Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 448–452

P- ISSN: 0976-1675 | **E-** ISSN: 2249-4538

www.rjas.org

Research Paper

Effect of 5 MIN on the Growth and Yield Attributes of Rice under Saline Conditions

G. Baradhan[1], S. M. Suresh Kumar[2] and G. Sathiya Narayanan*[3]

Received: 02 Jan 2021 | Revised accepted: 26 Feb 2021 | Published online: 15 Mar 2021

ABSTRACT

Rice (*Oryza sativa* L.) is global grain and staple food for more than half of the global population. Micronutrient refers to the relative quantity of a nutrient that is required for plant growth and is a key element in various metabolic activities; enzymatic process/catalysts etc., and directly or indirectly help in plant growth and development. 5- MIN is a proprietary product of T. Stanes and Company Ltd. and is a microbial formulation that possesses characteristic attributes to rapidly colonize and thrive in harsh conditions of soil and enables nutrient mobilization (Zn, P, Fe, S & fix N). 5-MIN provides natural nutrients, precursors and cofactors for improving the growth and vigor of the plants. The presence of biopolymers ensures longer viability of the microbes and act as biocatalysts for the plants under saline/acidic and alkaline conditions. Among the treatments, T_4- 100% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage was increasing the growth and yield components of rice grown under saline stress condition. This treatment also was found to increase nutrient availability and nutrient use efficiency in rice and improving the organic content and microbial population of the soil thereby enhancing crop productivity.

***Key words*:** Rice, 5MIN, Consort, Growth attributes, Yield attributes

Rice accounts for a significant contribution to the total food grain production in India. According to the projections made by the Population Foundation of India, the demand for rice will be 121.2 million tonnes by the year 2030, 129.6 million tonnes by the year 2040 and 137.3 million tonnes by the year 2050. Nutrient management is an important aspect in rice that needs to be given pivotal importance so as to attain sustainability of grain yield production [1]. The demand for agricultural crops is increasing but the impact chemicals have raised public concerns, about the sustainability and security of the food supply, paving way for safer Agri-inputs.

The essential plant nutrient elements (eight) defined as micronutrients like boron (B), zinc (Zn), manganese (Mn), iron (Fe), copper (Cu), molybdenum (Mo), chlorine (Cl) and silicon (Si) are required only in small amounts (5 to 200 ppm, or less than 0.02% dry weight) [2]. The visual symptoms may be caused by more than one nutrient and the deficiency of one nutrient may be related to an excess quantity of another. Continuous use of inorganic fertilizer have not only brought about loss of soil fauna and flora but also resulted in loss of secondary and micro nutrient in rice and wheat fields [3]. Sustainable agriculture relies greatly on renewable resources like beneficial microbes that play an important role in maintaining soil fertility and propping up plant growth. 5-MIN a microbial formulation of T. Stanes and Company Ltd, with the potential to have a positive association with the plants and stimulate plant growth through a wide variety of mechanisms, could be an effective way to avoid over-use of chemical fertilizers and other supplements [4]. 5-MIN is a proprietary product of T. Stanes and Company Ltd. and its application facilitates the supply of soluble form of natural nutrients, precursor, cofactors for improving the growth and vigor of the plants [5]. The presence of biopolymers ensures longer viability of the microbes and acts as a biocatalyst and growth promoting activator for the plants under adverse conditions and aids in the mobilization of essential nutrients under saline, acid and alkaline soils. 5-MIN stimulates metabolic activities, solubilizes five minerals (Zn, P, Fe, S & fixes N); produces phyto hormones and lytic enzymes [6]. 5-MIN also produces volatile and non-volatile metabolites that act as inducers and trigger the physiological activities of the plant. The production of organic acids and enzymes catalyses the solubilization of the fixed nutrients (phosphate, Zn, Fe and S) and the diazotrophic activity enhances the availability of nitrogen to the plants. In addition, the production of ACC deaminase and growth promoting substances reduces the precursors of ethylene production, and increases the growth of roots and shoots and influences the overall morphology of the plants [7]. Thus, the integration of these potential microbial formulations

*G. Sathiya Narayanan
sathiyaa2005@gmail.com

[1-2]Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608 002, Chidambaram, Tamil Nadu, India

[3]Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608 002, Chidambaram, Tamil Nadu, India

along with the recommended cultural practices/fertilizers could serve as a reliable component in sustainable agricultural system. With this background, the present investigation was conducted at the farmer's field, Thittu Kattur, Cuddalore district, Tamil Nadu to study the effect of 5-MIN on the growth and yield attributes of paddy under salinity stress.

