"EFFECT OF LIQUID MICROBIAL CONSORTIUM ON PHYSIO CHEMICAL PROPERTIES OF RICE FIELD (*ORYZA SATIVA*) IN A *VERTISOL*"

ABSTRACT

A study was conducted during kharif 2020 to "Effect of liquid microbial consortium on physio chemical properties and microbialpopulation of rice field (*Oryza sativa*) in a V*ertisol*"at the Indira Gandhi Krishi Vishwavidyalaya's Research cum instructional farm in Raipur (C.G.). Experiment included seven treatments with a control (no fertilizer, no liquidNPK microbial consortia), two independent applications of 75 % RDF (90:45:30) and100% RDF (@120, 60, 40 N, P_2O_5, and K_2O kg ha^{-1}), and four various combinations of seed and soil application of liquid NPK microbial consortia. Seed coating with NPK consortia @5ml kg^{-1}, with 75% and 100% RDF and Seed coating with NPK consortia @5mlkg^{-1} + Soil application of NPK consortia @3 Lha^{-1} at 21 DAS with 75%RDF and 100%RDF. In the experiment, liquid biofertilizer products, such as liquid microbial NPK consortia were used. The results showed that application of microbial consortia as seed treatment and soil treatment with 75% RDF increased grain yield by 7.36 % (T4) and 10.63 % (T6) over application of 75% RDF without consortia (52.58 q ha^{-1}) whereas application of microbial consortia with 100 % RDF increased grain yield by 3.39 % (T5) and 3.83 % (T6) over application of 100 % RDF without consortia (58.46 q ha^{-1})which showed that application of seed coating with NPK consortia @ 5mlkg^{-1} and combined application of seed coating and soil application of NPK consortia @ 3 Lha^{-1} at 21 DAT with 75% RDF (T6) can produce an equal yield of the recommended dose of fertilizer (100%RDF) and save 25% of RDF.

1. Introduction

Bio-fertilizer is generally defined as a material which contains living microorganism. It contains various types of important micro-organisms include nitrogen fixers, phosphate solubilizing bacteria (PSB) and plant growth promoting rhizobacteria (PGPR). Such as *Azospirillum* and *Azotobacter* can be used as a nitrogen fixer in the crops like rice, sorghum, wheat, maize, mustard, and other vegetable crops. Phosphate solubilising bacteria (PSB) is used in all crops to solubilise and increase availability of soil phosphorous.

It adds nutrients through the natural processes of fixation of atmospheric nitrogen, solubilizing soil phosphorous and stimulating the plant growth through synthesis of growth- promoting substances (Vessey, 2003). Use of bio-fertilizers are an important component of integrated nutrient management for sustainable agriculture. Bio-fertilizers can improve soil physical, chemical, biological characteristics and agricultural production (Yosefi*et al.,* 2011).

The major constraint for rice production in this ecosystem is leaching of nutrients, among which nitrogen and potassium are the most important. Phosphorus deficiency is another important limiting factor of rice production. Though the productivity of rice is low in India, proper, judicious and balanced use of inorganic fertilizers is a main issue to improve the rice productivity. Day by day increasing in cost of chemical fertilizers is also forces the farmers to search for an alternative low-cost resource. In this context bio-fertilizers have gained prime importance. Nitrogen fixing bacteria, *Azospirillum*and phosphate solubilising bacteria has attracted the attention of many scientists for their commercial utilization in rice cultivation. Nitrogen fixing bacteria can fix atmospheric nitrogen and P- solubilizing microbes solubilize phosphate into soluble form (Dhanya *et al.*, 2006).

