International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 560-565

Received: 18-07-2020
Accepted: 20-08-2020

AJ Suvarna Latha
Assistant Professor,
Department of Soil Science and Agricultural Chemistry,
Agricultural College, Bapatla, Guntur, Andhra Pradesh, India

Dr. N Trimurtulu
ANGRAU, Special Officer APGC, LAM, Guntur, Andhra Pradesh, India

Corresponding Author:
AJ Suvarna Latha
Assistant Professor,
Department of Soil Science and Agricultural Chemistry,
Agricultural College, Bapatla, Guntur, Andhra Pradesh, India

Integrated effect of bio fertilizers, organic manures and inorganic fertilizers on growth & yield of chickpea

AJ Suvarna Latha and Dr. N Trimurtulu

DOI: https://doi.org/10.22271/chemi.2020.v8.i5h.10355

Abstract
A field experiment was conducted on vertisols of Agricultural Research Station, Amaravathi, Guntur dt, Andhra Pradesh during rabi of 2017-18 & 2018-19 to find out the influence of bio fertilizers and organic manures on growth and yield of chickpea. A desi variety JG-11 was grown in *Rabi* in Krishna zone. All six treatments were randomly allocated and replicated thrice in a randomized block design The results of the study indicates that even though soil pH, EC not significantly varied, significant variation in yield is attributed to the increased uptake of N and P. Application of bio fertilizers influenced the dry matter accumulation at all growth stages and yield of chickpea. Higher dry matter accumulation and yield of chickpea was recorded with 100% RDF (20:50:0:40) followed by 50% RDF + vermicompost@2.5 t ha^{-1} + Rhizobium + PSB @2kg ha^{-1} applied to chickpea during both the years of experimentation. Proliferation of microbial population was observed in organic manure treated plots.

Keywords: Bio fertilizers, rhizobium, PSB, chickpea

Introduction

Chickpea (*Cicer arietinum* L) is crop grown in most of the rainfed areas in Guntur and Prakasam districts of Andhra Pradesh during *Rabi*. It is cultivated because of its low cost of cultivation. It is a legume crop with assured income generation and a source of soil fertility build up through nitrogen incorporation. Chickpea is also a dominant crop in organic cropping systems. To be sustainable, organic farming need to be self-sufficient in nitrogen through the fixation of atmospheric nitrogen by legumes and also application of organic manures such as farm yard manure and vermicompost. It is often reported that application of organic manure improved the soil physical properties, protect soil from erosion, and also increase soil organic matter content and in turn soil fertility. In order to reduce the fertilizer application and to improve the soil characteristics it is essential to apply organic manures to the soil. It also helps in improving soil health and enhances crop production. Most of the mineral fertilizers added to soil consist of concentrated soluble nutrients that will impact short term microbial activity. The concentrated salt around a dissolving fertilizer granule or band can cause temporary osmotic stress to nearby microorganisms until the nutrients diffuse in to the soil. Balanced fertilizer did not significantly influenced the diversity of bacterial population which are specific to important N transformations. An analysis by Geissler and Scow (2014) [4] reported that mineral N fertilizer application was associated with an average13% increase in soil organic carbon compared with unfertilized control soils.

Nitrogen and phosphorus are the major nutrients required for increasing yield potential. Phosphorus is present as mineral deposits are nonrenewable natural resources. There is a concern about energy and growing costs involved in mining rock phosphate and its transportation costs.

Bio fertilizers are renewable source of fertilizers and a promising source of essential plant nutrients and growth promoting substances. The combined inoculation of Rhizobium and PSB was well studied in increasing nodulation in legume crops and increasing yield by making available the phosphorus from soil. Complex reactions with symbiotic and free living microorganisms are necessary and normal for healthy crop growth. Soil microorganisms interact intimately with plants to stimulate productivity by supplying essential nutrients in a soluble form. Healthy plants in turn stimulate microbial community of the soil through the root exudates they secrete and organic residues they leave behind.

