Original Research Article

Enhancing Yield Potential of Rice using Nutrients and Plant Growth Regulators

ABSTRACT

Rice (*Oryza sativa* L.) is one of the major cereal and the staple food crop which is cultivated all over the world. In order to meet the growing demand of population, it is important to increase the productivity of crop. The productivity of crop is influenced by nutrients and growth hormones. With this background, a field experiment was conducted during navarai season (January) 2023 at wetland farms, Tamil Nadu Agricultural University, Coimbatore to evaluate the effect of different foliar nutrients and growth regulators on growth, physiology, biochemical and yield attributes in rice. The experimental layout was FRBD with two varieties (CO55 and ADT 57). The treatments consisted of foliar spray of T_1- Control (water spray), T_2- Nutrio-hormonal consortia 1, T_3- Nutrio-hormonal consortia 2, T_4- Rice booster 1, T_5- Rice booster 2 were given at booting stage and 15 days after first spray. Among the treatments, T_5- Rice booster 2 significantly improved leaf area (1813.99 cm^2, 2059.78 cm^2), leaf area index (4.53, 5.15), crop growth rate (32.07 g/m^2/day, 37.89 g/m^2/day), chlorophyll index (37.60, 41.73), photosynthetic rate (27.15 µmol CO_2 m^{-2} s^{-1}, 30.04 µmol CO_2 m^{-2} s^{-1}), Transpiration rate (11.83 mmol H_2O m^{-1} s^{-1}, 14.20 mmol H_2O m^{-1} s^{-1}), soluble protein content (16.23 mg/g, 17.30 mg/g), nitrate reductase activity (98.15 µg of NO_2/g/h, 112.47 µg of NO_2/g/h) in ADT- 57 variety at both spray respectively. Foliar application of rice booster 2 (T_5) resulted in higher number of productive tillers (23), number of spikelet per panicle (165.5), spikelet fertility (95.48%), 1000 grain weight (17.35g), grain yield/ plant (31.40g), grain yield/hectare (6694.32 Kg/ha), harvest index (45.44%) in ADT 57 and resulted in 15% yield increment over the control. Thus the present study concluded that the foliar application of rice booster 2 (T_5) significantly improved the growth, physiology, biochemical and yield attributes in rice variety ADT 57.

Key words: Rice, Foliar spray, nutrients, plant hormones, growth, physiology, yield attributes.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major cereal and the staple food crop which is cultivated all over the world. It is known as “global grain” and have considerable importance on nutritional and food security in the world [1]. Asia is on the top in terms of production and consumption of rice [2]. Global rice production is about 512.8 million tonnes [3]. In 2021-2022 the total area under rice cultivation in India is 463.7 lakh hectare, with the production and productivity of 127.93 million metric tonnes and 2807 kg/hectare [4]. According to Madhukeshwara *et al*. [5] the population of India during 2050 is expected to be 1.6 billion. In order to meet the demand of the increasing population additional production of 1.5 tons is needed every year and in order to sustain food security in India it is necessary to increase the productivity of rice under limited resources. An appropriate crop management strategies are required to improve the efficient use of inputs which is needed to enhance the productivity. Foliar application of nutrients and phytohormones gives immediate results by increasing crop growth and yield. Fertilizer when applied exogenously not only increased crop yields but also decreased the amount of fertilizer supplied through soil [6].

Macro and Micro nutrients are essential for crops as it plays a vital role in physiology and biochemical properties. Nitrogen increases grain yield and quality by accelerating tillering, leaf area and grain formation. Phosphorus concentration influences grain yield in rice and its application at the maturity stage gradually improves its accumulation in leaves, stem and panicle and thus enhances the grain yield in rice [7]. Potassium is an essential macronutrient which plays a key role in various physiological processes, energy transfer, water uptake, nutrient transport and enhances the growth and development in plants [8]. Micronutrients such as Zn, B, Fe etc.., which are required in trace amounts influences the metabolism of plants by involving in enzyme activation. Foliar application of nutrients in rice enhanced plant height, number of tillers and significantly increased photosynthetic rate and dry matter production through translocation of carbohydrates to the sink [9, 10].