Biofertilizers are generally applied to soil, seeds or seedlings, with or with or without some carrier. The use of carrier-based bio-fertilizers poses constraints due to low shelf life, poor survival rate, high degree of contamination and low water activity of inoculums. Liquid microbial consortium (Liquid bio-fertilizers) is special liquid formulation containing not only the desired beneficial microorganisms and their biological secretions, but also special cell protestants or substances that encourage the formation of dormant spores or cysts for longer shelf life and tolerance to adverse conditions. Liquid bio fertilizer formulation is the promising and updated technology of the conventional carrier-based productions technology with many advantages over the agrochemicals. Application of liquid bio-fertilizers can aid a major significance in the yield of Rice crop, thus holding great advantage to world's food security. Considering all the facts in mind, the present experiment entitled, **"**Physio chemical properties and microbialpopulations of rice field (*Oryza sativa*) in a *vertisol*" was carried out during the kharif season of 2020.

2. Experimental details

2.1. Experimental site

The experiment was conducted on Research cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during kharif season 2020. Raipur is situated between 22^o 33' N to 21^o 14' N latitude and 82^o 6' E to 81^o 38' E Longitude with the altitude of 293m above Mean Sea Level. The exact location of research site i. e. IGKV Farm 21.2514^o N Latitude and 81.6296^o E longitude. The soil of the experimental Rice field (0 to 15 cm depth) was black (*Vertisol*- locally known as "Kanhar") and clayey in texture, with a neutral pH (7.47). The physico-chemical properties of the experimental field were suitable for the rice crop. It was non saline (EC 0.28 dSm^{-1}) and low in organic carbon content (0.59%). The soil was low in available nitrogen (223 kg ha^{-1}), high in available phosphorus (24.4 kg ha^{-1}) and high in available potassium (384 kg ha^{-1})

2.2. Soil analysis

A representative soil sample was taken from surface (0-15 cm depth) of the field as an initial sample before the transplanting of rice and prepared for analysis of initial characters of experimental soil. After harvesting of the crop, treatment wise surface soil samples (0-15 cm depth) were collected from each plot. Treatments wise soil samples were prepared with wooden rod and sieved with 2 mm sieve. Properly prepared and labelled soil sample were kept for analysis in the laboratory. Soil pH was determined in 1: 2.5 ratio soil- water suspensions (Piper, 1966). Electrical conductivity (dSm^{-1}) of supernatant liquid was recorded by Electrical conductivity meter (Black, 1965), Organic carbon (%) was estimated by the Walkley and Black's rapid titration method (1934). Available Nitrogen(kg ha^{-1}) in soil was determined by alkaline potassium permanganate method as described by Subbiah and Asijia (1956), phosphorus in the soil was carried out by the method as given by Olsen *et al.*, (1954). Available potassium was determined by extracting soil with neutral normal ammonium acetate solution. The estimation of potassium was carried out by Flame photometer as described by Jackson (1967). Available micronutrients (available zinc, iron, manganese and copper) were estimated by the DTPA extraction method using AAS given by Lindsay and Norvel (1978). To estimate the micronutrients 20 ml DTPA reagent were added in the 10 g of soil sample and shaking was done for two hours. Estimation of zinc, iron, manganese or copper was carried out in the extract by atomic absorption spectrophotometer.

2.3. Liquid microbial consortium

IFFCO made liquid consortia were used as a testing material in this experiment. It contains nitrogen fixing bacteria, (*Azotobacter* /*Azospirillum*/*Rhizobium*), Phosphate Solubilising Bacteria (*Pseudomonas mallei, Pseudomonas cepaceae, Penicillium sp.*) and Potash Solubilising Bacteria (KSB) which CFU (Minimum Count) 1 X 10^{-}8 per ml with the total viable count- 5 X 10^{-}8 cells per ml.

2.4. **Treatment detail**

Experiment consist of seven treatments, viz. T1- Control (0:0:0), T2- 75% RDF (90:45:30), T3- 100% RDF (120:60:40), T4-75% RDF + Seed coating with NPK Liquid Microbial Consortia @5ml kg^{-1}, T5- 100% RDF + Seed coating with NPK Liquid Microbial Consortia @5ml kg^{-1}, T6- 75% RDF + Seed coating with NPK Liquid Microbial Consortia @5ml kg^{-1} + Soil application of NPK consortia @3 L ha^{-1} at 21 DAS, and T7- 100% RDF + Seed coating with NPK Liquid Microbial Consortia @5ml kg^{-1} + Soil application of NPK Liquid Microbial Consortia @3 L ha^{-1} at 21 DAS. with three replications were used in a complete randomized block design.

