Life Science Informatics Publications

Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences

Journal Home page http://www.rjlbpcs.com/

RJLBPCS
ISSN 2454-6348

Original Research Article **DOI: 10.26479/2018.0405.19**

INFLUENCE OF FERTILIZERS AND VERMICOMPOST ON *ORYZA SATIVA* L.

N Ramesh[1*], E Saraswathi[1], G Rajesh[1], K Babu Rao[2], G Rajanikanth[2]

1.PG & Research Department of Botany, Government Arts College for Men, Krishnagiri, Tamil Nadu, India.

2.Department of Biotechnology, JJ College of Arts and Science, Pudukkottai, Tamil Nadu, India.

ABSTRACT: *Oryza sativa* L. family - Poaceae, locally known as Nellu in Tamil, Paddy in English. The increased population of the world needs more food to live on the earth. Biofertilizers have attracted greater attention particularly in developing countries like India as a substitute for costly chemical fertilizers. The *O. sativa* seeds cultivated in poly bag contain the red soil. After five days of seeds germination, the seedling treated with biofertilizer, vermicompost, chemical fertilizer individually and in combination and watered daily. The plant height, shoot length, lamina length and width were observed periodically on 10^{th}, 20^{th}, 30^{th} and 40^{th} days of cultivated plant. The chlorophyll-a, b, and total chlorophyll contents estimated from the control and experimental leaves on 40^{th} days of cultivation. The maximum content of total chlorophyll recorded in *O. sativa* G_6 group (24.93 ±1.53µmg/g) followed by G_8 (23.93±1.16 µg/g), G_3 (23.51±0.43µg/g), G_2 (22.76 ±0.52µg/g) respectively. The chlorophyll-a, higher values were recorded in G_6 (8.28±0.86µg/g) followed by G_3 (7.67±1.45µg/g) and G_8 (7.65±0.75 µg/g) group leaves. The better content of Chlorophyll-b recorded in G_6 (16.71 ±0.67 µg/g) followed by G_8 (16.34 ±0.41µg/g) and G_3 (15.89 ±0.98µg/g), and lowest was recorded in G_7 (10.35 ±0.09µg/g) respectively. The present investigation has proved that the combination of phosphobacteria and vermicompost is an active fertilizer mixture for the influence of better plant growth and enrichment the chlorophyll content in *O. sativa.*

KEYWORDS: *Oryza sativa*, biofertilizer, vermicompost, chlorophyll.

***Corresponding Author: Dr. N Ramesh** Ph.D.

PG & Research Department of Botany, Government Arts College for Men, Krishnagiri, Tamil Nadu, India. Email Address: nprg@rediffmail.com

1.INTRODUCTION

Cultivation of plants, animals, birds and other life forms for food, fibers, biofuels and additional products for the supreme beingness of human life. Today, global agriculture is at crossroads as a consequence of the climatic change, increased population pressure and detrimental environmental impacts. The increased population needs more food to live on the earth. Indian agriculturalists are in a position to improve our food production within the available cultivated land. Application of commercial fertilizers to the soil is more expensive and also resulted in soil degradation. A new mechanism should be found to ensure food security through sustainable crop production systems that supply adequate nutrition, without harming the agroecosystem [1]. Biofertilizers have focused greater attention in developing countries like India as a substitute for chemical fertilizers. They can be treated to seed, root or soil mobilize the availability of nutrients by their biological activity and turn the soil health in general. Biofertilizers provide eco-friendly organic agro-input and are more cost effective than chemical fertilizers [2]. Biofertilizers containing beneficial bacteria, algae, and fungi improve soil chemical and biological characteristics, phosphate solutions and agricultural production [3],[4]**.** Microbial fertilizers are essential to environment-friendly sustainable farming practices [5]. The Biofertilizers includes mainly the nitrogen-fixing, phosphate solubilizing and plant growth promoting microorganisms [6]. These microorganisms require organic matter for their growth and activity in soil and provide valuable nutrients to the plant [7]. Biofertilizers are eco-friendly fertilizer, which improves soil quality and provide yield increments. It dramatically benefits a farmer with only a minimal input cost [8],[9],[10]. Rice is a staple food for about 50 percent of the world's population that resides in Asia, where 90% of the world's rice is grown and consumed. In Asia, India has the most significant area for cultivation under rice (41.66 million ha) accounting for 29.4 percent of the global rice area. Of the total area, about 46 percent irrigated, 28 percent is rainfed lowland, 12 percent is rainfed upland, and 14 percent is flood-prone [11]. Rice is a staple food crop of 63 to 65 percent people of India. The 96.7 million tons rice yield at present from the paddy plants grown in 43 million hectares of land. Its production of rice has to be raised to 160 million tons by 2030 with a minimum annual growth rate of 2.35 percent [12]. The present investigation helps to find out the exact fertilizer to enhance the growth and chlorophyll content of plant and will improve the quantity and quality of rice production.

