The Pharma Innovation Journal 2021; 10(12): 2664-2668

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(12): 2664-2668

www.thepharmajournal.com
Received: 12-09-2021
Accepted: 27-10-2021

VG Salvi
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra, India

RS Mane
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra, India

Sayali Biradar
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra, India

Bhakti Raut
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra, India

Corresponding Author:
Sayali Biradar
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri, Maharashtra, India

Effect of inorganic fertilizers and organic manure on microbial activity and carbon dioxide evolution and their correlation with yield of Yam bean on Lateritic soils of Konkan region

VG Salvi, RS Mane, Sayali Biradar and Bhakti Raut

Abstract
A field experiment was conducted during Kharif season of 2019 at Central Experiment Station, Wakawali, Dr. Balsaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri to study the effect of inorganic fertilizers and organic manure on microbial population, CO2 evolution and their correlation with yield of yam bean in lateritic soils of Konkan region of Maharashtra. There were thirteen treatments which were replicated thrice in randomized block design. The treatments consisting three levels of nitrogen (80,100,120 kg ha^{-1}), phosphorous (40, 60, 80 kg ha^{-1}), FYM (10, 15, 20 t ha^{-1}), a constant dose of potassium (100 kg ha^{-1}) and an absolute control treatment. The results of the experiment revealed that the application of different levels of inorganic fertilizers and organic manure exhibited significant increase in microbial population as well as CO2 evolution in soil. Significantly, superior bacterial (200.33 × 105 cfu g^{-1} soil), fungal (31.33 × 103 cfu g^{-1} soil) actinomycetes (113.33×105 cfu g^{-1} soil) population and CO2 evolution (71.87 mg 100 g^{-1} soil 24 hr $^{-1}$) was recorded at 60 days of sowing as compared to 30 days of sowing and at harvest due to the treatment receiving the highest level of inorganic fertilizers and organic manure application @120:80:100 N:P2O5: K2O kg ha^{-1} + 20t FYM ha^{-1}. As far as the yield of yam bean tuber was concerned, the total tuber yield and marketable tuber yield showed significant positive relationship with bacteria (r = 0.96**, 0.90**), fungi (r = 0.97**, 0.92) and actinomycetes (r = 0.98**, 0.90**) population as well as CO2 evolution (r = 0.88**, r = 0.81**) in soil, respectively.

Keywords: Lateritic soil, inorganic and organic nutrient sources, yam bean, microbial population, CO2 evolution

Introduction
Yam bean (*Pachyrrhizus erosus* L.) is a tropical tuber crop which belongs to the family Leguminaceae, commonly called as Mishrikand, Shankalu or Sankeshalu in different parts of India and is consumed as a vegetable. Tropical tuber crops are an important source of dietary energy and are considered as secondary staples after cereals. It contains more than 82 per cent water, 1.5 per cent protein, 10 per cent starch and 5-6 per cent sugar (Naskar, 2009) [14]. Application of organic and inorganic fertilizers to soil would provide multiple benefits for improving the chemical and physical status of the soil which results in improved crop yield. Both organic and inorganic are sources of mineral elements, which plants require for effective development and growth. Nitrogen, phosphorus and potassium have great effects in plant development and growth. Nutrients available in organic manures are released slowly, remain in the soil for longer time and are available to plants, thereby maintaining soil fertility and enhances the soil microbial population (Belay *et al*., 2001) [4]. Researchers reported that application of various organic manures stimulated the plant growth, activity of soil micro-organism, resulting in higher population of fungi, bacteria and actinomycete and higher activity of soil enzymes (Knapp *et al*., 2010) [9].
The population and functions of microorganisms can involve in balancing and maintaining soil health because microorganisms provide living environment to the soil and perform various functions like transformation of nutrients to plant usable form, decomposition of organic residue, biochemical activities and enzymatic activities (Baun *et al*., 2003) [2]. Soil microbial diversity is important for sustainable agriculture because microbes can mediate many biochemical processes that support agricultural production. Rhizosphere microorganisms release extracellular enzymes for the initial degradation of high molecular polymers such as

cellulose, chitin and lignin, proteins, leading to their mineralization to mineral N, P and S (Burns 1982; Nannipieri *et al.*,1996) [5, 13]. These processes include recycling of plant nutrients, maintenance of soil structure and degradation of agro-chemicals. Considering the above facts in mind, it was decided, to study the effect of inorganic fertilizers organic manure on periodical changes in microbial population as well as in CO2 evolution and their correlation with yield of yam bean (*Pachyrrhizus erosus* L.) in Konkan region of Maharashtra.