Hormones are key players in activating or inactivating the gene expression, behavior of plants and have added a novel way for modifying the metabolism which influences its growth and development [11]. They play a significant role in manipulating plant growth and development and when exogenously applied, plants have the ability to store them as reversible conjugates and release the active hormone during its growth period when required [12]. Plant growth hormones enhances grain yield by controlling source and sink size in plants and regulate the movement of accumulated carbohydrate to the sink [13-15]. With this background, the current study was formulated to determine the effect of foliar spray on nutrients and plant growth hormones in rice crop.

2. MATERIALS AND METHODS

A field experiment was conducted during navarai season (January) of 2023 at wetland farms in Tamil Nadu Agricultural University, Coimbatore situated at 11^0 N latitude and 77^0 E longitude with an altitude of about 426.72m above Mean Sea Level with the aim to increase the yield potential of rice by exogenous application of nutrients and plant growth regulators. The experiment was conducted in Factorial Randomized Block Design with five treatments and four replication. The treatments are T_1- Control (water spray), T_2- Nutrio-hormonal consortia 1(macro and micronutrients and major plant hormones), T_3- Nutrio-hormonal consortia 2 (T_2+ $ZnSO_4$), T_4- Rice booster 1 (MAP, KCl, $ZnSO_4$, $FeSO_4$, Borax and major phytohormones), T_5- Rice booster 2 (T_4+ melatonin and salicylic acid) were given during booting stage and 15 days after first spray. Treatments were prepared as a 1% foliar spray solution, T_2 (50 ml in 1L) T_3 (33.3 ml in 1L) T_4 and T_5 (20 ml in 1L) respectively. Two different rice varieties such as CO 55 and ADT 57 were used in this experiments. Rice varieties were planted with a spacing of 20cm x 20cm in net plot area of 12.21 m^2. A fertile land with good irrigation facility was selected for raising nursery. Transplanting was done in a well puddled plot. The observation was recorded on growth parameters *viz*., leaf area, leaf area index, crop growth rate, Physiological parameters such as chlorophyll index, transpiration rate, photosynthetic rate, biochemical parameters such as leaf soluble protein, nitrate reductase activity and yield parameters *viz.*, number of productive tillers, total number of spikelet/panicle, spikelet fertility, 1000 grain weight, grain yield/plant, harvest index. All the observations were recorded on 10 days after first and second spray and before harvest. The data obtained were subjected to statistical analysis by using SPSS software. The difference in treatment means were compared at 5% significant level.

3. RESULT AND DISCUSSION

3.1 Growth Attributes

3.1.1 Leaf area (Cm^2)

Rice growth characters such as leaf area, leaf area index and crop growth rate were significantly influenced by the foliar application of nutrients and phytohormones. The highest leaf area was recorded in ADT 57 variety at first spray (1813.99 cm^2) and second spray (2059.78 cm^2) in T_5 (Rice booster 2) when compared with control (water spray) as indicated in Table 1. Plant growth hormones and nutrients plays a crucial role in enhancing cell division and shoot branching which in turn influences the leaf area in rice. Nutrients and growth enhancers plays a key role in chlorophyll synthesis and helps in transfer of solar energy through photosynthesis in leaves. Thus the application of nutrients influences the leaf soluble protein content which leads to enhancement of leaf area in rice [16]. These results are in line with the results reported by Pillai *et al.* [17] and Goutam *et al.* [18].

3.1.2 Leaf area index

Among the two different varieties ADT 57 resulted in increased LAI at first spray (4.53) and second spray (5.15) under T5 (Rice booster 2) than CO 55 variety respectively which was significantly higher than the control (Table 2). The LAI is directly correlated with the leaf area and amount of light that is captured by the plants during crop growth [19]. Foliar application of plant growth regulator such as salicylic acid significantly increased LAI in rice [20]. Our finding are in consistent with other studies where Pal *et al.* [21] observed that the foliar application of growth enhancers significantly increased LAI in rice. The results are in accordance with Sudhagar Rao *et al.* [22] who reported that application of nutrients during different growth stages in rice increased leaf area index in rice.