2.MATERIALS AND METHODS

Plant material and cultivation

Oryza sativa L. (Nellu in Tamil language and paddy in English) is a perennial grass in the Poaceae (grass family) that originated in India. *Oryza sativa* seeds procured from the Tamil Nadu Agriculture University, Paiyur, Krishnagiri District, Tamil Nadu and the seeds cultivated in poly bag contain the red soil at Botanical Garden, PG & Research Department of Botany, Government Arts College for Men, Krishnagiri. After five days of seeds germination, the seedling treated with biofertilizer, vermicompost, and chemical fertilizer individually and in combination (Table 1). The plants were watered daily in a traditional method.

Table 1: Design of the experiment

Name of the Group	Nature of fertilizers applied to *Oryza sativa*
G_0	Control (Free to fertilizer)
G_1	Vermicompost - 50 g/pot
G_2	Azospirillum (Biofertilizer) -50 g/pot
G_3	Phosphobacteria (Biofertilizer) -50 g/pot
G_4	Azospirillum + Vermicompost – 25 +25g/ pot
G_5	Azospirillum + Phosphobacteria - 25 +25g/ pot
G_6	Phosphobacteria + Vermicompost - 25 +25g/ pot
G_7	Urea - 10 g/pot
G_8	DAP - 10 g/pot

Morphological analysis of *Oryza sativa* leaves

The plant height, shoot length and length and width of leaves were observed periodically on 10^{th}, 20^{th}, 30^{th} and 40^{th} days of cultivated plant.

Biochemical analysis of leaves

The chlorophyll-a, b and total chlorophyll contents of the leaves estimated from the control and experimental *O. sativa*.

Determination of chlorophyll pigments

The quantity of total chlorophyll, chlorophyll-a, and chlorophyll-b contents was estimated using the Arnon's method [13]. 250 mg of fresh leaf tissues homogenized with 10 ml of 80 % acetone. Then the content was centrifuged at 3000 rpm for 15 min. After centrifugation, the supernatant transferred in the separate test tube. The residue was mixed with 5 ml of 80 % acetone and centrifuged again then the supernatant was collected and transferred in to already collected one, the step repeated until the pellet become colorless. The supernatant made up to 10 ml with 80 % acetone, and then the extract observed at 663 nm and 645 nm in a spectrophotometer. The chlorophyll content of the leaf calculated by the following formula and noted in the content of chlorophyll pigment in µg/gram weight of fresh leaf tissue.

µg of chlorophyll-a/g tissue = 12.7 (A663)-2.69 (A645) xv/1000 x w

µg of chlorophyll-b/g tissue = 22.9 (A645)-4.68 (A663) x v/1000 x w

µg total chlorophyll/g tissue = 20.2 (A645)+8.02 (A663) x v/1000xw

Where,

A = absorbance on specific wavelengths

V = final volume of chlorophyll extract in 80 % acetone

W = fresh weight of tissue extracted

Statistical analysis

All experiments carried out thrice, and the data values recorded. The data were analyzed statistically using standard deviation and also calculated standard error. The processed data were tabulated in tables and represented in the form of a bar diagram of the graph.