Materials and Methods

A field experiment was conducted at Central Experimental Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, during *Kharif* season of 2019. The study area is located at 17040' to 17045' N and 73016' to 73019' E with 167 m to 234 m above mean sea level having hot and humid climate with average and annual rainfall of 3500 mm. The experimental soil (Table 1) was sandy loam in texture, moderately acidic (5.33) in reaction with low (0.04 dS m^{-1}) electrical conductivity. These results are in accordance with the results reported by Rathod *et al.*, (2019) in coastal region of Maharashtra and Jadhav *et al.*, (2019) [8] in lateritic soils of Konkan region of Maharashtra. The soil showed very high content of organic carbon (10.05 g kg^{-1}), medium content of available nitrogen (370.80 kg ha^{-1}), low content available phosphorus (10.50 kg ha^{-1}) and high content of available potassium (285.30 kg ha^{-1}). Almost similar findings have been reported by Salvi *et al.*, (2017) [20] who reported high content of organic carbon, medium content of available nitrogen, low content of available phosphorous and high content of available potassium in cashew growing gardens in Sindhudurg district of Konkan region. The experiment was laid out in a randomized block design comprising of thirteen treatments *viz.*, T1 = Absolute control; T2 = 80:40:100 N, P2O5, K2O kg ha- 1; T3 = 100:60:100 N, P2O5, K2O kg ha^{-1}; T4 = 120:80:100 N, P2O5, K2O kg ha^{-1}; T5 = 80:40:100 N, P2O5, K2O kg ha^{-1} +10t FYM ha^{-1}; T6 = 100:60:100 N, P2O5, K2O kg ha^{-1} +10t FYM ha^{-1}; T7 = 120:80:100 N, P2O5, K2O kg ha^{-1} + 10 t FYM ha^{-1}; T8 = 80:40:100 N, P2O5, K2O kg ha^{-1}+ 15 t FYM ha^{-1}; T9 = 100:60:100 N, P2O5, K2O kg ha^{-1} + 15t FYM ha^{-1}; T10 = 120:80:100 N, P2O5, K2O kg ha^{-1} + 15 t FYM ha^{-1}; T11 = 80:40:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1}; T12 = 100:60:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1} and T13 = 120:80:100 N, P2O5, K2O kg ha^{-1}+ 20t FYM ha^{-1} which were replicated thrice.

Table 1: Initial Physico-chemical properties of experimental soil.

Parameters	Content	Parameters	Content
Physical properties		Chemical properties	
Mechanical Analysis		pH (1:2.5)	5.33
a) Sand (%)	75.20	Electrical conductivity (dS m^{-1})	0.04
b) Silt (%)	9.55	Organic carbon (g kg^{-1})	10.05
c) Clay (%)	15.25	Available N (kg ha^{-1})	370.80
Textural class	Sandy loam	Available P2O5 (kg ha^{-1})	10.50
Particle density (Mg m-3)	2.50	Available K2O (kg ha^{-1})	285.30
Bulk density (Mg m-3)	1.32	Microbial count	
Porosity (%)	48.23	Bacteria (105 cfu g^{-1} soil)	80
MWHC (%)	47.50	Fungi (103 cfu g^{-1} soil)	6.67
		Actinomycetes (105 cfu g^{-1} soil)	25.33
		CO2 evolution (mg 100 g^{-1} soil 24 hr^{-1})	24.73