MATERIALS AND METHODS

The field experiment was conducted in farmer's field located at Thittu Kattur, Cuddalore district, Tamil Nadu.The soils of the experimental fields were clay loam. The soil was low in available nitrogen, medium in available phosphorus and high in available potassium. The crop rice was raised during *Samba* season (October'2018 – February' 2019). For the rice crop, variety BPT 5204 was selected for the study. The experiment was laid out in Randomized Block Design (RBD) with three replications. The treatments were comprised of T_1- Control (Farmers practice)-100% RDF alone without soil application of 5 MIN, T_2-50% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage, T_3-50% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage, T_4-100% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage ,T_5-100% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage, T_6- 50% RDF + soil application of Consort @ 6 kg ha^{-1} at basal before transplantation and T_7- Soil application of Consort @ 6 kg ha^{-1} at basal before transplantation (without chemical fertilizers).Transplanting was done @ 2 seedlings hill^{-1}. The spacing adopted was 20 × 10 cm. Care was taken to fill the gaps on seventh day with the seedlings of the same age to maintain uniform population. For the treatment T_1, recommended dose of inorganic fertilizer nutrients viz., nitrogen through urea, phosphorus through single superphosphate and potash through muriate of potash was applied. 100 per cent and 50 per cent recommended dose of inorganic fertilizer were applied for the treatments T_4, T_5, and T_2, T_3, T_6 respectively. Nitrogen was applied in four equal splits, at basal, tillering, panicle initiation and heading stages and half K_2O at basal, remaining K_2O in two equal split doses at tillering and panicle initiation stages along with recommended full dose of P_2O_5 at basal were applied. No chemical fertilizers were given for the treatment T_7.

As per the treatment schedule, soil application of 5-MIN at specified doses of 100 g and 300 g ha^{-1} and soil application of Consort @ 6 kg ha^{-1} were taken up at basal and foliar application of 5-MIN at specified doses were taken up at different stages *viz.*, vegetative stage and flowering stages. Ten hills in rice were chosen at random within each net plot and tagged for recording biometric observations at various stages as described below. Plant height was recorded from ground level to the tip of top most leaf panicle^{-1} for rice at tillering, flowering and at harvest and expressed in cm. The number of tillers produced m^{-2} was recorded at maximum tillering stage. Five plants were removed at random from each treatment plot without damaging the roots and washed. The samples were sun dried initially for 24 hours and subsequently oven dried at 80°C to attain a constant weight. Then the DMP was recorded at harvest and expressed in kg ha^{-1}. The panicles were randomly chosen for recording the number of grains panicle^{-1} .The total number of grains panicle^{-1} were counted and recorded. The panicles were randomly chosen for recording the panicle length. The length of panicles is measured in cm from the base to the tip of the panicle. Thousand filled grains were counted from the bulk of grains drawn at random in each plot and weighed at 14 per cent moisture content and expressed in g. The matured crop was harvested from the net plot area, the grains were separated by hand threshing, winnowed, and sun dried sufficiently. The dried grains were weighed at 14 per cent moisture level and recorded plot wise and computed and expressed in kg ha^{-1}. The statistical analysis of data was done by adopting the standard procedure given by [8]. The critical difference was worked out for five per cent (0.05) probability.