The present study was done to study sustainable soil fertility and evaluate the combined effect of reduced mineral fertilization along with application of biofertilizer and organic manure on chickpea.

Materials & Methods

A field experiment was conducted on clay soils of Agricultural Research Station, Amaravathi, and Guntur during rabi of 2017-18 & 2018-19 to find out the influence of bio fertilizers on growth and yield of chickpea which is a desi variety JG-11 under rainfed agro-climatic condition of Krishna zone. The climate is sub-tropical with mean annual rainfall of 950 mm. The soil of experimental field was clay in texture, slightly alkaline in reaction (pH 7.9 to 8.2). Low in available N (152 kg ha^{-1}), medium in P_2O_5 (16.5 kg ha^{-1}) and high in K_2O (320 kg ha^{-1}) and low in organic carbon (0.21%) respectively. All treatments were randomly allocated and replicated four times in a randomized block design was adopted for both years of the experimentation. Farm yard manure was applied@10 t ha^{-1} in treatment receiving Rhizobium and PSB and compared with vermicompost treated plot with the application of 2.5 t ha^{-1}.Application of chemical fertilizers @50% along with FYM and Vermicompost were also studied. These treatments were compared with 100% RDF and control. The experiment consists of six treatments viz.

T1: FYM @ 10 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}
T2: Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}
T3: 50% RDF + FYM@ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}
T4: 50% RDF+ Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}
T5: 100% RDF (20:50:0:40)
T6: Control

The soil properties were studied at the beginning of the experiment.

Table 1: Initial soil properties

Texture	Clay (Sand: 12%, Silt: 21 Clay: 67%)
Bulk density(Mg m^{-3})	1.31
Water Holding Capacity	47%
Soil pH	8.1
Soil EC (dSm^{-1})	0.22
Soil OC (%)	0.23
Soil N(kg ha^{-1})	152
Soil P_2O_5(kg ha^{-1})	16.5
Soil K_2O(kg ha^{-1})	320
microbial population	3 CFU X10^6

Soil reaction (pH) was measured by glass electrode pH meter in 1:2.5 ratio of soil water suspension (Jackson, 1973) [5] Bulk density of soils after harvest was determined by clod method (Dastane, 1967) [4]. Water holding capacity was estimated by Keen cup method as described by Sankaram (1966) [15]. Electrical Conductivity is measured in supernatant liquid of 1:2.5 soil water suspension by using electrical conductivity meter (Jackson, 1973) [5]. Walkley and Black's (1934) [19] wet digestion method as given by Jackson (1973) [5] was followed to determine the organic carbon content of the soils at harvest. Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit (Subbiah and Asija, 1956) [18]. Available P was estimated using Olsen's reagent (Olsen *et al*., 1954) [20], and spectrophotometer as described by Watanabe and Olsen (1965) [20] and Available K estimated with the help of flame photometer (Jackson, 1973) [5].

Results & Discussion

Effect of integrated use of organic and inorganic fertilizers along with biofertlizers on available nutrient status

Data pertaining to soil available nutrients are presented in table 6. The results showed a significant increase in soil available nitrogen by application of biofertilizers, organic manures and inorganic fertilizers. The highest soil nitrogen was observed in 100% RDF (T5). However treatment receiving 50% RDF + Rhizobium + PSB + Vermicompost@2.5Kg ha^{-1} was on par with treatment with 100%RDF. Similar results were obtained by Yuvaraj (2016) who reported that combined application of inorganic fertilizers and bio fertilizers increased the available nitrogen in soil.

Phosphate solubilizing bacteria (PSB) are used as bio fertilizers since 1950s. These microorganisms secrete different types of organic acids like carboxylic acid thus lowering the pH in the rhizosphere and consequently dissociate the bound forms of phosphate like $Ca(PO_4)_2$ in calcareous soils. Before sowing, seeds were treated with Rhizobium cultures in T1, T2, T3 and T4 treatments @10 ml per kg. Soil cores from 0-15 cm of each plot were collected for and routine soil analysis was done.