The calculated quantity of FYM was applied into soil as per the treatments at the time of layout and N, P and K were applied through Urea, Single super phosphate and muriate of potash through chemical fertilizers, respectively. Entire dose of phosphorous and potassium was applied at the time of planting along with the half dose of nitrogen. The remaining half with interculturing and earthing up operations. The representative surface soil samples (0- 22 cm) were collected from each treatment plot at the initial stage, 30 days after sowing, 60 days after sowing and at harvest stage and were analysed by following standard procedures. The initial soil samples were analysed by adopting alkaline KMnO4-N, Bray and Kurtz-P and NH4OAc-K methods given by Subbiah and Asija (1956) [21], Black (1965) [3] and Jackson (1973) [7], respectively. The periodical soil samples at 30 and 60 days after sowing and at harvest were collected for estimation bacterial, fungi, actinomycetes population and CO2 evolution from each plot. The microbial population of bacteria, fungi and actinomycetes was measured by serial dilution (Pramer and Schmidt, 1964) [16] and by barium chloride method (Debnath and Hajra, 1972) [6]. The data of the experiment was analysed by the method of analysis of variance to find out the critical difference values for making interpretations as outlined by Panse and Sukhatme (1967) [15]. The correlation coefficient between microbial population and CO2 evolution with yield of the crop was derived.

Table 2: Effect of inorganic and organic manure on soil microbial population and CO2 evolution under yam bean cultivation

Tr. no.	Bacteria (cfu × 10^5)			Fungi (cfu × 10^3)			Actinomycetes (cfu × 10^5)			CO2 evolution (mg 100 g^{-1} soil 24 hr^{-1})		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T1	96.67	109.33	69.33	7.33	12.33	5.33	32.00	49.00	30.33	30.07	41.07	28.60
T2	108.67	141.00	79.67	10.33	17.67	7.00	40.67	64.67	40.33	31.53	43.27	29.33
T3	118.67	145.00	81.33	11.33	19.00	9.00	39.00	71.33	43.67	32.27	44.00	29.33
T4	125.00	152.00	88.33	12.33	21.67	9.33	49.33	75.67	46.67	32.27	44.00	33.00
T5	139.33	154.67	93.00	14.00	23.67	9.67	55.33	69.67	46.67	34.47	46.93	32.27
T6	140.00	158.00	97.00	14.67	25.33	10.33	57.33	80.67	50.33	37.40	49.87	34.47
T7	148.67	162.33	102.00	15.67	26.00	11.67	61.00	88.33	54.00	39.60	53.53	35.20
T8	151.33	164.67	108.00	16.00	26.33	13.67	58.33	97.33	57.33	37.40	56.47	33.73

T9	153.33	170.33	112.00	16.67	26.67	14.00	61.33	94.00	59.67	43.27	60.13	35.93
T10	150.00	174.33	119.33	17.00	27.67	14.33	63.67	100.00	62.33	42.53	63.07	37.40
T11	152.00	184.00	118.00	18.00	28.00	15.00	66.00	104.00	63.33	44.00	63.80	39.60
T12	156.00	190.00	123.33	19.00	30.00	16.00	72.67	108.33	65.00	44.00	66.73	38.13
T13	157.33	200.33	129.00	21.33	31.33	18.00	73.67	113.33	67.67	45.57	71.87	41.07
S.E. (±)	2.30	3.54	2.82	0.73	0.91	0.91	2.20	2.14	1.47	1.69	2.08	2.32
CD (P=0.05)	6.71	10.34	8.23	2.14	2.64	2.66	6.43	6.24	4.28	4.94	6.07	6.78

T1 = Absolute control; T2 = 80:40:100 N, P2O5, K2O kg ha^{-1}; T3 = 100:60:100 N, P2O5, K2O kg ha^{-1}; T4 = 120:80:100 N, P2O5, K2O kg ha^{-1}; T5 = 80:40:100 N, P2O5, K2O kg ha^{-1} +10t FYM ha^{-1}; T6 = 100:60:100 N, P2O5, K2O kg ha^{-1} +10t FYM ha^{-1}; T7 = 120:80:100 N, P2O5, K2O kg ha^{-1} + 10 t FYM ha^{-1}; T8 = 80:40:100 N, P2O5, K2O kg ha^{-1}+ 15 t FYM ha^{-1}; T9 = 100:60:100 N, P2O5, K2O kg ha^{-1} + 15t FYM ha^{-1}; T10 = 120:80:100 N, P2O5, K2O kg ha^{-1} + 15 t FYM ha^{-1}; T11 = 80:40:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1}; T12 = 100:60:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1}; T13 = 120:80:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1}