3.1.3 Crop growth rate (g/m^2/day)

In the present study, the data (Table 2) showed that ADT 57 recorded highest Crop Growth Rate in first spray (32.07 g/m^2/day) and second spray (37.89 g/m^2/day in T_5 (Rice booster 2) followed by T_4 (Rice booster 1) than control (water spray). Higher CGR under foliar application of nutrients might be due to increase in LAI and improved chlorophyll synthesis which results in high biomass production. As nutrients helps in activating different physiological and biochemical processes such as stomatal regulation and enzyme activation that leads to increased crop growth rate [23]. Crop growth rate is closely related to the amount of dry matter accumulated and the rate of photosynthetic efficiency of the crops [24]. Ghasal *et al.* [25] noted that the foliar spray of nutrients given at maximum tillering and panicle initiation increases crop growth rate in aromatic rice.

3.2 Physiological Parameters

3.2.1 Chlorophyll index (SPAD value)

Chlorophyll is an essential photosynthetic pigment which influences the efficiency of photosynthesis process by light absorption thereby it increases the growth and development of plants. As given in Fig.1 the maximum SPAD value was noted in ADT 57 at foliar application of T_5 at two different stages of spray which was respectively (37.60 and 41.73). The minimum SPAD value was observed in control (water spray) at both the spray. Similar finding was reported by Silalert and Pattanagul [26] that the chlorophyll content was higher when melatonin given as a foliar spray. Foliar feeding with different plant hormones increased chlorophyll content in rice [27]. Nutrients plays a key role in chlorophyll synthesis and are an integral part in chlorophyll structure. The build up of photosynthetic products and enzymes which are involved in numerous physiological metabolisms are facilitated by the exogenous application of plant hormones during anthesis stage in rice. The increase in carbohydrate concentration increased sink activity that delay leaf senescence by enhancing chlorophyll content in rice [28]. Bala *et al.* [29] also stated that the foliar application of nutrients enhanced chlorophyll content in rice.

3.2.2 Photosynthetic rate (µmol CO_2 m^{-2} s^{-1})

The ADT 57 variety performed better and recorded higher photosynthetic rate under the foliar application of T_5 during first spray (27.15 µmol CO_2 m^{-2} s^{-1}) and second spray (30.04 µmol CO_2 m^{-2} s^{-1}) as given in Fig. 2. The foliar application of nutrients considerably increases the biochemical activity in the leaf as well as the concentration of chlorophyll and carotenoid, which in turn improves the rate of photosynthesis in plants [30]. Our result are in confirmatory with Raghunath *et al*. [31] who observed that foliar spray of both plant growth hormones and nutrients increased photosynthetic rate in rice.

3.2.3 Transpiration rate (mmol H_2O m^{-1} s^{-1})

Transpiration rate is directly linked to the amount of water taken up by the crop for its physiological and biochemical process. It was observed that among the two varieties used in this study, maximum transpiration rate was found in ADT 57 (11.83, 14.20 mmol H_2O m^{-1} s^{-1}) than in CO 55 (10.72, 12.44 mmol H_2O m^{-1} s^{-1}) under T_5 at first and second spray (Fig.3). Similar finding was observed when nutrients and plant growth hormones given as foliar spray enhanced transpiration rate in rice [32-33].

