (Stein-Bachinger and Werner 1997). Organic manures influence soil productivity through their effect on soil physical, chemical and biological properties (Watson et al 2002). The present experiment was therefore conducted to study the effect of different organic nutrient sources on the growth and yield of pigeonpea-based intercropping system and their influence on soil fertility.

MATERIAL and METHODS

A field experiment was conducted at Pulses Research Unit, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra (220 42' North latitude and 770 02' East longitude and at an altitude of 307.42 m amsl) during Kharif season of 2013-14 on inceptisol. The initial soil was medium clayey in texture, medium in organic carbon (0.53), available nitrogen (167.6 kg/ha), available phosphorous (19.6 kg/ha), available potassium (422 kg/ha) and sulphur (10.2 ppm) with pH 8.10 and electrical conductivity (EC) 0.16 dS/m. The experiment was laid out in split plot design with three replications consisting of three cropping systems viz pigeonpea + greengram, pigeonpea + blackgram and sole pigeonpea, three levels of organic manures viz farm yard manure (FYM) + pigeonpea stalk, FYM + phosphocompost and recommended dose of fertilizers (RDF) (Table 1). Pigeonpea variety PKV TARA, greengram variety PKV Greengold and blackgram variety PKV Udid-15 were sown. Average rainfall was 591.3 mm during crop period. The crops were sown on 1 July 2013 and harvested at their physiological maturity. The intercrops were incorporated within the interspaces after picking of pods of greengram and straw of blackgram after threshing. The seed and straw samples were analysed for nutrient content by standard procedure given by Piper (1966). The organic manures like FYM, pigeonpea stalk (chopped to 1-2 cm pieces) and phosphocompost were incorporated a day before sowing and inorganic fertilizers during sowing. The NPK concentration of soil was analysed with standard methods given by Jackson (1973) and microbial count was determined by serial dilution technique (Dhingra and Sinclair 1995). The intercrops were sown with intra row spacing of 45 cm. Statistical analysis of data was carried out using standard analysis of variance (Gomez and Gomez 1984). The significance of the treatment effect was determined using the F-test. To determine the significance of the difference between the means of two treatments least significant difference was computed at 5 per cent probability level.

RESULTS and DISCUSSION

Physical properties

Among intercropping systems pigeonpea + greengram, pigeonpea +

Table 1. Chemical composition and quantity of nutrients added to soil through various sources

Organic manure/fertilizer	Nutrient content of organic sources (%)			Quantity of nutrients added in soil (kg/ha)		
	N	P	K	N	P	K
25% N through FYM (12.50 q/ha)	0.48	0.20	0.44	6.25	2.50	5.50
Phosphocompost (24.4 q/ha)	1.23	1.94	0.70	30.25	47.35	17.08
25% N through pigeonpea stalk (4.46 q/ha)	1.40	0.20	0.89	6.25	0.90	4.00
Phosphocompost (25 q/ha)	1.23	1.94	0.70	30.75	48.50	17.50
100% RDF	-	-	-	25	50	-

blackgram and sole pigeonpea did not influence the bulk density significantly. However lower bulk density was noticed with pigeonpea + blackgram (1.30 g/cc) followed by pigeonpea + greengram (1.31 g/cc) intercropping system and sole pigeonpea (1.32 g/cc) (Table 2). The addition of biomass of intercrops and further fallen leaves of base crop (pigeonpea) during the growth period under intercropping system helped in reduction of bulk density (BD). Application of organic manures and crop residue exerted significant reduction in bulk density. The lowest bulk density has been noticed with combine application of FYM + phosphocompost (1.29 g/cc) followed by (1.29 g/cc) pigeonpea stalk + phosphocompost over (1.34 g/cc) RDF alone. Bhatia and Shukla (1982) recorded that addition of organics reduced the bulk density of soil. A similar result was also found by Sharma et al (2000) and Shukla and Tyagi (2009).