Result and Discussion

Bacterial population

The application of inorganic fertilizers and organic manure enhanced the bacterial population at 30 days after sowing over control as well as initial microbial population in soil. Significantly highest bacterial population (157.33 × 105 cfu g^{-1} soil) was observed due to T13 treatment receiving 120:80:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1} application. The same treatment was significantly superior over all other treatments except T12, T9, T11 and T8 treatment which were at par with each other.

At 60 days after sowing and at harvest of yam bean crop, the application of inorganic fertilizers and organic manure increased the bacterial population significantly and it varied from 109.33 to 200.33 × 105 cfu g^{-1} and 69.33 to 129.00× 105 cfu g^{-1} soils, respectively. The treatment T13 comprising 120:80:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1} application noted significantly highest bacterial population, which showed its superiority over all other lower doses of fertilizers and FYM application except treatments T12, both the treatments were at par with each other. The bacterial population significantly increased during 60 days after sowing as compared to 30 DAS as well as at harvest stage which might be due to addition of FYM which attributed to increase in mineralizable carbon. Similar findings were also reported by Thakre and Wake (2015) [22] who reported that the increase in graded levels of organic substance significantly increased the bacterial population. An increase in the bacterial population due to application of compost enriched with microbial inoculant have also been reported by Salvi *et al*., (2015) [19] in okra.

Fungal population

The fungal population was increased gradually from 30 days after sowing to 60 days after sowing and thereafter decreased at harvest stage. When inorganic fertilizers were combined with organic material especially FYM, the fungal population was further influenced, which might be attributed to the decayed food material, addition of carbon through leaf fall and added FYM as well as due to changes in physico-chemical properties of soil. Significantly higher population of fungi under legumes crop might be due to the preferential stimulation exerted by the excretory products of their roots. The above results are in accordance with the results reported by Arbad and Syed Ismail (2011) [1] who observed the maximum fungal populations with the combined application of organic and inorganic fertilizers. Mhalshi (2013) [12] also reported that the application of organic matter in lateritic soils of Konkan showed increasing trend of the microbial population of fungi. An increase in the microbial population of fungi due to integrated nutrient management was also reported by Rathod et al., (2018) [17] in ridge gourd cultivation in lateritic soils of Konkan region.

Actinomycetes population

The actinomycetes population in soil at 30 days after sowing ranged from 32 to 73.67 × 103 cfu g^{-1} soil. There was graded increase in actinomycetes population with the increasing doses of inorganic fertilizers and organic manure. The highest actinomycetes population (73.67 × 103 cfu g^{-1}) in soil was observed in treatment T13 with the application 120:80:100 N, P2O5, K2O kg ha^{-1} + 20t FYM ha^{-1} which was at par with T12 treatment. Both the treatment, i.e., T13 and T12 were significantly superior over all other remaining treatments. The application of different levels of inorganic fertilizers and organic manure increased the actinomycetes population significantly at 60 days after sowing and at harvest and it varied from 49 to 113.33 × 103 cfu g^{-1} soil, respectively. The significantly highest actinomycetes population in soil was recorded due to treatment T13, which was at par with T12 treatment. Both the treatments were found to be significantly increased during 60 days after sowing as compared to 30 days after sowing as well as at harvest stage. The actinomycetes population was increased gradually at 60 days after sowing of yam bean which may be due to the carbonaceous materials and substrate such as amino acids, sugar and organic acids added to the soil from the decomposing organic materials as well as due to decay of roots under the plant canopy which was important for energy for microbial population.