3.3 Biochemical Parameters

3.3.1 Leaf soluble protein (mg/g)

Leaf soluble protein is influenced by the photosynthetic process in plants. Increase in soluble protein increases the leaf area and improves the plant growth and development. Among five treatments T_5 recorded increased leaf soluble protein content in ADT 57 (16.23 mg/g, 17.30 mg/g) at both the stage of foliar application than T_1 control (Fig 4). Increase in soluble protein content is probably by the higher amount of chlorophyll and photosynthetic rate. Application of macronutrients increases RuBisCO enzyme activity which accounts for major portion of protein part in plant, enhanced the photosynthetic rate thereby the leaf soluble protein content [34]. Plant growth regulators also plays a vital role in increasing the leaf soluble protein content in rice. Li *et al.* [35] studied that application of growth hormones such as melatonin significantly increased soluble protein content in rice. Further Chen *et al.* [28] found that the foliar feeding of Salicylic acid at 200 mg L^{-1} enhanced leaf soluble protein content in rice. Our finding are in agreement with the above results.

3.3.2 Nitrate reductase (µg of NO_2/g/h)

Nitrate reductase is a key enzyme involved in the nitrogen assimilation process which leads to amino acid synthesis. On comparison with the T_1 (control), all the treatment significantly increased nitrate reductase activity. Within the treatments the higher value was found under the T_5 application in ADT 57 (98.15, 112.47 µg of NO_2/g/h) than CO 55 variety (90.43, 103.19 µg of NO_2/g/h) at both the stage of foliar application (Fig. 5). Asma *et al*. [36] observed that exogenous application of salicylic acid enhanced nitrate reductase activity in rice.

3.4 Yield and yield components

3.4.1 Number of productive tillers

Foliar application of T_5 at booting stage and 15 days after first spray increased number of productive tillers (23) in ADT 57 respectively when compared with that of CO 55 (20). Control plots resulted in lesser number of productive tillers in both the varieties (Fig 6). The increase in number of productive tiller was mainly by the foliar spray of nutrients which contributed to the activation of hormones that triggers the growth of primordial reproductive organ and the photosynthates partitioning in plants [37]. The result of the present study are in accordance to the finding of Ramesh *et al*. [38] who reported that the increase in the number of effective tillers and panicle per m^{-2} was mainly by the application of plant growth hormones. Jagathjothi *et al.* [9] also observed that the number of productive tillers m^{-2} enhanced by the foliar spray of nutrients.

3.4.2 Total number of spikelet per panicle

The data on number of spikelet per panicle (Table 3) revealed the significant effect of T_5 foliar application than other treatments and recorded higher value than control. ADT 57 (165.5) showed higher values than CO 55 (147.50) variety. Application of micronutrients facilitate protein and carbohydrate synthesis that led to bolder seeds and thus enhanced number of spikelets/panicle [39]. Grain filling is a crucial stage that affects crop yield [40]. However exogenous spray of growth enhancers increases grain filling in rice. Pan *et al*. [41] also reported that application of growth hormones increased number of spikelet per panicle in rice.

3.4.3 Spikelet fertility (%) and 1000 grain weight (g)

The data presented (Table 3 and Table 4) indicated that the maximum spikelet fertility (95.48%) and 1000 grain weight (17.35g) was observed on ADT 57 by the foliar application of T_5 (rice booster 2). Next higher result was obtained from T_4. The least value was recorded in T_1 (control). Nutrients and plant growth hormones enhanced spikelet fertility. Our findings are supported by the result of Golada *et al.* [42] that hormones such as salicylic acid increased the cellular membrane integrity which may have increased the transport of photoassimilation to grains, which in turn spikelet fertility in rice. Haifaa *et al*. [15] also stated that enhanced amount of spikelet fertility was observed by the exogenous spray of phytohormones in rice.

3.4.4 Grain yield and harvest index (%)

Grain yield and harvest index was significantly enhanced by the foliar application of nutrients and growth enhancers. Among the two different varieties ADT 57 showed increased grain yield (31.40 g/plant, 6694.32 Kg/ha) and harvest index (45.44%) compared to CO 55 (Fig.7 and Table 4) under the effect of foliar application of T_5 followed by T_4 on comparison with control (water spray). Higher grain production may be attributed by greater vegetative development which improved light absorption and enhanced dry matter production towards the economic part. Nutrients, generally influences starch production and their allocation to grain production [43]. The nutrients facilitated source to sink transport and improved partitioning efficiency in reproductive growth than vegetative biomass [44]. Increase in harvest index was mainly due to the better mobilization of reserve food material that resulted in higher grain yield and lesser straw production. Our result was in consistent with Singh *et al.* [45] and Elankavi *et al.* [14]. Pal *et al*. [46] also reported that the extent of available form of photosynthates and the photosynthetic area directly linked with the grain formation.