Effect of integrated use of organic and inorganic fertilizers along with biofertlizers on soil physico-chemical properties:

In this study, the pH in different treatments at harvest ranges between 7.9 to 8.2. Electrical conductivity in response to application of organic, inorganic and biofrtilizers varied between 0.20 to 0.28dSm-^{1}. Highest EC was recorded by treatment receiving 100% RDF, followed by treatments receiving 50% RDF+ FYM@ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1} and 50% RDF + Vermicompost@2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}. The results obtained show that there is no significant difference among treatments in soil pH, soil texture and bulk density but OC and water holding capacity were higher in treatments receiving50% RDF + Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1} and 50% RDF + FYM@ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}.

Effect of integrated use of organic and inorganic fertilizers along with biofertlizers on growth parameters

Higher dry matter accumulation and grain yield of chickpea was recorded with 100% RDF(20:50:0:40) (table:2) and the highest yield of chickpea was recorded with 100% RDF followed by 50% RDF + Vermicompost@2.5 t ha^{-1} + Rhizobium + PSB @5kg ha^{-1}applied to chickpea during both the years of the experimentation. Application of biofertilizers influenced the dry matter accumulation at 45 DAS as well as at harvest of the crop. PSB along with effective *Rhizobium* spp. enhanced the chickpea nodulation (table: 2) and nitrogen fixation, which resulted in supplementation of more nitrogen to the crop. Rhizobium and Brady rhizobium are responsible for fixing atmospheric Nitrogen in to ammonium-based compounds for plant nutrition. They are responsible for the increase in yield of Bengal gram. The increase in yield is attributed to increase in available phosphorus content which becomes soluble due to the organic acids released from the phosphorus solubilizing bacteria like Pseudomonas and Bacillus sp.

The long term effect of mineral fertilizer inputs on microbial processes was studied in a 160 year field. The result indicates that, although rhizobia can surely persist in soils, their efficacy can be enhanced by carbon addition in the form of organic matter. Here vermicompost treatment proved better than farm yard manure in increasing the grain yield of chickpea.

Similar results were obtained by Kanzaria *et al.* (2010) [7] with application of 50%RDF along with 25%compost (2.5tha^{-1}) and 500 kg castor cake produced highest grain yield. Singh *et al.* (1999) [16] reported that application of NPK through chemical fertilizer + farm yard manure gave similar results to that of 100 percent recommended dose of fertilizers.

Single and dual inoculation along with P fertilizer is 30-40% better than only P fertilizer and dual inoculation without P fertilizer improved grain yield up to 20% as compared to P application alone was reported by Afzal *et al.* (2008)

Table 2: Effect of Bio fertilizers, inorganic fertilizers and organic manures on nodulation and plant growth.

Treatment	2017-18			2018-19		
	Plant height (cm)	No of nodules	No of Pods	Plant height (cm)	No of nodules	No of Pods
T_1- FYM @ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	34.75	4	13.0	38.25	6	14.0
T_2- Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	40.0	7	15.0	40.5	7	16.0
T_3-50% RDF + FYM@ 10 t ha^{-1} +Rhizobium + PSB@5kg ha^{-1}	42.0	6	14.0	41.5	5	15.0
T_4-50% RDF + Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	44.5	8	18.0	42	8	21.0
T_5-100% RDF(20:50:0:40)	46.0	3	19.0	43	4	24.0
T_6-- Control	27.5	2	12.0	31.25	2	10.0
SE(m)±	1.34	0.55	0.80	0.75	0.53	0.93
CD	NS	1.67	2.41	NS	1.61	2.82
CV%	6.69	10.8	10.9	3.81	9.42	11.29

Table 3: Effect of Bio fertilizers, inorganic fertilizers and organic manures on dry matter at 45 DAS & harvest and yield of chickpea