2.5. Data analysis

Data were collected through various observations of soil on different dates was carried out in split plot design with two levels each replicated three times as described by Gomez and Gomez (1984). Test of significance of the treatments were computed with the critical difference at 5 percent level of significance.

3. Results and Discussion

3.1. Soil physio chemical properties

3.1.1. Effect of microbial consortium on soil pH, EC and OC content (%).

soil reaction (pH) salt concentration (Electrical conductivity) and organic carbon status were not significantly influenced by the different treatments of fertilizer levels and microbial consortia applied. Slightly decrease in the soil reaction (pH) and slightly increase in the OC status after the harvesting of rice were observed from their initial soil values (before application of treatments). It might be due to the addition of organic matter as plant residues (straw and roots) of rice crop gown in the field. As compared to untreated- control (T1) a non-significant decrease in pH and increase in organic carbon content due to application of fertilizer and microbial consortia were also recorded. Ramlakshmi*et. al.*, (2008), also observed slightly reduction in soil pH and increase in organic carbon content in biofertilizer inoculated treatments as compared to the un-inoculated control soil.

Table 1: Effect of microbial consortium on soil pH, EC, and OC status in soil after harvesting.

Treat.	**Treatment**	**pH**	**EC (dSm^1)**	**OC (%)**
T1	Control (0:0:0)	7.30	0.27	0.59
T2	75% RDF (90:45:30)	7.29	0.26	0.59
T3	100% RDF (120:60:40)	7.27	0.26	0.60
T4	75% RDF + Seed coating with NPK consortia @ 5ml kg^{-1}	7.27	0.25	0.58
T5	100% RDF + Seed coating with NPK consortia @ 5ml	7.25	0.25	0.61

	kg^{-1}			
T6	75% RDF + Seed coating with NPK consortia @ 5ml kg^{-1} + Soil application of NPK consortia @ 3 L ha^{-1} at 21 DAS	7.26	0.26	0.59
T7	100% RDF + Seed coating with NPK consortia @ 5ml kg^{-1} + Soil application of NPK consortia @ 3 L ha^{-1} at 21 DAS	7.25	0.26	0.60
	CD at 5%	**NS**	**NS**	**NS**
	SEM$\pm$	0.0437	0.0125	0.0151

Changes due to NPK liquid bio fertilizer consortia on N, P and K status.

3.1.2. Soil available nitrogen (kg ha^{-1})

Data on Table 2 shows that the residual status of available nitrogen in the soil after the harvesting of rice was not significantly influenced by the fertilizer levels and microbial consortia applied. Among the all treatments, maximum available nitrogen (228.7 kg ha^{-1}) was recorded with application of 100% RDF @ 120:60:40 kg ha^{-1} (T3), while minimum soil available nitrogen (219.9 kg ha^{-1}) was found with the control (T1).

The data showed non-significant variation in the residual available nitrogen status due to the application of microbial consortia with the chemical fertilizer at either 75% RDF or 100% RDF. Values of soil nitrogen were observed to be higher in the 100% RDF and 75% RDF applied treatments (T2-T7) than the control. The treatments T2-T7 showed a marginal increase in residual available N in the soil from the initial level (223.7 kg ha^{-1}). It might be due to the addition of nitrogen through the fertilizer (90-120 kg ha^{-1}) and less uptake of nitrogen from the soil, leading to a substantial amount of leftover N nutrient in the soil, while due to no application of nitrogen fertilizer and uptake from the stored soil nitrogen, the lowest value was recorded with the treatment of no fertilizer (control). Due to the low yield and overall, less uptake of soil nitrogen in the control plot, the decrease was observed to be non-significant.