3.RESULTS AND DISCUSSION

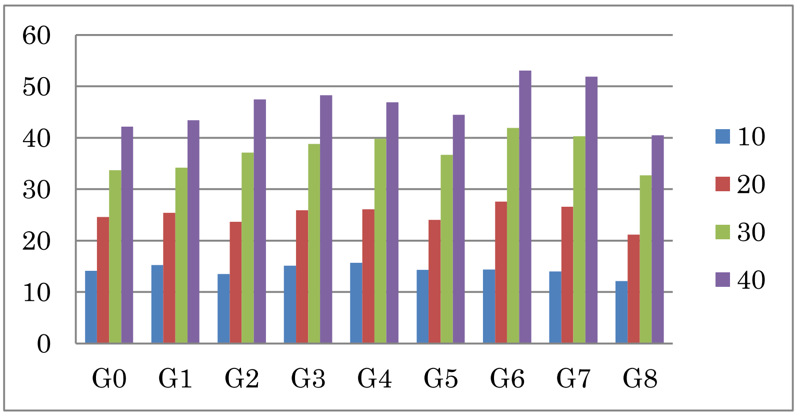
The morphological character of *Oryza sativa*

The morphological parameters of plant height, leaf sheath length, and width of lamina were measured (Table 2 & 3, Graph 1-3) from the control and experimental *O. sativa* (G_0-G_8). The maximum height of paddy observed in phosphobacteria + vermicompost treated plant (53.1±0.78 cm) compare to control (42.2 ±0.79 cm) Table - 2 and Graph - 1. All the paddy plants (G_1-G7 groups) height observed between 43.4±0.80 and 53.1±0.78 cm except G_8 (40.5±1.25) compare to control plant (G_0 - 42.2 ±0.79). The maximum lamina length and width saw in G_6 group of paddy show 26.2±1.75 x 0.82±1.24 cm, and the minimum value as recorded in vermicompost treated paddy (19.5±0.68 x 0.74±0.38 cm). The better lamina length and width were observed in plant treated with Azospirillum, phosphobacteria, vermicompost and chemical fertilizer alone and in combination compared to control (G_0) Table -3 and Graph - 2 &3. In this study revealed that the phosphobacteria + vermicompost are more responsible for regulating the plant growth and the formation of maximum length and width of the leaf (Table 2 & 3). Similarly, the chemical fertilizer DAP is suitable for maximum growth development of paddy compare to urea.

Table 2: Growth performance (height) of *O. sativa* by the influence of fertilizers and vermicompost at different time intervals (days)

Name of the Group	Plant height (cm) in days			
	10	20	30	40
G_0	14.12±0.92	24.62±0.46	33.7±0.46	42.2 ±0.79
G_1	15.23±1.04	25.4±0.90	34.2±1.37	43.4±0.80
G_2	13.52±0.31	23.7±0.74	37.10±1.13	47.5±1.02
G_3	15.12±0.26	25.9±0.07	38.8±0.70	48.3±0.72
G_4	15.69±0.72	26.10±1.03	39.8±0.52	46.9±1.20
G_5	14.32±1.08	24.03±0.68	36.7±0.55	44.5±1.23
G_6	14.37±0.43	27.6±0.66	41.02±0.68	53.1±0.78
G_7	14.02±0.74	26.62±0.46	40.32±0.61	51.9±0.92
G_8	12.17±0.64	21.2±0.46	32.68±0.41	40.5±1.25

The observed data revealed that the paddy grows successfully by the influence of applied fertilizers; among the fertilizers, phosphobacteria + vermicompost combined organic fertilizer is suitable for the successful growth of paddy (Table 2).