Treatment	2017-18			2018-19		
	Dry matter (kg ha^{-1})		Grain yield (kg ha^{-1})	Dry matter (kg ha^{-1})		Grain yield (kg ha^{-1})
	45 DAS	90 DAS		45 DAS	90 DAS	
T_1- FYM @ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	340	700	1098	389	850	1056
T_2- Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	385	833	1120	392	936	1140
T_3-50% RDF + FYM@ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	400	745	1405	430	958	1415
T_4-50% RDF+ Vermicompost@ 2.5 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}	445	899	1545	443	1031	1554
T_5-100% RDF(20:50:0:40)	469	1000	1576	446	1035	1630
T_6- Control	320	645	1054	258	816	1007
SE(m)±	11.59	8.51	45.89	21.60	19.23	26.23
CD	34.04	25.65	138.87	65.13	57.98	79.09
CV%	5.45	5.14	7.06	10.98	14.1	5.2

PSB along with effective *Rhizobium* spp. stimulated chickpea nodulation and nitrogen fixation and supply more nitrogen to the crop. (Mohammadi *et al*., 2010) [9]. the higher yield of chickpea under improved technologies was due to the use of integrated nutrient management in high yielding varieties (Tomar, 2010). Bharadwaj *et al*. (2014) [3] concluded that organic farming practices are a promising way of meeting the challenges of increased crop production through improved soil health. The increase in growth and yield components of chickpea by combined inoculation of Rhizobium, PSB and organic manure may be due to cumulative effects such as enhanced supply of N and P to crop in addition to growth promoting substances produced by these organisms as reported by Sahani *et al.* (2008) [14].The combined inoculation of Rhizobium and phosphate solubilising bacteria has increased nodulation, growth and yield parameters in chickpea was reported by Jain *et al.* (1999) [6] and similar results were obtained by Rudresh *et al*., (2005) [13].

Effect of integrated use of organic and inorganic fertilizers along with biofertlizers on microbial population.

Initially, the microbial population of the soil used in this study was 3X10^{6}CFU per gram (Table: 1). It was significantly influenced by different treatments, as shown in fig 1. At 45 DAS highest population was recorded in treatment receiving 50% RDF + Vermicompost@2.5t ha^{-1} + Rhizobium + PSB@5Kg ha^{-1} (176 x10^{7}CFU) followed by T_3-50% RDF + FYM@ 10 t ha^{-1} + Rhizobium + PSB@5kg ha^{-1}(149 x10^7 CFU). The population has drastically reduced at harvest but showed the same trend. Lowest population was recorded in control (12 x10^{7}CFU). This study clearly showed that a significant decrease in microbial population at the time of harvest as compared to 45 DAS as shown in fig 2. Availability of root exudates and nutrients in rhizosphere soil get decreased at crop maturity stage (Raul *et al.*, 2009) [12]. The application of organic fertilizers combined with inorganic fertilizers increased the organic carbon content of the soil and thereby increasing the microbial counts. The use of inorganic fertilizers resulted in low organic carbon content, microbial counts and microbial biomass carbon of the soil, although it increased the soil's NPK level by the rates of fertilizers being applied was reported by Nakhro and Dikhar, (2010) [10].

Table 4: Effect of Bio fertilizers, inorganic fertilizers and organic manures on soil physico-chemical properties at harvest.

Treatment	2017-18					2018-19				
	pH	EC (dS m-1)	OC%	B.D (Mg m-3)	WHC (%)	pH	EC (dS m-1)	OC%	B.D	WHC (%)
T_1- FYM @ 10 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	8.1	0.20	0.21	1.27	52.5	8.0	0.21	0.21	1.3	51
T_2- Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	8.0	0.22	0.22	1.21	53	7.9	0.22	0.22	1.24	52.5
T_3-50% RDF+ FYM@ 10 t ha^{-1} +Rhizobium +PSB@5kg ha^{-1}	8.2	0.25	0.26	1.29	50.25	7.9	0.26	0.28	1.26	50.75
T_4-50% RDF+ Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	8.0	0.24	0.30	1.28	53.5	8.1	0.25	0.31	1.29	52.75
T_5-100% RDF(20:50:0:40)	8.1	0.28	0.22	1.3	50	8.1	0.27	0.23	1.3	48.5
T_6-- Control	7.9	0.21	0.21	1.3	47.75	8.1	0.21	0.22	1.32	47.75
SE(m)±	0.1	0.006	0.014	0.05	1.17	0.1	0.006	0.016	0.06	1.07
CD(0.05)	NS	0.018	0.04	NS	3.54	NS	0.02	0.05	NS	3.24
CV (%)	2.35	5.13	7.73	8.75	4.62	3.34	5.75	8.32	6.75	4.25