RESULTS AND DISCUSSION

Application of 5 MIN showed significant effect on increasing plant height, LAI and DMP of rice. From the perusal of experimental results, it is evident that the values of rice growth and yield attributes at varied stages of crop growth were significantly higher with the application of 5 MIN at basal before transplantation, vegetative and flowering stages of rice. Application of 100% RDF + soil application of 5 MIN @ 300 g ha^{-1} at basal before transplantation; at vegetative and flowering stage (T_4) significantly registered–increase in plant height of 79.46 and 90.15 cm respectively at flowering and harvest stages [9]. Likewise, this treatment recorded highest leaf area (37.90cm) at flowering and dry matter production (8450 kg ha^{-1}) at harvest. This was followed by the treatment of 100% RDF + soil application of 5 MIN @ 100 g ha^{-1} at basal before transplantation, vegetative and flowering stage (T_5), 100% RDF alone without soil application of 5 MIN (Farmers practice) (T_1), 50% RDF + soil application of 5 MIN @ 300 g ha^{-1} at basal before transplantation, at vegetative and flowering stage (T_2) and 50% RDF + soil application of 5 MIN @ 100 g ha^{-1} at basal before transplantation; at vegetative and flowering stage (T_3). The treatment (T_7) soil application of Consort @ 6 kg ha^{-1} alone (without chemical fertilizers) recorded the least plant height of 60.10 and 65.20 cm respectively at flowering and harvest stage, leaf area (17.12cm) and DMP (5510 kg ha^{-1}).

Significant increase in growth characters of rice might be due to the application of 5-MIN, which played a major role in growth, development and metabolism of rice. Plant height is a very important factor for maximizing plant growth and ultimately yield. The increase in growth attributes viz. plant height and leaf area is also due to the 5-MIN which enables the availability of mineral nutrients required at developmental stages through the production of organic acids, enzymes and volatile organic compounds. Zinc is the essential mineral for IAA synthesis [10]. Zinc deficiency is closely related to the inhibition of RNA synthesis, reduced root growth, shoot growth and chlorophyll concentration in leaves [11]. In addition, the production of ACC deaminase reduces the precursors for ethylene production and increases the growth of roots and shoots. The increase in the growth parameters in 5-MIN plots can be attributed to the fact that the microbes in the formulation also produce growth promoting hormone and hydrolytic enzymes. Soil and foliar application of 5-MIN could have also triggered the physiological responses of the plant as it contains oligosaccharides that act as metabolic inducers. In addition, foliar application of 5-MIN at critical stages of the crop enhanced plant vigor, strengthened the stalk and improved the systemic resistance in plants. The increase in growth of plants treated with 5 MIN, could be due to increased nutrient availability and nutrient use efficiency in plants [12].

Application of 5-MIN in rice resulted in good shoot initiation and improved vegetative growth. The application of 5MIN also enhanced the yield of the rice crop under saline condition through increased translocation of nutrients and development of roots. Soil application of 5-MIN enabled higher nutrient uptake and utilization of nutrients which could have resulted in increased photosynthate production and crop canopy establishment. This has positively reflected on crop dry matter production. The treatment of soil application of Consort @ 6 kg ha^{-1} alone (without chemical fertilizers) resulted in the least values of growth parameters attributable to the absence of beneficial effect of 5-MIN and chemical fertilizers [13].

Table 1 Effect of application of 5-MIN on growth attributes of rice under saline conditions

Treatments	Plant height (cm)		Leaf area at harvest (cm)	Dry matter production (kg ha^{-1})
	Flowering	Harvest		
T_1- Control (Farmers practice)-100% RDF alone without soil application of 5 MIN	75.96	85.29	32.83	7977.13
T_2- 50% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	74.52	83.29	30.76	7783.13
T_3- 50% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	72.73	80.80	28.16	7540.63
T_4- 100% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	79.46	90.15	37.90	8450.00
T_5- 100% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	77.67	87.66	35.30	8207.50
T_6- 50% RDF + soil application of Consort @ 6 kg ha^{-1} at basal before transplantation	70.92	78.28	25.54	7295.70
T_7- Soil application of consort @ 6 kg ha^{-1} at basal before transplantation (without chemical fertilizers)	60.10	65.20	17.12	5510.00
S.Ed.	0.78	1.09	1.13	105.84
CD (p=0.05)	1.42	1.97	2.05	191.58

Table 2 Effect of application of 5-MIN on yield attributes of rice under saline conditions