Chemical properties

Soil pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium were not significantly influenced by different cropping systems. The lowest soil pH (7.97) and electrical conductivity (0.15 dS/m) were found in pigeonpea + blackgram followed by pigeonpea + greengram intercropping system and sole pigeonpea. Whereas higher organic carbon (5.56 g/kg), available nitrogen (182.8 g/kg), phosphorus (22.5 g/kg) and potassium (431.8 g/kg) were analysed in pigeonpea + blackgram and pigeonpea + greengram intercropping system and lowest available nitrogen, phosphorus and potassium were recorded in sole pigeonpea (Table 2). It might be due to addition of organic matter through biomass of intercrops, root nodules and huge leaf fall decomposition in the system (Srinivasulu et al 2000). The effect of organic manure (FYM), crop residue (pigeonpea stalk) and fertilizer alone on soil pH, electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium was found significant. Lower soil pH (7.96) and electrical conductivity (0.14 dS/m) were found with the application of FYM + phosphocompost over pigeonpea

stalk + phosphocompost and RDF alone. The marginal increase in electrical conductivity in RDF alone might be due to accumulation of soluble salts at the surface where fertilizers were applied alone. The results are in accordance with the findings of Pawar and Patil (2007) and Kumar et al (2008) who reported that pH and EC reduced slightly with application of FYM and crop residues while significantly higher organic carbon (5.61 g/kg), available nitrogen (183.9 kg/ha), phosphorus (23.4 kg/ha) and potassium (431.9 kg/ha) were recorded in FYM + phosphocompost and pigeonpea stalk + phosphocompost over RDF alone. Increase in availability of N in soil with application of organic manure might be due to increase in nodulation, release of higher amount of N compounds by root nodules at early stage of crop growth and their subsequent decomposition at later stage.

Further increase in available N due to organic materials application might also be attributed to the greater multiplication of microbes caused by the addition of organic materials for the conversion of organically bound N to inorganic form. Similar result was found by Walia and Kler (2006) and Patra et al (2011) who reported that application of organic manure significantly increased available nitrogen. It is evident that the application of organic manure with phosphocompost resulted in an increase in available phosphorus content in soil. The built up of available phosphorus was higher in these organic manure treated plots that might be due to release of organic acid during microbial decomposition of organic matter which might have helped in the solubility of native phosphates thus increasing available phosphorus pool in the soil. In addition the organic anions compete with phosphate ions for the binding sites on the soil particles. The complex organic anions chelate Al^{+3}, Fe^{+3} and Ca^{+3} and thus decrease the phosphate precipitating power of these cations thereby increasing the phosphorus availability. The result is in close agreement with that of Patra et al (2011) who reported that phosphocompost when applied either solely or in combination (poultry manure, neem cake, vermicompost) with organic manure and also with the result of Singh et al (2012).This might be due to the reason that application of organic manure secreted organic acid during process of decomposition which led to mineralization of the fixed potassium and increased the availability of potassium. Moreover humus retains divalent cations (Ca^{++}, Mg^{++}) more strongly than the monovalent cations. Weaker retention of potassium relative to Ca and Mg may increase K availability.

Biological properties

Effect of different intercropping systems was found significant on soil microbial biomass carbon (Table 3, Plate 1 and 2). The significantly highest SMBC (222.00 µg/g) was observed under pigeonpea + blackgram and pigeonpea +

Table 2. Effect of cropping systems and organic manures on physical and chemical properties of soil