Positive effect of inorganic fertilizers and consortium biofertilizers on fertility status of the soil was reported by various scientists. Maragatham and Martin, (2010),reported that application of 100 percent RDF + biofertilizers increased the availability of nitrogen as compared with control. Ramlakshmi*et. al*., (2008), also reportedthat status of soil available nitrogen was higher in the treatments where *Azospirillum* was a component as compared to control. Yuvaraj, (2016), was observed statistically higher nitrogen in the treatment having inorganic fertilizers and consortium biofertilizers.

Table 2: Effect of liquid NPK Consortia on soil available N, P and K (kg ha^{-1}) after harvesting of rice.

Treat.	Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T1	Control (0:0:0)	219.89	21.82b	370.3
T2	75% RDF (90:45:30)	225.79	24.69ab	376.3
T3	100% RDF (120:60:40)	228.73	27.11a	379.5
T4	75% RDF + Seed coating with NPK consortia @ 5ml/kg	224.85	24.84 ab	372.6
T5	100% RDF + Seed coating with NPK consortia @ 5ml/kg	227.94	26.95a	377.1
T6	75% RDF + Seed coating with NPK consortia @ 5ml/kg + Soil application of NPK consortia @ 3 L/ha at 21 DAS	226.94	25.42a	374.1
T7	100% RDF + Seed coating with NPK consortia @ 5ml/kg + Soil application of NPK consortia @ 3 L/ha at 21 DAS	226.55	27.68a	375.3
	CD at 5%	**NS**	**3.54**	**NS**
	SEM±	**2.9984**	**1.1486**	**7.0079**
	CV %	**2.29**	**7.80**	**3.24**
	Initial values kg/ha	**223.70**	**24.36**	**384.44**

3.1.3. Soil available phosphorus (kg ha^{-1})

Data on Table 2 shows that residual available phosphorus in the soil after harvesting of rice was significantly influenced by the fertilizer levels and microbial consortia. Among all the treatments, the maximum residual available phosphorus (27.7 kg ha^{-1}) in the soil was obtained in treatment of combined application of consortia as seed treatment + soil application with 100% RDF (T7), while the minimum available phosphorus (21.8 kg ha^{-1} P) was found in control treatment (T1).

Among the various treatments of application of chemical fertilizers (T2 and T3), 100% of the recommended dose of fertilizer (27.1 kg ha^{-1} P) was found at par residual available phosphorus with 75% of the RDF (24.7 kg ha^{-1} P) and observed significantly higher than the control (21.8 kg ha^{-1} P).Data showed that among the various treatments of microbial consortia (seed treatment + soil application) with the 75% RDF, the residual available phosphorous of T4 (24.8 kg ha^{-1}) and T6 (25.4 kg ha^{-1}) were observed at par with each other. They also found at par residual soil P with the 75% RDF alone (24.7 kg ha^{-1}) and 100% RDF alone (T3) which shows that application of 75% RDF + Seed coating with NPK consortia @ 5ml/kg (T4) and 75% RDF + Seed coating with NPK consortia @ 5ml kg^{-1} + Soil application of NPK consortia @ 3 L ha^{-1} at 21 DAS (T6) were found best for manage the residual available phosphorous in the soil and save 25% phosphorous fertilizer.

The residual available phosphorous in the treatments of consortia with 100% RDF (T5 and T7) were found at par with each other and also with alone application of 100% RDF (27.1 kg ha^{-1}). These treatments recorded 27.7 (T7) and 26.9 kg ha^{-1} (T5) soil available phosphorus which showed marginal increase in soil available P from the initial level (24.36 kg ha^{-1}) due to higher dose (100%) of applied phosphorous.

Applications of microbial NPK consortia with 100% RDF (@ 60 kg ha^{-1} P) showed higher residual phosphorous value than the treatments where microbial NPK consortia were applied with 75% RDF (@ 45 kg ha^{-1} P) this might be due to greater addition of inorganic nutrients to the soil.