Treatments	Number of tillers m^{-2}	Panicle length (cm)	No. of grains panicle^{-1}	Grain yield (kg ha^{-1})
T_1- Control (Farmers practice)-100% RDF alone without soil application of 5 MIN	388.54	24.93	199.56	5305.56
T_2- 50% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	379.53	24.23	191.75	5176.56
T_3- 50% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	368.27	23.35	181.99	5015.31
T_4- 100% RDF + soil application of 5 MIN @ 300 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	410.50	26.65	218.60	5620.00
T_5- 100% RDF + soil application of 5 MIN @ 100 g ha^{-1} twice at basal before transplantation and vegetative stage and foliar application at flowering stage	399.24	25.77	208.84	5458.75
T_6- 50% RDF + soil application of Consort @ 6 kg ha^{-1} at basal before transplantation	356.89	22.46	172.13	4852.45
T_7- Soil application of consort @ 6 kg ha^{-1} at basal before transplantation (without chemical fertilizers)	305.40	18.60	130.50	3830.00
S.Ed.	4.92	0.38	4.26	70.38
CD (p=0.05)	8.90	0.70	7.71	127.39

Leaf is an important factor for determining the dry matter production of a crop and subsequently the yield. Soil application of recommended dose of N, P_2O_5, K_2O along with application of 5-MIN @ 300 g ha^{-1} during vegetative stage and flowering stages recorded significantly higher leaf area (37.90 cm^2) over RDF alone (32. 83cm^2). This resulted in higher assimilatory surface area that helped in the development of efficient photosynthetic system with better availability of nutrients to set forth higher dry matter in leaves. The solubilization of soil nutrients by the microbial formulation 5MIN provided the essential minerals required as cofactors for stimulating several biochemical processes like nucleotide synthesis, enzyme activation, chlorophyll production, maintenance of membrane activity, increase rate of seed and stalk maturation [14]. Yield is the result of growth and development as indicated by total dry matter production per plant, and its distribution in various parts. The growth characters and yield attributes of the plants has significantly contributed to the increased grain yield in rice [15]. The application of 5-MIN along with RDF (both 75 and 100%), significantly increased the dry matter content and its accumulation indifferent parts viz. leaves, stem and reproductive parts as compared to T_1- Control (100% recommended dose without foliar application of 5-MIN).

Application of 100% RDF + application of 5 MIN @ 300 g ha^{-1} at basal before transplantation and flowering stage (T_4) significantly registered the highest tillers m^{-2} (410), panicle length (26.65 cm), number of grains $panicle^{-1}$ (218.60) and grain yield (5620 kg ha^{-1}). Yield is the manifestation of yield attributing characters [16] and the higher grain yield could be due to yield attributing components like number of tillers $plant^{-1}$, panicle length and number of grains $panicle^{-1}$. The significant increase in yield of rice due to the application of 5-MIN could be further attributed to improved organic content and microbial population of the soil. Higher total dry matter production was due to the fact that crop nitrogen requirement was met throughout the crop growth. This in turn might have increased the yield attributing characters and yield of rice. Tillering is the outcome of the expansion of auxiliary buds which is closely associated with the nutritional condition of the mother culm and as tiller receives carbohydrates and nutrients from the mother culm during its early growth period which was improved after foliar application of 5-MIN. Increase in tiller production can be attributed to the greater availability of N with efficient utilization for cell multiplication, enlargement and formation of nucleic acids and other vitally important organic compounds in the cell sap [17].

The synergistic activity of the microbial formulation (5-MIN) with rice plants enabled to increased growth in the plants treated with 5- MIN. The direct positive effect on plant growth by microbes could be due to the improved nutrient acquisition and hormonal stimulation. It enabled the solubilization of the fixed phosphate, Zn, Fe and S through the production of organic acids, enzymes and enhanced the availability of nutrients to plants and fixation nitrogen. Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country and causes poor tillering leading to decreased productivity of crop, as zinc is a co-factor carbonic anhydrase and aldolase [18]. Economic yield is a complex inter-relationship of its components, determined by supply of essential nutrients & suitable growth conditions in the vegetative phase and its subsequent reflection in reproductive phase.