4. CONCLUSION

In our study, foliar nutrition helps to overcome the nutritional and hormonal deficiencies in rice. Hence, use of foliar formulations in an appropriate and comprehensive manner is essential to improve growth and development of rice crop. Thus present study, concluded that the foliar application of rice booster 2 (T_5) at booting stage and 15 days after first spray significantly improved growth, physiology, biochemical, and yield attributes in ADT 57 rice variety which performed better for most of the traits and produced higher yield (6694.32 Kg/ha) than that of CO 55 (6353.26 Kg/ha) and resulted in 15% yield enhancement over the control.

REFERENCES

1. Kumaravel S, Nandakumar P, Mathialagan M, Maheshwaran K. Effect of different plant growth regulators on the growth of transplanted rice (*Oryza sativa* L.). The Pharma Innovation Journal. 2022; 11(12): 1461-1464.
2. Afrose M, Singh R, Indu T. Effect of Different Age of Seedlings and Nitrogen Levels on Growth and Yield of Rice (*Oryza sativa* L.). International Journal of Plant and Soil Science. 2022; 34(14): 68-73.
3. FAO (Food and Agriculture Organisation). FAO Production Year Book. India; 2022.
4. USDA (United States Department of Agriculture). Commodity Intelligence Report. India; 2021.
5. Madhukeshwara PB, Deshpande VK. Effect of GA_3 with Organic and In-Organic Supplements in KRH-4 Hybrid Rice Seed Production. International Journal of Pure and Applied Bioscience. 2018; 6(4): 728-732.
6. Bhuyan MHM, Ferdousl R, Iqbal MT. Foliar Spray of Nitrogen Fertilizer on Raised Bed Increases Yield of Transplanted Aman Rice over Conventional Method. International Scholarly Research Network, ISRN Agronomy. 2012; 1-9.
7. Wei Z, Zhang Y, Liu Z, Peng M, Wang T, Cao N. Change in phosphorus requirement with increasing grain yield for rice under saline-sodic stress in Northeast China. Frontiers in Environmental Science. 2022; 1-9.
8. Hasanuzzaman M, Bhuyan Borhannuddin MHM, Nahar K, Hossain MD, Muhmud JA, Hossen MS, Masud AAC, Moumita, Fujita M. Potassium: A Vital Regulator of Plant Responses and Tolerance to Abiotic Stresses. Agronomy. 2018; 8(31): 1- 29.
9. Jagathjothi N, Muthukrishnan P, Amanullah MM. Influence of Foliar Nutrition on Growth and Yield of Transplanted Rice. Madras Agricultural Journal. 2012; 99(4-6): 275-278.
10. Mahmoodi B, Moballeghi M, Eftekhari A, Mogadam NM. Effects of Foliar Application of Liquid Fertilizer on Agronomical and Physiological Traita of Rice (*Oryza sativa* L.). Acta Agrobotanica. 2020; 73(3): 1-12.
11. Nirmal Kumar, Deepak KR, Amit K, Kushwaha SP. The response of different bio-regulators on growth and physiological traits of hybrid rice. 2018; 7(4): 257-260.