The results are supported by finding of many scientists.Significant variation in the residual available phosphorus in the soil was also reported by Maragatham and Martin, (2010), they also found highest and at par availability of phosphorous in application of 100 per RDF and 100 per cent RDF + biofertilizers. Ramlakshmi*et. al*., (2008), also reportedincreased available phosphorus in the soil due to application of phosphobacteria. Sreedevi, (2014),revealed that applications of 75 per cent recommended dose of nitrogen and phosphorus along with *Azospirillum* + PSB were found to be the best schedule with saving of 25 per cent of N and P requirement.

3.1.4. Soil available potassium (kg ha^{-1})

Data on Table 2 shows that the residual status of available potassium in the soil after the harvesting of rice was not significantly influenced by the treatments of microbial consortia. Among all the treatments, maximum available potassium (379.5 kg ha^{-1}) was recorded with T3 (100% RDF alone), while minimum soil available potassium (370.3 kg ha^{-1}) was found with control (T1).

Data showed non-significant variation in the residual available potassium status (372.6-377.1 kg ha^{-1}) due to the application of microbial consortia along with 75 - 100 % recommended dose of chemical fertilizer. Values of soil potassium were observed to be higher in the treatments of 75% RDF and 100% RDF alone or with microbial consortia (T2-T7) than in the control (T1). It might be due to the addition of potassium through the fertilizer (30-40 kg ha^{-1}) and less uptake of potassium from the soil, leading to a substantial amount of left-over K nutrient in the soil (treatments T2-T7), while due to no application of potassium fertilizer and uptake from the stored soil potassium, the lowest value was recorded with the treatment of no fertilizer application (control). Due to the low yield and over all less uptake of soil potassium in the control plot (in comparison with other treatments), the decrease in soil potassium was not found to be significant. The treatments showed a marginal decrease in residual available K in the soil from the initial level (284.4 kg ha^{-1}) might be due to the uptake of potassium from the soil. A decrease in the K status (from the initial level) was observed less where a full dose of NPK fertilizers (100%) was applied. The results were also supported by Sreedevi, (2014) and Yuvaraj, (2016).

4. **CONCLUSION**

The results show after one year of experiment, the of effect of liquid NPK consortia on the soil reaction, such as pH, and salt concentration in the soil, such as electrical conductivity, were not significantly influenced by the fertilizer levels and NPK consortia applied. The residual soil fertility also exhibited that after the one-year experimentation, there were no significant differences in the soil organic carbon status were recorded among the treatments. The application of NPK consortia with 100% RDF resulted in the highest soil organic carbon (0.60- 0.61%), while the lowest organic carbon (0.58- 0.59%) was found with the control and lower fertilized treatments. No changes in the above parameters may be due to the first year of application of liquid NPK microbial consortia; in the long term, it may show a significant effect.

The residual available nitrogen in the soil after the harvesting of rice was not significantly influenced by the fertilizer levels and NPK consortia applied. The initial status of the experimental soil was low for available nitrogen (224 kg ha^{-1}), medium for available phosphorus (24.5 kg ha^{-1}) and high for available potassium (384 kg ha^{-1}). Due to the addition of nitrogen through the fertilizer (90-120 kg ha^{-1}) and less uptake of native nitrogen from the soil, a marginal increase in the residual available N in the soil from the initial level was observed in all treatments except the control (no fertilizer, no consortia). The residual status of available potassium was also not significantly influenced by the applied fertilizer doses and NPK consortia. A marginal decrease in the residual available K status after the harvesting of rice was observed in all treatments. A decrease was found in the control plot. A decrease in the K status (from the initial level) was observed less where a full dose of NPK fertilizers (100%) was applied with the NPK consortia.

Residual available phosphorus in the soil after harvesting of rice was significantly influenced by fertilizer and NPK consortia applied. Except for the control, all treatments found at par and showed a marginal increase in soil available P from the initial level. Applications of NPK consortia with 100% RDF (@ 60 kg ha^{-1} P) showed higher residual available phosphorous (26.9–27.7 kg $ha^{-1)}$ than the treatments where liquid microbial consortia were applied with 75% RDF (ranged from 24.8–25.4 kg ha^{-1} available P). All these treatments of NPK consortia with 75 and 100% RDF were observed to have equal residual available phosphorous with each other and showed at par with application of 75 % RDF (24.7 kg ha^{-1} P) and 100% RDF (27.11 kg ha^{-1} P).