Soil application of 5- MIN along with the recommended dose of N, P_2O_5, K_2O @ 300 g ha^{-1} during vegetative stage and flowering stage recorded significantly higher grain yield of 5620 kg ha^{-1} over application of RDF alone (5305.56 kg ha^{-1}). This could be due to higher yield components viz., number of tillers $plant^{-1}$, panicle length, and number of grains $panicle^{-1}$ recorded with the same treatment, which is highly correlated to total yield of crop produce. Increase in grains per panicle is attributed to application of 5MIN which solubilizes the fixed nutrients (Zn, P, Fe, S and N) in the saline soil (trial plot soil) into a simpler form and makes it available directly to the plants through the enhanced production and transportation of the photosynthates and partitioning of assimilates between their sites of utilization i.e., sink, which are the major determinants of crop yield.

Grain yield is the manifestation of yield attributing characters in rice [19]. Grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The synthesis, accumulation and translocation of photosynthates depends upon the extent of translocation into sink (grains) and on plant growth and development during early stages of crop growth. This may be attributed to fulfillment of the demand of the crop by higher assimilation and translocation of photosynthates from source (leaves) to sink (grains), through supply of required nutrients that has been enabled by the application of 5-MIN. From the economic point of view, it is inferred that the use of soil application of 5 MIN @ 300 g ha^{-1} at basal before transplantation, vegetative stage and flowering stage along with 100% NPK could be recommended for increasing both unit productivity and also net returns in rice [20-21].

It is largely, true that rice varieties have high rate of responsiveness towards fertilizer application and more particularly for N because of their conducive genetic makeup. In physiological term, yield of most cereals is largely governed by source (photosynthesis) and sink (grain growth) relationship. Zn deficiency is the most widespread micronutrient disorder in lowland rice and application of Zn along with NPK fertilizer increases the grain yield dramatically in most cases [22-23]. It is quite obvious from the pooled data that 100 per cent RDF along with application of 5-MIN @ 300 g ha^{-1} brought about significant improvement in grain yield and established superiority over the treatment 100 per cent RDF alone without 5-MIN (T_1). This could be due to production of plant growth promoting hormone like substances, mobilization of minerals by the microbes in the formulation. The enhanced activity of metabolic enzymes and growth hormones, are reported to induce more starch formation, promote seed filling, maturation and ultimately yield [24].

CONCLUSIONS

On the basis of the result of the field experiment, it may be inferred that soil application of the formulation 5MIN that consist of plant growth promoting microbes (@ 300 g ha^{-1} at basal, vegetative and flowering stage along with 100% NPK could be recommended for increasing the growth and yield components of rice grown under saline stress condition. It enhanced the plant growth and yield of rice crop under saline conditions and enable the increase of the translocation of nutrients. Application of 5 MIN was found to increase nutrient availability and nutrient use efficiency in rice and improving the organic content and microbial population of the soil thereby enhancing crop productivity.

LITERATURE CITED

1. Singaram P, Kamalakumari K. 1995. Long-term effect of FYM and fertilizers on enzyme dynamics of soil. *Journal of Indian Society of Soil Science* 43: 378-81.
2. Banerjee S, Ghosh M, Pal SK, Mazumdar D, Mahata D. 2013. Effect of organic nutrient management practices on yield and economics of scented rice Gobindabhog. *Oryza* 50(4): 365-369.