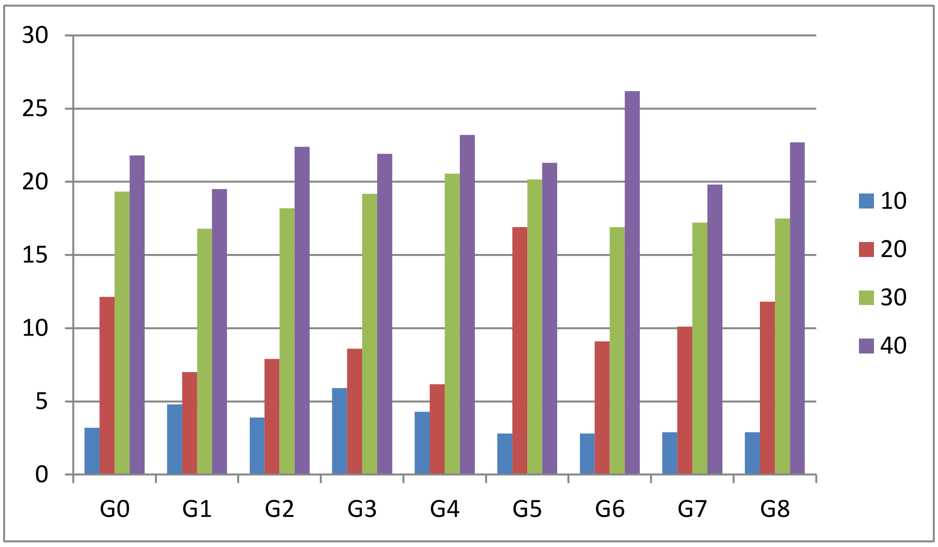
Graph 1: Growth performance (height) of *O. sativa* by the influence of fertilizers and vermicompost at different time intervals (days)

G_0- Control, G_1 – Vermicompost, G_2- Azospirillum, G_3- Phosphobacteria, G_4 - Azospirillum+ Vermicompost, G_5 – Azospirillum + Phosphobacteria, G_6 Phosphobacteria + Vermicompost, G_7 – Urea, G_8- DAP

The graph expresses the processed data in the form of bar diagram expose that the phosphobacteria + vermicompost combination is suitable for efficient growth of paddy compared to all other treatment (Graph - 1) group.

Table 3: Growth performance (leaf sheath length and width) of the *O. sativa* by the influence of fertilizers and vermicompost at different time intervals (days)

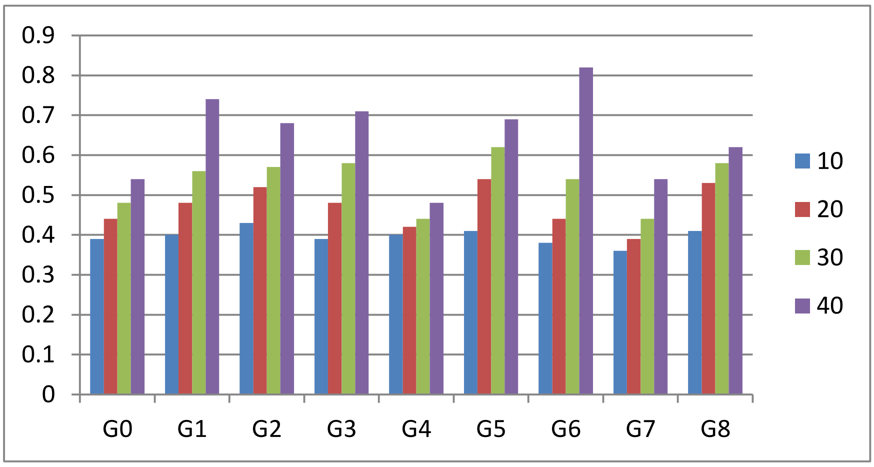
Name of the Group	The surface area of leaf sheath (cm) in days							
	Leaf sheath length				Leaf sheath width			
	10	20	30	40	10	20	30	40
G_0	3.20±0.17	12.14±1.59	19.34±1.59	21.8±0.67	0.39±0.10	0.44±0.05	0.48±0.05	0.54±0.36
G_1	4.80±0.72	7.05±1.15	16.8±1.84	19.5±0.68	0.40±0.12	0.48±0.04	0.56±0.09	0.74±0.38
G_2	3.90±0.38	7.98±0.37	18.2±0.88	22.4±0.69	0.43±0.14	0.52±0.04	0.57±0.05	0.68±0.42
G_3	5.90±1.74	8.60±0.09	19.18±0.91	21.9±0.70	0.39±0.10	0.48±0.04	0.58±0.09	0.71±0.53
G_4	4.30±2.12	6.18±1.35	20.56±0.51	23.7±0.82	0.40±0.04	0.42±0.03	0.44±0.05	0.48±0.64
G_5	2.80±0.54	16.90±0.67	20.16±1.85	21.3±1.62	0.41±0.12	0.54±0.14	0.62±0.17	0.69±0.74
G_6	2.80±0.18	9.10±1.72	16.9±0.67	26.2±1.75	0.38±0.17	0.44±0.05	0.54±0.14	0.82±1.24
G_7	2.90±0.04	10.10±1.59	17.2±1.65	19.8±1.76	0.36±0.10	0.39±0.14	0.44±0.05	0.54±1.25
G_8	2.90±0.74	11.80±1.59	17.5±1.45	22.7±1.89	0.41±0.50	0.53±0.24	0.58±0.09	0.62±1.39