In general, it was observed that the application of inorganic fertilizers alone showed relatively less population of bacteria, fungi and actinomycetes. However, addition of FYM with increasing levels with inorganic fertilizers resulted in rapid stimulation of microbial growth, multiplication and their development in soil which may be due to increment in organic matter in soil that serves as a food and energy source for microbes. These results are supported by the findings of Malewar *et al.*, (1999) [11]. The increase in the microbial population of bacteria, fungi and actinomycetes due to application of organic manure, fertilizers and bio fertilizers have also been reposted by Mhalshi (2013) [12] and Salvi *et al.*, (2015) [19] who found an increasing trend of microbial population with the application of RDF + zinc sulphate + borax + FYM + *Azospirillium* as compared to control treatment and application of chemical fertilizers alone.

CO_2 evolution

The graded doses of fertilizers and FYM significantly increased the CO2 evolution at 30 days after sowing and it ranged from 30.07 to 45.57 mg 100 g^{-1} soil 24 hr^{-1}. The highest CO2 evolution (45.57 mg 100 g^{-1} soil 24 hr^{-1}) was found due to the treatment receiving 120:80:100 N, P2O5,

K_2O kg ha^{-1} + 20t FYM ha^{-1}. The minimum CO_2 evolution (30.07 mg 100 g^{-1} soil 24 hr^{-1}) was observed in absolute control treatment receiving no fertilizers and FYM. At 60 days after sowing the application of fertilizers and FYM increased CO_2 evolution significantly and it varied from 41.07 to 71.87 mg 100 g^{-1} soil 24 hr^{-1}. The treatment T13 recorded significantly highest CO_2 evolution (71.87 mg 100 g^{-1} soil 24 hr^{-1}) as compared to remaining treatments. There was graded influence in CO_2 evolution with graded dose fertilizers and FYM application. Significantly highest CO_2 evolution (41.07 mg 100 g^{-1} soil 24 hr^{-1}) was recorded with highest dose of fertilizers and FYM application comprising 120:80:100 N, P_2O_5, K_2O kg ha^{-1} + 20t FYM ha^{-1} as compared to remaining treatments.

These results indicated that the soil organic matter supplies the energy source for aerobic microorganism respiration. These results evident significantly linear correlation between microbial populations and the rate of CO_2 evolution. Similar results were also reported by Mhalshi (2013) [12] who observed that the treatment receiving N: P_2O_5: K_2O @ 25:75:50 kg ha^{-1} along with seed inoculation with biofertilizer recorded the highest CO_2 evolution in lateritic soil.

Relationship between microbial population and yield of yam bean

The data presented in Table 3 indicated that the biological properties showed positive and significant correlation with total and marketable tuber yield with r values as bacteria (r = 0.96**, 0.90**), fungi (r = 0.97**, 0.92**) and actinomycetes (r = 0.98**, 0.93**). The CO_2 evolution also showed positive and significant correlation, but lesser than the microbial population, with r values 0.88** and 0.81** for total tuber yield and marketable tuber yield, respectively. Thus, the results indicated that the application of inorganic and organic manure at balance properties not only helps to enhance the microbial activity of soil but also augment the crop yields. Similar findings were also reported by Thakare and Wake (2015) [22], Salvi *et al.*, (2015) [19] and Laxminarayana (2017) [10]. Rathod *et al*., (2018) [17] also reported significant increase in Ridge gourd yield in lateritic soil due to conjunctive use of inorganic fertilizers, organic manure and biofertilizers.

Table 3: Correlation coefficients (r) between microbial population and yield of yam bean

Biological properties	Total tuber yield	Marketable tuber yield
Bacteria	0.96**	0.90**
Fungi	0.97**	0.92**
Actinomycetes	0.98**	0.93**
CO_2 evolution	0.88**	0.81**
*Significant at 5% level, **Significant at 1% level		

Conclusion

On the basis of the results obtained during present investigation, it was concluded that the application of 120:80:100 N, P_2O_5, K_2O kg ha^{-1} + 20t FYM ha^{-1} to yam bean is essential for improving microbial activity of soil as well as total tuber yield of yam bean in lateritic soils of Konkan region of Maharashtra.