Over all, maximum residual available phosphorus (27.68 kg ha^{-1}) was obtained with the application of 100% RDF + Seed coating with NPK consortia @ 5ml kg^{-1} + Soil application of NPK consortia @ 3 L ha^{-1} at 21 DAT (T11), while the minimum available phosphorus (21.82 kg ha^{-1} P) was found in the control. Treatments of application of NPK consortia with 75% RDF (T4 and T6) can manage residual available phosphorous in the soil and save 25% phosphorous fertilizer.

REFERENCES

1. Agricultural statistics at a glance, 2020-21. Ministry of Agriculture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics, Govt. of India.
2. Agricultural statistics, 2019-20. Govt. Of Chhattisgarh. Department of Revenue, Chhattisgarh
3. Alam, Zahanggir, Md., Sadekuzzaman, Md., Sarker Souvic, Hafizur Rahman Hafiz, Md., 2015. Reducing soil application of nitrogenous fertilizer as influenced by liquid fertilization on yield and yield traits of kataribhog rice. Vol. 6, No. 1, p. 63-69.
4. Black CA., 1965. Method of soil analysis part-1. *American Soc. Agron. Inc. Agron*. 9 Madison USA, 770.
5. Fitriatin, B.N., Amanda, A.P., Kamaluddin, N.N., Khumairah, F.H., Sofyan E.T., Yuniarti, A., and Turmuktini, T., 2021. Some soil biological and chemical properties as affected by

biofertilizers and organic ameliorants application on paddy rice. *Eurasian J Soil Sci,* 10 (2) 105 - 110

6. Gaur, A.C. and Singh, R., 1982. Integrated nutrient supply system. Fertilizer News. 27 (1): 87-98.
7. Islam, Md. Z., M. A., Ashrafuzzaman, M., Mohd Saud, H. and Uddin, M. K., 2012. Improvement of yield potential of rice through combined application of biofertilizer and chemical nitrogen. *African Journal of Microbiology Research.* Vol. 6(4): 745-750.
8. Jackson, M. L., 1967. Soil Chemical Analysis. Prentice-Hall of India Pvt. Ltd., New Delhi, India
9. Kumar, K. S., Saravanam, A., Natrajan, S.K., Veerabadran, V. and Mani, S., 2005. Microbial population and enzymatic activity as influenced by organic farming. *Res. J. Agric. and Biol. Sci*., 1(1):85-88
10. Kumari, M.B.G.S., Subbaiah, G., Veeraraghavaiah, R. and Rao, C.V.H., 2000. Effect of plant density and nitrogen levels on growth and yield of rice. *The Andhra Agricultural Journal,* 47: 188-190.
11. Kundu, B.S. and Gaur, A.C., 1984. Rice response to inoculation with N_2 fixing and P-solubilizing microorganisms. *Plant and Soil,* 79: 227-234.
12. Mathews, Dhanya V., Patil, P. L. and Dasog, G.S., 2006. Effect of Nutrients and Biofertilizers on Growth Parameters of Rice in Coastal Alluvial Soil of Karnataka. *Karnataka J. Agric. Sci*.,19(4):793-798.
13. Meena, B.P., Kumar, A., Lal, B., Sinha, N.K., Tiwari, P.K., Dotaniya, M.L., Jat, N.K. and Meena, V.D., 2015. Soil microbial, chemical properties and crop productivity as affected by organic manure application in popcorn (*Zea mays* L. var. everta). *African Journal of Microbiology Research,* Vol. 9(21), 1402- 1408
14. Olsen *et al*., 1954**.** Estimation of available phosphorus (in soil) by Olsen"s method for slightly acidic, neutral and alkaline soils. Pp 14-15
15. Piper CS., 1996. Soil and Plant Analysis, Hans Publishers, Bombay, India.
16. Ramalakshmi, A., Iniyakumar, M., and Anthoni, S., 2008. Influence of biofertilizers on soil physico-chemical and biological properties during cropping period. *Asian Journal of Bio Science,* Vol. 3 No. 2: 348-351.
17. Rekha Lasya Mohana D., Lakshmipathy R. and Gopal Vijaya A., 2018. Effect of Microbial Consortium and Organic Manure on Growth and Nutrients Uptake in Pearl Millet (Pennisetum glaucum L.). *Int. J. Curr. Microbiol. App. Sci* 7(6): 2256-2261
18. Sah Amit Kumar, Singh Mahendra, Pradhan Amit Kumar, Prasad Sambhu, Chatoopadhyaya N., Behera Subrat Keshori, and Kiran Kajal, 2018. Effect of organic fertilizer and microbial