Graph 2: Growth performance (leaf sheath length) of the *O. sativa* by the influence of fertilizers and vermicompost at different time intervals (days)

G_0- Control, G_1 – Vermicompost, G_2- Azospirillum, G_3- Phosphobacteria, G_4 - Azospirillum+ Vermicompost, G_5 – Azospirillum + Phosphobacteria, G_6 Phosphobacteria + Vermicompost, G_7 – Urea, G_8- DAP.

The recorded data showed that the paddy grew successfully and enhanced leaf sheath development by the impact of applied fertilizers, among the fertilizers; phosphobacteria + vermicompost combination is suitable for better leaf development (Table 3; Graph 2 & 3).



Graph 3: Growth performance (leaf sheath width) of the *O. sativa* by the influence of fertilizers and vermicompost at different time intervals (days)

G_0- Control, G_1 – Vermicompost, G_2- Azospirillum, G_3- Phosphobacteria, G_4 - Azospirillum+ Vermicompost, G_5 – Azospirillum + Phosphobacteria, G_6 Phosphobacteria + Vermicompost, G_7 – Urea, G_8- DAP

Chlorophyll Contents in *O. sativa* leaves

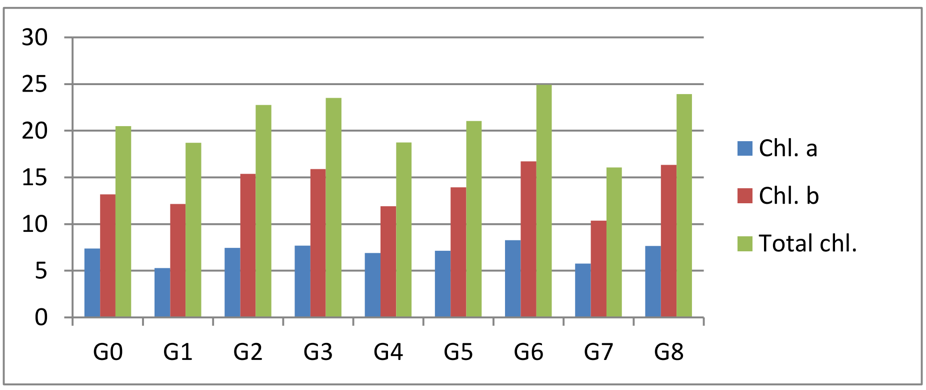
The better total chlorophyll contents recorded in *O. sativa* - G_6 group (24.93 ±1.53µg/g) followed by G_8 (23.93 ±1.16), G_3 (23.51 ±0.43µg/g), G_2 (22.76 ±0.52 µg/g) respectively. Similarly, the better values of chlorophyll-a recorded in G_6 (8.28 ±0.86µg/g) followed by G_3 (7.67 ± 1.45µg/g) and G_8 (7.65 ±0.75µg/g) group leaves (Table 4; Graph 4).