Treatment	BD (g/cc)	pH	EC (dS/m)	OC (g/kg)	Available nutrient (kg/ha)		
					N	P	K
Main plot (cropping system)							
C_1- PP + GG (1:2)	1.31	7.98	0.15	5.46	182.6	22.4	431.7
C_2- PP + BG (1:2)	1.30	7.97	0.15	5.56	182.8	22.5	431.8
C_3- Sole PP	1.32	7.99	0.16	5.36	181.3	21.8	426.2
SEm±	0.01	0.01	0.01	0.06	0.95	0.68	1.30
$CD_{0.05}$	NS	NS	NS	NS	NS	NS	NS
Sub-plot (organic manure)							
M_1- 25% N through FYM (12.5 q/ha) + PC (24.4 q/ha)	1.29	7.96	0.14	5.61	183.9	23.4	431.9
M_2- 25% N through PP stalk (4.46 q/ha) + PC (25 q/ha)	1.29	7.97	0.15	5.49	182.7	22.4	430.5
M_3- RDF (25:50 kg N: P_2O_5/ha)	1.34	8.02	0.16	5.27	180.1	20.9	427.4
SEm±	0.01	0.01	0.004	0.03	0.94	0.55	0.99
$CD_{0.05}$	0.03	0.05	0.01	0.10	2.91	1.71	3.10
Interaction (main plot × sub-plot)							
SEm±	0.02	0.03	0.01	0.06	1.63	0.96	1.72
$CD_{0.05}$	NS	NS	NS	NS	NS	NS	NS
Initial	1.34	8.10	0.16	5.30	167.6	19.6	422.8

PP= Pigeonpea, GG= Greengram, BG= Blackgram, PC= Phosphocompost, FYM= Farm yard manure, RDF= Recommended dose of fertilizers, BD= Bulk density, EC= Electrical conductivity, OC= Organic carbon

Table 3. Effect of cropping systems and organic manures on soil microbial biomass carbon (SMBC) and microbial count

Treatment	SMBC (µg/g soil)		Microbial count					
			Fungi (10^4 cfu/g soil)		Bacteria (10^7 cfu/g soil)		Actinomycetes (10^6 cfu/g soil)	
	Initial	At harvest	Initial	At harvest	Initial	At harvest	Initial	At harvest
Main plot (cropping system)								
C_1- PP + GG (1:2)	180.90	220.64	5.22	7.67	40.22	52.11	21.22	32.22
C_2- PP + BG (1:2)	180.70	222.00	5.00	8.22	41.22	54.33	21.56	35.33
C_3- Sole PP	180.18	187.39	4.78	6.89	39.22	45.78	19.11	25.00
SEm±	1.68	1.30	0.44	0.26	2.92	1.64	1.43	2.00
$CD_{0.05}$	NS	5.13	NS	0.95	NS	6.46	NS	7.83
Sub-plot (organic manure)								
M_1- 25% N through FYM (12.5 q/ha) + PC (24.4 q/ha)	180.54	217.23	4.89	8.22	40.33	54.33	20.11	35.67
M_2- 25% N through PP stalk (4.46 q/ha) + PC (25 q/ha)	180.42	215.73	5.11	7.78	39.78	52.00	20.78	31.00
M_3- RDF (25:50 kg N: P_2O_5/ha)	180.83	197.07	5.00	6.78	40.56	45.89	21.00	25.89
SEm±	0.64	1.29	0.24	0.25	1.86	1.50	1.34	2.14
$CD_{0.05}$	NS	3.99	NS	0.85	NS	4.64	NS	6.60
Interaction (main plot × sub-plot)								
SEm±	1.10	2.24	0.41	0.47	3.23	2.60	2.33	3.71
$CD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS

PP= Pigeonpea, GG= Greengram, BG= Blackgram, PC= Phosphocompost, FYM= Farm yard manure, RDF= Recommended dose of fertilizers

greengram intercropping system being at par with each other and were found significantly superior over sole pigeonpea. It might be due to addition of biomass of intercrop (greengram and blackgram). Similar observations were recorded by Kumar (2012). Soil microbial biomass carbon was significantly affected due to application of organic manure and crop residue with phosphocompost. Significantly highest SMBC was found with the application of FYM + phosphocompost which was statistically at par with pigeonpea stalk + phosphocompost and significantly superior to chemical fertilizers (RDF). The higher microbial biomass pool size may accumulate after regular addition of manures and crop residues under organic practices. Lundquist et al (1999) observed higher microbial biomass carbon as an indicator of carbon availability in soil under organic practices. This might be due to the supply of additional mineralizable and readily hydrolysable carbon as a result of organic matter application resulting in higher microbial activity and in turn higher microbial biomass carbon. The lowest SMBC was observed with the application of RDF alone. These results are in close conformity with those of Manna et al (2001) and Chandrashekhar (2012).