inoculants on soil biological properties and yield of scented rice (Oryza sativa L.). *Journal of Applied and Natural Science* 10 (3): 995 - 1002

19. Salamone, I. E.G.D., Funes, J.M., Salvo, L.P.D., Ortega, J.S.E., Dauria, F., Ferrando, L. and Scavino, A.F., 2012. Inoculation of Paddy Rice with *Azospirillumbrasilense*and *Pseudomona*s *flurescens*: Impact of plant genotypes on rhizosphere microbial communities and field crop production. *Applied Soil Ecology* 196-204.
20. Shaban, K.A., A.M. Helmy and A.H. Abd El-Rhman, 2008. Nutrient uptake and yield quality of soybean as affected by bio and organic nitrogen fertilizers. *Zagazig J. Agric. Res*., 35: 343-362.
21. Singh, A., Sravan, U.S., Kumar, S. and Singh, S.P., 2017. Impact of fertility levels and bio-fertilizers on growth, yield and economics of basmati rice. *International Journal of Current Microbiology and Applied Sciences*, *6*(4), pp.1471-1476.
22. Subba Rao, N.S., 2007. Soil microorganisms and plant growth. Oxford IBH publication, New Delhi.
23. Subbiah and Asija, 1956. Estimation of available nitrogen in soil by Alkaline permanganate method, Pp 12-13
24. Sukhada, M., 1999. Biofertilizers for horticultural crops. *Indian Hort* 44(1):32-35.
25. Suliasih and S Widawati, 2018. The Effect of Biofertilizer Combined with Organic or Inorganic Fertilizer on Growth of Caesalpinia pulcherrima and Bacterial Population in Soil. Earth Environ. Sci. 166. doi :10.1088/1755-1315/166/1/012024
26. Sundara Rao, W.V.B. and Sinha, M.K., 1963. Phosphate dissolving organisms in the soil and rhizosphere. *Indian Journal of Agricultural Science*, 33: 272- 278.
27. Swędrzyńska, D. and Sawicka, A., 2001. Effect of inoculation on population numbers of Azospirillum bacteria under winter wheat, oat and maize. P*olish Journal of Environmental Studies* 10(1)
28. Tejaswini, M., Sreedevi, B., Baby Akula, Kumar Anil B., and Singh, Aarti, 2017. Effect of Cultivars and Biofertilizers on Growth, Yield and Nutrient Content of Aerobic Rice (*Oryza sativa L*). *Environment & Ecology* 35 (4C): 3022-3027.
29. TualarSimarmataa, Tien, T.M., Endang Kantikowati, Betty Natalie, Mieke Setiawati, YuyunYuwariah, and Benny Joy. 2012. Restoring the health of paddy soil by using straw compost and biofertilizer efficiency and rice production with sobari (system of organic based aerobic rice intensification). *Asian Journal of Agriculture and Rural Development,* Vol.2, No.4, pp.519-526.

30. Yuvaraj, K., 2016. Effect of bio-fertilizers and inorganic fertilizers on soil health, growth and yield of rice (*Oryza sativa* L.) crop. Doctoral dissertation, Punjab Agricultural University Ludhiana.