Table 4: Level of chlorophyll contents in *O. sativa* leaves. The plant treated with various fertilizers

Name of the group	Chl. a µg/g f. wt	Chl. b µg /g f. wt	Total chl. µg/g f. wt
G_0	7.36 ± 0.12	13.18 ±0.04	20.49 ±0.16
G_1	5.28 ±0.66	12.15 ± 0.37	18.71 ±1.03
G_2	7.44 ±0.21	15.37 ±0.31	22.76 ±0.52
G_3	7.67 ± 1.45	15.89 ±0.98	23.51 ±0.43
G_4	6.88 ±0.04	11.90 ±0.27	18.75 ±0.31
G_5	7.15 ±1.74	13.94 ±1.54	21.05 ±3.28
G_6	8.28 ±0.86	16.71 ±0.67	24.93 ±1.53
G_7	5.75 ±0.12	10.35 ±0.09	16.07 ±0.21
G_8	7.65 ±0.75	16.34 ±0.41	23.93 ±1.16

G_0- Control, G_1 – Vermicompost, G_2- Azospirillum, G_3- Phosphobacteria, G_4 - Azospirillum+ Vermicompost, G_5 – Azospirillum + Phosphobacteria, G_6 Phosphobacteria + Vermicompost G_7 – Urea, G_8- DAP

The better content of Chlorophyll-b recorded in G_6 (16.71 ±0.67µg/g) followed by G_8 (16.34 ±0.41µg/g) and G_3 (15.89 ±0.98 µg/g), and the lowest value was recorded in G_7 (10-35 µg/g) respectively (Table - 4, Graph - 4). Chlorophyll content is significant for quantifying the photosynthetic efficiency of the plant and is an essential constituent in assessing the quality of foliage. Total chlorophyll content of fresh *O. sativa* leaves ranged from 16.07 – 24.92 µg/g. The high content of chlorophyll observed in the G_6 group of *O. sativa*. The present investigation reveals that the combination of phosphobacteria and vermicompost is a compelling combination for both growth developments as well as enriches of the chlorophyll content among the treatment of the experimental plant.



Graph 4: Level of chlorophyll contents in *O. sativa* leaves. The plants treated with various fertilizers.

G_0- Control, G_1 – Vermicompost, G_2- Azospirillum, G_3- Phosphobacteria, G_4 - Azospirillum+

Vermicompost, G_5 – Azospirillum + Phosphobacteria, G_6 Phosphobacteria + Vermicompost, G_7 – Urea, G_8- DAP.