3. Kharub AS, Chander S. 2008. Effect of organic farming on yield, quality and soil- fertility status under basmati rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* 53(3): 172-177.
4. Meena RN, Singh SP, Singh K. 2010. Effect of organic nitrogen nutrition on yield, quality, nutrient uptake and economics of rice (*Oryza sativa*) - table pea (*Pisum sativum* var. hortense)- onion (*Allium cepa*) cropping sequence. *Indian Journal of Agricultural Sciences* 80(11): 1003-1006.
5. Singh SK. 2011. Effect of organic farming on productivity, soil fertility and economics of scented rice-tomato–bottle gourd cropping system. *Oryza* 48(4): 343-346.
6. Zeng L, Poss JA, Wilson C, Draz AE, Gregorio GB, Grieve CM. 2003. Evaluation of salt tolerance in rice genotypes by physiological characters. *Euphytica* 129: 281-292.
7. Wankhade SD, Cornejo MJ, Mateu-Andres I, Sanz A. 2013. Morpho-physiological variations in response to NaCl stress during vegetative and reproductive development of rice. *Acta Physiology Plant* 35: 323-333.
8. Panse VS, Suhktame PV. 1967. *Statistical Methods for Agricultural Workers*. ICAR, New Delhi. pp 152-155.
9. Kharub AS, Chander S. 2008. Effect of organic farming on yield quality and soil fertility status under basmati rice (*Oryza sativa*) – wheat (*Triticum aestivum*) cropping system. *Indian Jr. Agri. Science* 77(8): 512-515.
10. Alloway BJ. 2008. Zinc in soils and crop nutrition, 2nd Edition, published by IZA and IFA Brussels, Belgium and Paris, France.
11. Rana WH, Kashif SR. 2014. Effect of different zinc sources and methods of application on rice yield and nutrients concentration in rice grain and straw. *Journal of Environmental and Agricultural Sciences,* 1–9.
12. Ramesh P, Panwar NR, Singh AB, Ramana S. 2008. Effect of organic manures on productivity, soil fertility and economics of soybean (*Glycine max*) – durum wheat (*Triticum durum*) cropping system under organic farming in Vertisols. *Indian Journal of Agricultural Sciences* 78(12): 1033-1037.
13. IRRI. 2000. Nutritional disorders and nutrient management in rice. International Rice Research Institute, Manila, Philippines.
14. Neue HU, Lantin RS. 1994. Micronutrient toxicities and deficiencies in rice. *In*: Yeo AR, Flowers TJ, editors. Soil mineral stresses: Approaches to Crop Improvement. Berlin: Springer. pp 175-200.
15. Zhu JK. 2001. Plant salt tolerance. *Trends Plant Science* 6(2): 66-71.
16. Matsushima S. 1976. High yielding rice cultivation: A method for maximizing Rice yield through ideal plants. University of Tokyo press, Japan. pp 367.
17. Cardeans M. 1990. Effect of application of filter cake mixture on some of the physico-chemical properties. 16th Annual Meeting. *Mexican Sugar Technology Review* 4(3): 22.
18. Khanam T, Akhtar N, Halimand MA, Hossain F. 2018. Effect of irrigation salinity on the growth and yield of two Aus rice cultivars of Bangladesh. *Jahangirnagar University Journal of Biological Science* 7(2): 1-12.
19. Nisar A. 2000. *Integrated Plant Nutrition Management in Pakistan: Status and Opportunities*. Proc. Symp. IPNS. NFDC, Islamabad. pp 18-37.
20. Duan J, Li J, Guo S, Kang Y. 2008. Exogenous spermidine affects polyamine metabolism in salinity-stressed *Cucumis sativus* roots and enhances short-term salinity tolerance. *Journal of Plant Physiology* 165: 1620-1635.
21. Kamal MZU, Yamaguchi M, Azuchi F, Kinose Y, Wada Y, Funada R, Izuta T. 2015. Effects of ozone and soil salinity, singly and in combination, on growth, yield and leaf gas exchange rates of two Bangladeshi wheat cultivars. *Asian Journal of Atmos. Env*. 9(2): 173-186.
22. Fageria NK, Dos Santos AB, Cobucci T. 2011. Zinc nutrition of lowland rice. *Communications in Soil Science and Plant Analysis* 42: 1719-1727.
23. Singh V, Raghuvansi N, Singh AK, Kumar V, Yadav RA. 2017. Response of zinc and sulphur on growth and yield of rice (*Oryza sativa* L) under sodic soil. *International Journal of Current Microbiology and applied sciences* 6(8): 1870-1879.
24. Singh YV, Dhar DW. 2011. Influence of organic farming on soil microbial diversity and grain yield under rice-wheat-green gram cropping sequence. *Oryza* 48(1): 40-46.