The effect of intercropping system on (microbial population) fungal, bacterial and actinomycetes population was significant. The results indicated that significantly highest microbial population was recorded with pigeonpea + blackgram closely followed by pigeonpea + greengram compared to sole pigeonpea. This was possibly due to root exudates of base crop (pigeonpea) and intercrops (greengram and blackgram) and incorporation of biomass of intercrops. Further decomposing root tissues and root nodules also provide carbon and energy to the soil microbes resulting in multiplication of microbial population. Similar results were also reported by Sharma and Guled (2012) and Singh et al (2012). Fungal, bacterial and actinomycetes population was significantly affected due to application of organic manures and crop residue with phosphocompost. Highest fungal, bacterial and actinomycetes population was recorded with FYM + phosphocompost and pigeonpea stalk + phosphocompost that was superior over chemical fertilizers. The higher microbial population might be due to the addition of organic manures and crop residue into the soil. Sharma et al (2000) and Shwetha et al (2011) reported that organic treatment recorded higher microbial population than inorganic treatments or absolute control.

Nutrients added to soil through biomass of intercrops and fallen leaves of pigeonpea (Table 4 and 5)

Total nutrient addition was recorded of N and K through sole pigeonpea due to generation of higher straw yield and fallen leaves under sole pigeonpea and higher P through pigeonpea under

Table 4. Biomass of intercrop, fallen leaves of pigeonpea and total biomass added to soil (kg/ha) as influenced by different treatments

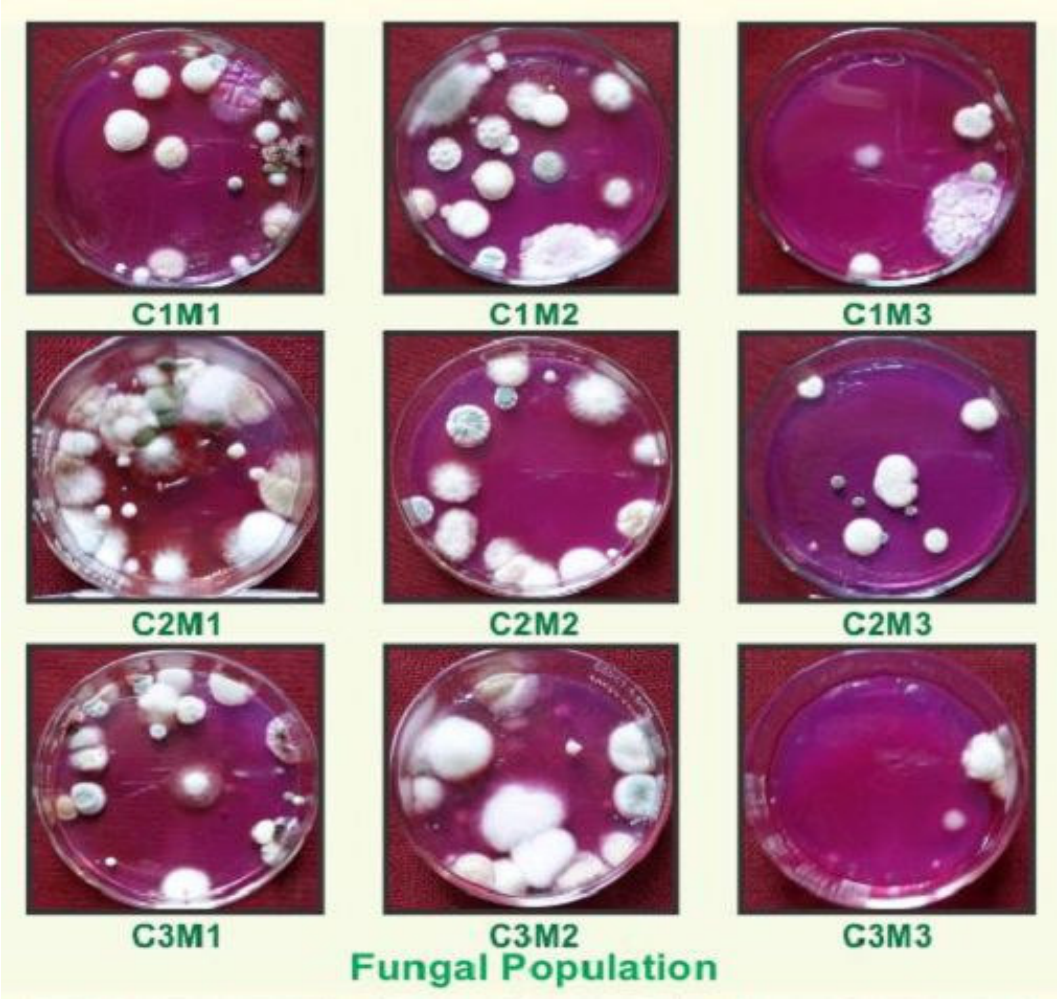
Treatment	Biomass of intercrop		Fallen leaves of pigeonpea	Total biomass added through system
	GG	BG		
Main plot (cropping system)				
C1- PP + GG	862	-	1707	2569
C2- PP + BG	-	999	1787	2786
C3- Sole PP	-	-	2802	2802
Sub-plot (organic manure)				
M_1- 25% N through FYM (12.5 q/ha) + PC (24.4 q/ha)	862	992	2145	3999
M_2- 25% N through PP stalk (4.46 q/ha) + PC (25 q/ha)	855	995	2122	3972
M_3- RDF (25:50 kg N: P_2O_5/ha)	869	1011	2208	4088
GM	862	999	2129	3990