The graphical presentation of the data denoted the actual content of chlorophyll in the control and experimental groups. The high content of chlorophyll observed in the G_6 group of *O. sativa*. The present investigation reveals that the combination of phosphobacteria and vermicompost is a compelling combination for both growth development and enriches the chlorophyll content among the treatment of the experiment. The individual effect of organic fertilizer was significant as well as enhancing the vegetative characteristics of summer squash plants [14]. Similarly, the indirect impact of Azotobacter is mainly through the improvement of soil structure [15] and to release of compounds like polysaccharides that help keep the soil particles intact [16]. The development of vegetative growth might be due to the role of organic fertilizer for increasing soil ventilation by increasing the porosity and this animal fertilizer being an organic matter in the ground is considered as a significant source of nutrient elements especially nitrogen and phosphorus. These findings positively correlated with the present study for the better growth of the plant. The improvement in vegetative attributes of the plant might be due to the ability of Azotobacter to fix atmospheric Nitrogen which may share its role in increasing the amount of mineral nutrient in the soil [17], [18]. Besides it increases the surface area of the root hairs followed by an increase in average absorption of mineral nutrients [19], [20]. Similarly, the Azotobacter could release specific chemical compounds that may affect the enhancement of plant growth [21]. The significant effect of both the bio and organic fertilizers on yield and quality of plant might be the release of growth promoting phytohormones like indole acetic acid [22], cytokinin [14], and gibberellins [23]. These substances change the physicochemical properties of soil, macro and micronutrient uptake, nitrogen transformation and nutritional composition [24], [25]. The excess and continuous use of chemical fertilizers for a more extended period has resulted in deterioration of soil character and to causes less productivity [25]. The increased leaf gas exchange and photosynthetic pigments in red chili due to vermicompost application [26]. The significant increase of photosynthetic pigments depends on the ratio of chlorophyll in beans [27]. The availability of chlorophyll in plant dramatically affects the production of secondary metabolites and other essential constituents in the plant. In this experiment, the content of chlorophyll increased in the vermicompost, and phosphobacteria treated paddy plant, this observation is positively related to the earlier report in marigold growth [28].

4.CONCLUSION

The present investigation thus proved that the combination of phosphobacteria and vermicompost is an active fertilizer mixture for the influence of better plant growth and enrichment the chlorophyll content in *O. sativa* compared to vermicompost, Azospirillum, phosphobacteria, urea, DAP individual and in a combination of Azospirillum + vermicompost, Azospirillum + phosphobacteria.

CONFLICT OF INTEREST

The authors have declared that they have no conflict of interest.

REFERENCES

1. Panwar JDS, Vijaya Laxmi V. In: Biological nitrogen fixation in pulses and cereals. Development in physiology, biochemistry and molecular biology of plants (Editor: Bandana Bose and A. Hemantaranjan) Published by New India Publishing Agency, New Delhi. 2005.
2. Amudha R, Karunakaran S, Dhanasekaran S, Hemalatha K, Monika R, Shanmugapriya P, Sornalatha T. Isolation and mass production of Biofertilizers (*Azotobactor and Phosphobacter*) International Journal of Latest Research and Technology. 2014; 3:79-81.
3. El-Habbasha SF, Hozayn M, Khalafallah MA. Integration effect between phosphorus levels and biofertilizers on quality and quantity yield of faba bean (*Vicia faba* L.) in newly cultivated sandy soils. Res J Ag Biol Sci. 2007; 3(6): 966-971
4. Yosefi K, Galavi M, Ramrodi M, Mousavi SR. Effect of bio-phosphate and chemical phosphorus fertilizer accompanied with micronutrient foliar application on growth, yield and yield components of maize (Single Cross 704). Aust J Crop Sci. 2011; 5 (2): 175-180.
5. Bloemberg GV, Wijfijes AHM, Lamers GEM, Stuurman N, Lugtenberg BJJ. Simulataneous imaging of *Pesudomonas flourescens* WCS 3655 populations expressing three different autofluorescent proteins in rizosphere: new perspective for studying microbial communities. Molecular Plant Microbe Interaction. 2000; 13: 1170–6.
6. Goel AK, Laura RDS, Pathak G, Anuradha G, Goel A. Use of bio-fertilizers: potential, constraints and future strategies review. International Journal of Tropical Agriculture. 1999; 17: 1–18.
7. Saini V, Berwal R, Sharma J, Singh A. Biofertilizers: current status and perspectives in agriculture. Poll Res. 2004; 23(4): 665-676.
8. Kumudha P. Studies on the effect of biofertilizers on the germination of *Acacia nilotica* Linn. seeds. Adv Plant Sci. 2005; 18(11): 679-684.
9. Kumudha P, Gomathinayagam M. Studies on the effect of biofertilizers on germination of *Albizia lebbek* (L.) Benth. seeds. Adv Plant Sci. 2007, 20(11): 417-421.
10. Viyas SC. Non-target effect of agricultural fungicides. CRC Press Inc, Boca Raton. 1988.
11. Mangla R. International year of rice – An overview. Indian Farming. 2004; 54 (8) : 3-6.
12. Mishra MM, Mohanty M, Gulati JML, Nanda SS. Evaluation of various rice (*Oriza sativa*) based crop sequances for enhanced productivity, profitability and energy efficiency in eastern plateau and hills zone of India. Indian J Agric Sci. 2013; 83(12): 1279-1284.
13. Arnon DI. Copper enzymes in isolated chloroplasts polyphenol oxidase in *Beta vulgaris*. Plant Physiol. 1949; 24 : 1-15.