Table 5: Influence of integrated use of biofertilizers and oranic and inorganic fertilizers on microbial population

Treatment	2017-18		2018-19	
	45 DAS CFUX10^7	90 DAS CFUX10^7	45 DAS CFUX10^7	90 DAS CFUX10^7
T_1- FYM @ 10 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	87	17	72	14
T_2- Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	92	23	88	9
T_3-50% RDF+ FYM@ 10 t ha^{-1} +Rhizobium +PSB@5kg ha^{-1}	149	50	106	55
T_4-50% RDF+ Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	174	57	160	60
T_5-100% RDF(20:50:0:40)	32	13	36	18
T_6-- Control	12	9	16	10
SE(m)±	2.38	1.35	8.47	3.16
CD(0.05)	7.96	4.50	25.68	9.57
CV (%)	5.21	9.60	10.10	7.66

Table 6: Effect of integrated use of Bio fertilizers, inorganic fertilizers and organic manures on available nitrogen, phosphorus and potassium at harvest.

Treatment	2017-18			2018-19		
	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T_1- FYM @ 10 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	178.75	26.50	336.00	181.25	29.25	362.75
T_2- Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	185.25	28.26	341.50	193.25	32.25	375.75
T_3-50% RDF+ FYM@ 10 t ha^{-1} +Rhizobium +PSB@5kg ha^{-1}	283.25	29.00	388.50	309.00	38.00	397.5
T_4-50% RDF+ Vermicompost@ 2.5 t ha^{-1} + Rhizobium+PSB@5kg ha^{-1}	310.25	30.14	408.75	340.50	40.00	412.25
T_5-100% RDF(20:50:0:40)	328.75	32.08	496.00	352.25	49.00	524
T_6-- Control	152.75	24.25	296.50	159.25	25.00	332.25
SE(m)±	5.38	0.69	11.73	13.17	2.27	8.79
CD(0.05)	16.23	2.10	35.37	39.72	6.86	26.50
CV (%)	4.95	4.9	6.21	5.6	11.49	6.05