PP= Pigeonpea, GG= Greengram, BG= Blackgram, PC= Phosphocompost, FYM= Farm yard manure, RDF= Recommended dose of fertilizers

Table 5. NPK added through biomass of intercrops, fallen leaves of pigeonpea, total NPK added by system (kg/ha) as influenced by different treatments

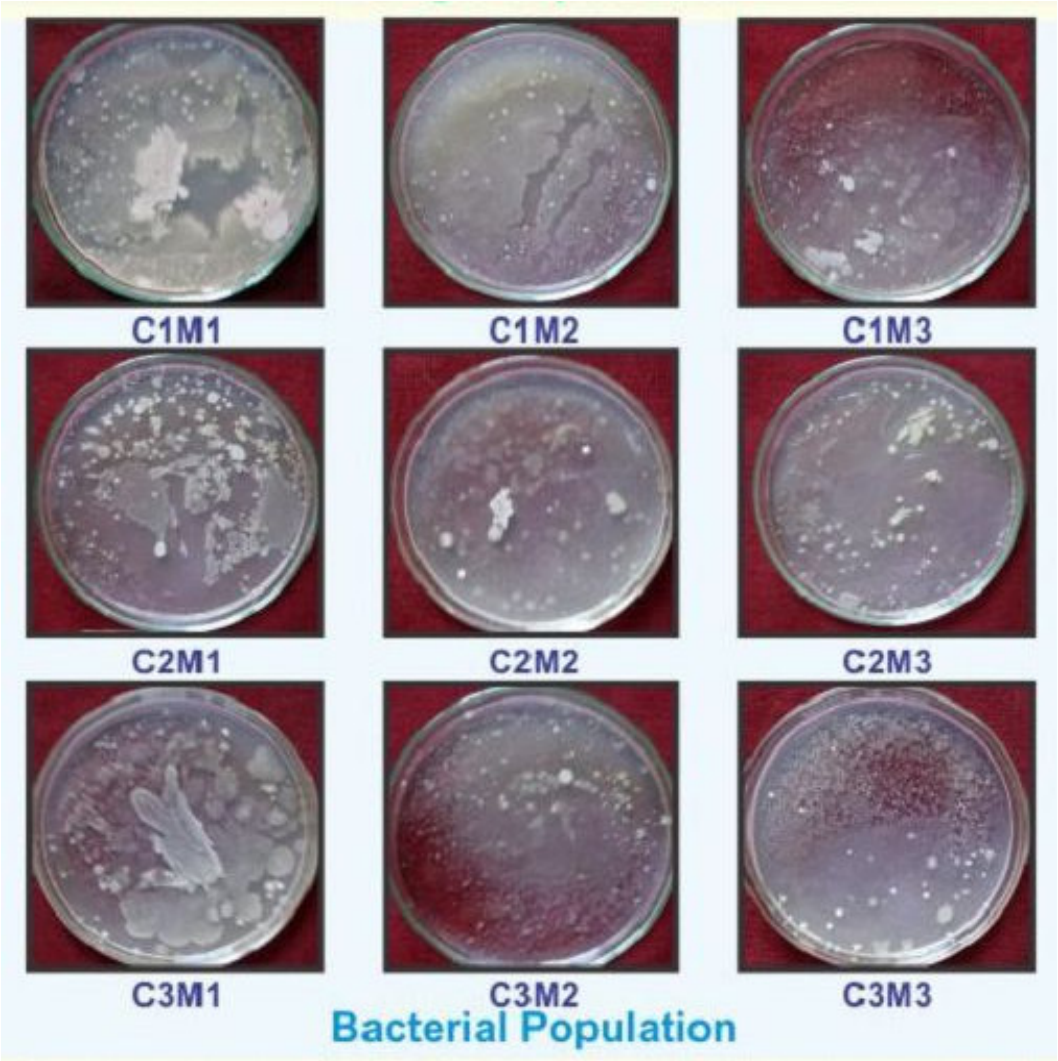
Treatment	Addition through intercrops						NPK added through fallen leaves of pigeonpea			Total NPK added by system		
	GG			BG								
	N	P	K	N	P	K	N	P	K	N	P	K
Main plot (cropping system)												
C1- PP + GG	7.5	4.1	6.8	-	-	-	25.3	5.4	15.6	32.5	9.5	22.4
C2- PP + BG	-	-	-	8.1	4.9	8.2	25.4	5.5	15.7	33.2	10.4	23.9
C3- Sole PP	-	-	-	-	-	-	38.8	8.4	24.4	38.8	8.4	24.4
Sub-plot (organic manure)												
M_1- 25% N through FYM (12.5 q/ha) + PC (24.4 q/ha)	8.9	4.2	7.0	10.2	5.2	8.4	30.2	6.7	18.9	49.2	16.1	34.3
M_2- 25% N through PP stalk (4.46 q/ha) + PC (25 q/ha)	7.2	4.0	6.7	7.4	4.9	8.2	29.9	6.5	18.5	44.3	15.4	33.4
M3- RDF (25:50 kg N:P_2O_5/ha)	6.5	3.9	6.6	6.6	4.6	8.0	29.4	6.1	18.3	42.2	14.6	32.9
G M	7.5	4.1	6.7	8.1	4.9	8.2	29.8	6.4	18.6	40.1	12.4	28.5