14. Tomar RKS, Namdeo KN, Raghu JS, Tiwar KP. Effect of Azotobacter and plant growth regulators on productivity of wheat (*Triticum aestirum*) in relation to fertilization application. Indian J Agric Sci. 1995; 65(4): 56-259.
15. Hamdi YA. Application of nitrogen-fixing systems in soil improvement and management. FAO Soil Bull. 1982; 49: 45-82.
16. Brown ME, Burlingham SK. Production of Plant Growth Substances by *Azotobacter chroococcum*. J gem Microbial. 1968; 53: 135-144.
17. Farida HB, El-Dsouky MM, Sadiek HS, Abo-Baker AA. Response of tomato to inoculation with oculants of different bacterial species. Assiut J Agric Sci. 2003; 34(5): 275-285.
18. Sarhan TZ, Mohammed GH, Teli JA. Effect of bio and organic fertilizers on growth yield and fruit quality of summer squash. Sarhad J Agric. 2011; 27(3): 377-383.
19. Abou-Hssein SD, El-Oksh I, El-Shorbagy T, Gomaa M. Effect of cattle manure, bio-fertilizers and reducing mineral fertilizer on nutrient content and yield of the potato plant. Egypt J Hort. 2002; 29(1): 99-115.
20. Mostafa MM. Effect of bio-fertilizer and magnetic technique on the growth of some annual plants. Alex J Agric. 2002; 47(2): 151-162.
21. Arteca R. Plant growth substances. Chapman and Hall, New York, USA. 1996.
22. Marha G, Sandera V, Jaime B, Patricia, M. Isolation of *Entrobcteria*, *Azotobacter* and *Psaeodomonas* Sp Producers of IAA and Siderophores from Colombian rice rhizosphere. Rev Amer J Microbiol. 2000; 42: 171-176.
23. Forlain MB, Pastorelli, R, Sarvilli S. Root potentially related properties in plant associated bacteria. J General Breed. Italy. 1995; 49(4): 343-352.
24. Mahesh MK, Hosmani SP. Morphological changes and nutrient uptake in some cultivars of rice treated with Bavistin. J. Ecotoxicol. Environ. Monitoring. 2004; 14:195-198.
25. Yadav BK, Lourduraj AC. Effect of organic manures and panchagavyga spray on nutrient composition of raw rice (*Oriza sativa* L.). Indian J Environ Ecol. Plan. 2005; 10: 873-878.
26. Berova M, Karanatsdis G. Influence of bio-fertilizer, produced by *Lumbricus rubellus* on growth, leaf gas exchange and photosynthetic content of pepper plants (*Capsicum annuum* L.). Acta Hort. 2009; 830: 447-452.
27. Fernandez-Luqueno F, Reyes-Varela V, MartinezSuarez C, Salomon-Hernandez G, YanezMeneses J, Ceballos-Ramirez JM, Dendooven L. Effect of different nitrogen sources on plant characteristics and yield of common bean (*Phaseolus vulgaris* L.). Bioresource Technology. 2010; 101: 396-403.
28. Subler S, Edwards CA, Metzger J. Comparing composts and vermicomposts. Bio Cycle. 1998; 39: 63–66.