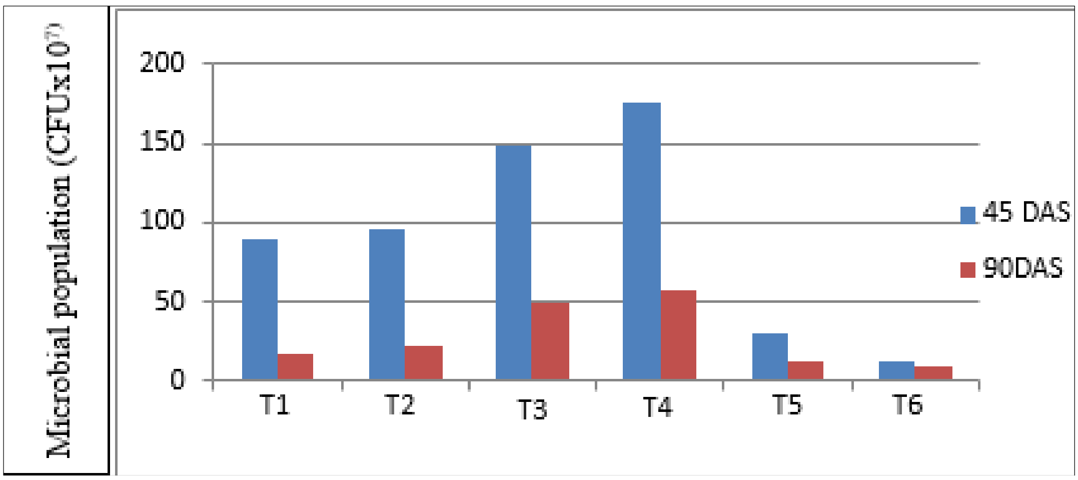

Fig 1: Microbial population year 2017-18 at 45DAS and 90 DAS

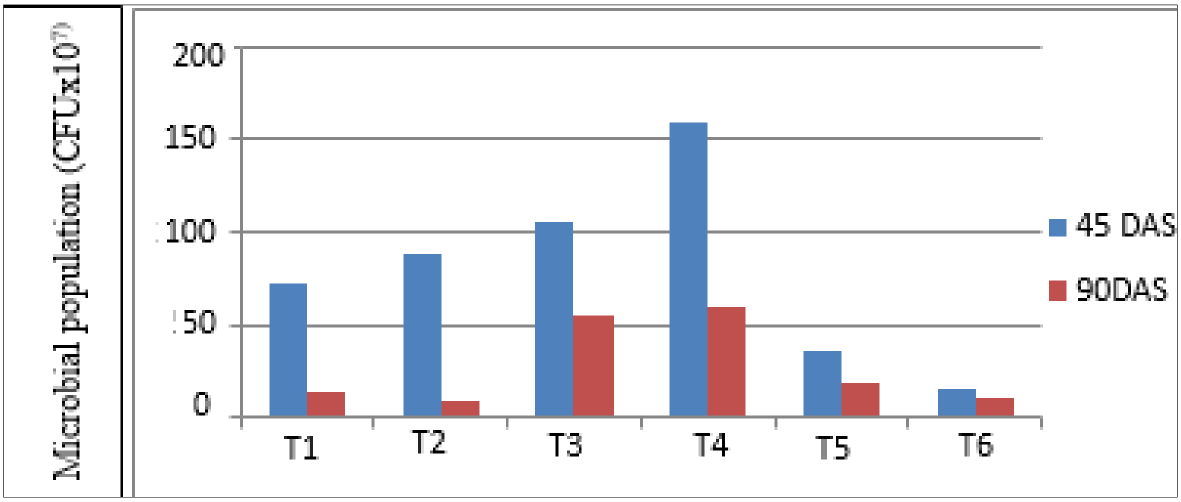

Fig 2: Microbial population year 2017-18 at 45DAS and 90 DAS

Conclusion

Chickpea yield was affected by different soil fertility systems. An increase in per cent grain yield was recorded under the application of with 100% RDF (20:50:0:40) and the highest yield of chickpea was recorded with 100% RDF followed by 50% RDF + Vermicompost@2.5 t ha^{-1} +Rhizobium+ PSB @5kg ha^{-1}applied to chickpea during both the years of the experimentation. Application of biofertilizers influenced the dry matter accumulation at 45 DAS as well as at harvest of the crop. The combined application of Rhizobium along with PSB with 50% recommended dose of chemical fertilizer and vermicompost@2.5 t ha^{-1} is on par with 100% RDF. This is due to microorganisms activity that excrete organic acids and phosphates could be able to get dissolved from the existing pool in the soil and increased the nutrient availability to plants. From the results we can conclude that by cutting down the chemical fertilizer application to half the dose and supplementing with organic manures and biofertilizers in production systems to increase the sustainability, soil health and in turn cost of production.