PP= Pigeonpea, GG= Greengram, BG= Blackgram, PC= Phosphocompost, FYM= Farm yard manure, RDF= Recommended dose of fertilizers



C1= Pigeonpea + greengram, C2= Pigeonpea + blackgram, C3= Sole pigeonpea,
M1= FYM + phosphocompost, M2= Pigeonpea stalk + phosphocompost, M3= RDF alone

Plate 1. Microbial count (Fungi)



C1= Pigeonpea + greengram, C2= Pigeonpea + blackgram, C3= Sole pigeonpea,
M1= FYM + phosphocompost, M2= Pigeonpea stalk + phosphocompost, M3= RDF alone

Plate 2. Microbial count (Bacteria)

intercropping with blackgram and lowest in pigeonpea + greengram intercropping system. Among organic manures highest total nutrients were added through application of FYM + phosphocompost followed by pigeonpea stalk + phosphocompost over inorganic fertilizers alone. It could be due to higher nutrient content in organic manure.

REFERENCES

Anonymous 2014. Agricultural statistics at a glance. Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. http://www.dacnet.nic.in/eands.

Bhatia KS and Shukla KK 1982. Effect of continuous application of fertilizers and manures on some physical properties of eroded alluvial soil. Journal of the Indian Society of Soil Science **30:** 33-36.