References

1. Arbad, Sayed Ismail. Influence of integrated nutrient management on yield, soil fertility status and changes in soil microbial population in soyabean (*Glysine max*)-safflower (*Carthamus tingtrous*) sequence cropping. *International Journal of Forestry and Crop Improvement* 2011;2:181-185.
2. Baun C, Leinweber P, Schliching A. Effect of chemical condition in rewetted peats: temporal variation in microbial biomass and acid phosphatase activity within the growing season. *Applied Soil Ecology* 2003;22:1-12.
3. Black CA. Method of soil analysis Part II. Chemical and microbiological properties. Madison, Wisc: American Society of Agronomy, Inc 1965.
4. Belay A, Classens AS, Wehner FC, Debeer JM. Influence of residual manure on selected nutrient elements and microbial composition of soil under long-term crop rotation. South African Journal of Plant and Soil 2001;18:1-6.
5. Burns RG. Enzyme activity in soil: Location and a possible role in microbial ecology. *Soil Biology and Biochemistry* 1982;14:423-427.
6. Debnath NC, Hajra V. Transformation of organic matter in soil in relation to mineralization of carbon and nutrient availability. Indian society of soil science 1972;20:95-102.
7. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 1973, 134-182.
8. Jadhav ST, Salvi VG, Deshmukh UV, Jadhav SC. Yield and quality of Alphanso mango as influenced by foliar application og nutrients in Lateritic soil. The Pharma Innovation Journal 2019;8(10):14-18.
9. Knapp BA, Ros M, Insam H. Do composts affects the soil microbial community? In: Insam H, Franke-Whittle I, Goberna M. (Eds), microbes at work: from wastes to resources. *Springer Berlin Heidelberg*, 2010, 93-114.
10. Laxminarayana K. Effect of mycorrhiza, organic sources, lime, secondary and micronutrient on soil microbial activities and yield performance of yam bean (*Pachyrhizus erosus* L) in Alfisols. *Communications in Soil Science and Plant Analysis* 2017;48:186-200.
11. Malewar GU, Hasanabade AR, Ismail S. CO2 evaluation and microbial population in soil as influenced by organic and NPK fertilizers under sorghum-wheat system. Journal of Maharashtra Agriculture University 1999;24:212-224.
12. Mhalshi RM. Chemical and biological properties of soil as influenced by different levels of P and K with and without biofertilizers to cowpea. M.Sc. (Ag.) Thesis submitted to Dr. Balasaheb Sawant Kokan Krishi Vidyapeeth, Dapoli (M. S.), India 2013.
13. Nannipieri P, Sequi P, Fusi P. Humus and enzyme activity. In: Piccolo A (ed) Humic substances in terrestrial ecosystems. Elsevier, New York, 1996, 293-328.
14. Naskar SK. Progress and status of yam bean research in India. 15th Triennial Symposium of the International Society for tropical Root Crops, 2009, 23-28.
15. Panse VG, Sukhatme PV. Statistical methods for agricultural workers, ICAR, New Delhi 1967.
16. Pramer D, Schmidit EL. Experimental Soil Microbiology. Burgess publishing company, Minnesota, 1964, 35-37.
17. Rathod PE, Salvi VG, Jadhav ST. Growth, yield and quality of ridge gourd as influenced by integrated nutrient management in Coastal region of Maharashtra. International Journal of Chemical Studies 2018;6(5):2357-2360.
18. Salvi SG, Salvi VG, Dhane SS, Sawant PS. Effect of

integrated nutrient management on yield and quality of okra grown in lateritic soils of Konkan. Journal of Maharashtra Agricultural Universities 2010;35:466-469.

19. Salvi VG, Shinde MG, Bhure SS, Khanvilkar MH. Effect of integrated nutrient management on soil fertility and yield of okra in coastal region of Maharashta. An Asian Journal of soil science 2015;10:201-209.
20. Salvi VG, Gajbhiye RC, Pawar SS. Nutritional status of cashew growing garden in Sindhudurg district of Konkan region (MS). International Journal of Chemical Studies 2017;5:1594-1597.
21. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soil. *Current Science* 1956;25:259-260.
22. Thakare R, Wake A. Soil microbial population and nutrients viability influenced by graded levels of organic manures under organically grown rainfed pearl millet in vertisol. Journal of Agroecology and Natural Resource Management 2015;2:1-5.