References

1. Aftab A, Asghari B, Rhizobium. Phosphate Solubilizing Bacteria improve the yield and phosphorus uptake in Wheat (*Triticum aestivum*) International journal of Agriculture & Biology. 2008, 1560-8530.
2. AOAC. In K. Helrich (Ed), official methods of analysis (15thed) Arlington, A/Washington, DC, USA: Association of Official Analytical Chemist, 1990.
3. Bharadwaj D, Ansari MW, Sahu RK, Narendra T. Biofertilizers function as key players in sustainable agriculture by improving soil fertility, plant tolerance and crop productivity. Microbial cell factories. 2014; 13:66.
4. Dastane NG. A Practical Manual for water use research, Navabharat, Prakashan Publication, Poona (India), 120, 1967. Geissler D, KM. Scow. Better crops with plant food. 2014; 98(4):13-15.
5. Jackson ML. Soil chemical analysis. Prentice Hall of India Private Ltd., New Delhi. 1973, 134-182.
6. Jain PC, Kushwaha PS, Dhakal H, Khan US, Trivedi SM. Response of chickpea (*Cicer arietinum* L) to phosphorus and biofertilizer. Legume Research. 1999; 22:241-244.
7. Kanzaria KK, Sutaria GS, Akbari KN, Vora VD, Padmani DR. Effect of integrated nutrient management on productivity of pearl millet and soil fertility of sandy loam soils under rain fed conditions. The Asian Journal of Horticulture. 2010; 5:154-156.
8. Khuran C, Sharma P. Effect of dual inoculation of phosphate solubilizing bacteria, *Bradyrhizobium* sp. and phosphorus on nitrogen fixation and yield of chickpea. Indian J Pulses Research. 2000; 3:66-67.
9. Mohammadi K, Ghalavand A, Agha, Alikhani M. Effect of Organic Matter and Biofertilizers on Chickpea Quality and Biological Nitrogen Fixation. International Journal of Agricultural and Biosystems Engineering, 2010, 4(8).
10. Nakhro N, Dikhar MS. Impact of organic and inorganic fertilizers on microbial populations and biomass carbon in paddy field soil. Journal of Agronomy. 2010; 9:102-110.
11. Ogilvie LA, Hirsch PR, Johnston AW. Microb. Ecol. 2008; 56:525-537.
12. Raul O, Pedraza Carlos H, Bellone. *Azospirillum* inoculation and nitrogen fertilization effect on grain yield and on diversity of endophytic bacteria in the phyllosphere of rice rainfed crop. European Journal of Soil Biology. 2009; 45:36-43.
13. Rudresh DL, Shivaprakash MK, Prasad RD. Effect of Combined application of Rhizobium, phosphate solubilising bacterium and Trichoderma spp. On growth, nutrient uptake and yield of Chickpea (*Cicer arietinum* L) Applied Soil Ecology. 2005; 28:139-146.
14. Sahani S, Sarma BK, Singh DP, Singh HB, Singh KP. Vermicompost enhances performance of plant growth promoting rhizobacteria in *Cicer arietinum* rhizosphere against Sclerotium rolfsii. Crop Protection. 2008; 27:369-376.
15. Sankaram A. A laboratory manual for agricultural chemistry. Asia publishing House. Bombay, 1966, 41-149.
16. Singh NP, Sachan RS, Panday PC, Bisht PS. Effect of a decade long fertilizer and manure application on soil fertility and productivity of rice wheat system on a Mollisol. Journal of Indian Society of Soil Science. 1999; 47:72-80.
17. Tomar. EJSS Eurasian Journal of Soil Science. 2016; 5(2):105-112.
18. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soils. Current Science. 1956; 25:259-260.
19. Walkley A, Black A. An Examination of degtjareff, method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 1934; 37:29-38.

20. Watanabe FS, Olsen SR. Test of ascorbic acid method for determining phosphorous in water and sodium bicarbonate extracts of soil. Soil Science Society of American Journal. 1965; 29:677-78.
21. Yuvaraj K. Effect of biofertilizers and inorganic fertilizers on soil health, growth and yield of rice (*Oryza sativa* L.) M.Sc Thesis. Department of Microbiology, College of Basic Sciences and Humanities, Punjab Agricultural University, 2016.