Chandrashekhar Pattar 2012. Effect of different resource conservation technologies on soil properties and productivity of cotton in vertisols. MSc thesis, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharastra, India.

Dhingra DA and Sinclair JB 1995. Basic plant pathology methods. 2nd edn, CRC Press, Boca Raton, Florida, USA.

Gomez KA and Gomez AA 1984. Statistical procedures for agricultural research. John Wiley and Sons, Inc, New York, 680p.

Jackson ML 1973. Soil chemical analysis. Prentice Hall of India Pvt Ltd, New Delhi, India.

Kumar B, Gupta RK and Bhandari AL 2008. Soil fertility changes after long-term application of organic manures and crop residues under rice-wheat system. Journal of Indian Society of Soil Science **56(1):** 80-85.

Kumar R 2012. Effect of conservation tillage on growth, yield and quality of pigeonpea based intercropping system under rainfed. MSc thesis, Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharastra, India.

Lundquist EJ, Scow KM, Jackson LE, Uesugi SL and Johnson CR 1999. Rapid response of soil microbial communities from conventional low-input and organic farming system to a wet/dry cycle. Soil Biology and Biochemistry **31:** 1661-1675.

Manna MC, Ghosh PK, Ghosh BN and Singh KN 2001. Comparative effectiveness of phosphate-enriched compost and single super phosphate on yield, uptake of nutrients and soil quality under soybean-wheat rotation. Journal of Agricultural Sciences **137:** 45-54.

Patra PS, Sinha AC and Mahesh SS 2011. Yield, nutrient uptake and quality of groundnut (*Arachis hypogaea*) kernels as affected by organic sources of nutrient. Indian Journal of Argonomy **56(3):** 237-241.

Pawar RB and Patil CV 2007. Effect of vermicompost and fertilizer levels on soil properties, yield and uptake of nutrients by maize. Journal of Maharashtra Agricultural Universities **32(1):** 11-14.

Piper CS 1966. Soil and plant analysis, Hans Publication, Bombay, Asian edn, pp 368-374.

Ramesh P, Singh M and Subba Rao A 2005. Organic farming: its relevance to the Indian context. Current Science **88(4):** 561-568.

Sharma A and Guled MB 2012. Effect of set-furrow method of cultivation in pigeonpea + greengram intercropping system in medium deep black soil under rainfed conditions. Karnataka Journal of Agricultural Sciences **25(1):** 18-24.

Sharma MP, Bali SV and Gupta DK 2000. Crop yield and properties of inceptisol as influenced by residue management under rice-wheat cropping sequence. Journal of the Indian Society of Soil Science **48(3):** 506-509.

Shukla L and Tyagi SP 2009. Effect of integrated application of organic manures on soil parameters and growth of mungbean (*Vigna*

radiata). Indian Journal of Agricultural Sciences **79(3):** 174-177.

Shwetha S, Narayana J, Shwetha BV and Girish R 2011. Effect of vermicompost on soil bacterial and fungal populations in rice crop (*Oryza sativa* L). Mysore Journal of Agricultural Sciences **45(1):** 7-10.

Singh A, Singh VK, Chandra R and Srivastava PC 2012. Effect of integrated nutrient management on pigeonpea-based intercropping system and soil properties in mollisols of the Tarai Region. Journal of the Indian Society of Soil Science **60(1):** 38-44.

Srinivasulu K, Singh RP and Madhavi K 2000. Performance of rainfed pigeonpea-based intercropping systems under varying plantings. Crop Research **20:** 56-61.

Stein-Bachinger K and Wemer W 1997. Effect of manure on crop yield and quality in an organic agricultural system. Biological Agriculture and Horticulture **14:** 221-235.

Walia SS and Kler DS 2006. Effect of farm yard manure on soil properties in maize-wheat system. Punjab Agricultural University Journal of Research **43(4):** 292-295.

Watson CA, Atkinson D, Gosling P, Jackson LR and Rayns FW 2002. Managing soil fertility in organic fanning systems. Soil Use and Management **18:** 239-247.

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