12. Tiwari DK, Pandey P, Giri SP, Dwivedi JL. Effect of GA_3 and Other Plant Growth Regulators on Hybrid Rice Seed Production. Asian Journal of Plant Sciences. 2011; 10(2): 133-139.
13. Ghodrat V, Rousta JM, Tadaion SM, Karampour A. Yield and Yield Components of Corn (*Zea mays* L.) In Response to Foliar Application with Indole Butyric Acid and Gibberellic Acid. American-Eurasian Journal of Agricultural and Environmental Science. 2012; 12(9): 1246-1251.
14. Elankavi S, Kuppuswamy G, Vaiyapuri V, Raman R. Effect of Phytohormones on growth and yield of rice. ORYZA- International Journal of Rice. 2009; 46(4): 310-313.
15. Haifaa IMD, Moses C. Effects of Foliar and Soil Application of Gibberellic Acid (GA_3) at Different Growth Stages on Agronomic Traits and Yield of Rice (*Oryza sativa* L.). Journal of Agricultural Science. 2022; 14(6): 55-67
16. Sridhar K, Srinivas A, Avil Kumar K, Ramprakash T, Raghuveer RP. Physiological Growth Parameters of Rabi Rice (*Oryza sativa* L.) under Alternate Wetting and Drying Irrigation with Varied Nitrogen Levels. International Journal of Current Microbiology and Applied Sciences. 2019; 8(1): 1-15.
17. Pillai SP, Surya MS. Physiological Response of Flag Leaf Nutrition in Rice (*Oryza sativa* L.). International Journal of Current Microbiology and Applied Sciences. 2021; 10(02): 1852-1862.
18. Goutam KP, Kushwaha SP, Chauhan D, Yadav V, Kumar S. Impact of Plant Growth Regulators on Growth, Phenology and Yield Character of Hybrid Rice. 2019; 8(01): 838-845.
19. Kumar R, Singh A, Yadav RB, Kumar A, Kumar S, Shahi UP, Singh AP. Growth, development and yield response of rice (*Oryza sativa* L.) as influenced by efficient nitrogen management under subtropical climatic condition. Journal of Pharmacpgnosy and Phytochemistry. 2017; 791-797.
20. Usharani G, Jayanthi M, Kanchana, Saranraj P, Sujitha D. Effect of Salicylic Acid and *Pseudomonas fluorescens* on Growth and Yield of Paddy Ir-50. International Journal of Microbiological Research. 2014; 5(1): 54-60.
21. Pal R, Mahajan G, Sardana V, Asthir B, Chauhan BS. Performance of Dry-Seeded Rice Genotypes under Varied Soil Moisture Regimes and Foliar-Applied Hormones. Plants. 2020; 9: 1-18.
22. Sudhagar Rao GB, Immanuel RR, Ramesh S, Baradhan G, Sureshkumar SM. Effect of zinc and iron fertilization on growth and development of rice. Plant Archives. 2019; 19(2): 1877-1880.
23. Tariq A, Anjum AS, Randhawa AM, Ullah E, Naeem M, Qamar R, Ashraf U, Nadeem M. Influence of Zinc Nutrition on Growth andYield Behaviour of Maizze (*Zea mays* L.) Hybrids. American Journal of Plant Sciences. 2014; 5: 2646-2654.
24. Shatoji SM, Sahoo C, Shetty S, Sahoo KC, Tudu S. Influence of foliar applied water-soluble nutrients (NPK) on growth and yield attributing characters of rice (*Oryza sativa* L.). The Pharma Innovation. 2023; 12(2): 780-786.
25. Ghasal PC, Shivay SY, Pooniya V, Kumar P, Verma RK. Zinc fertilization enhances growth and quality parameters of aromatic rice (*Oryza sativa* L.) Varieties. Indian Journal of Plant Physiology. 2016; 21(3): 323-332.
26. Silalert P, Pattanagul W. Foliar application of melatonin alleviates the effects of drought stress in rice (*Oryza sativa* L.) seedlings. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 2021; 49(3): 12417.
27. Yang J, Zhang J, Zhu ZWQ, Liu L. Abscisic acid and cytokinins in the root exudates and leaves and their relationship to senescence and remobilization of carbon reserves in rice subjected to water stress during grain filling. Planta. 2002; 215: 645-652.
28. Chen T, Zhao X, Zhang C, Yang Y, Feng B, Zhang X, Fu G, Tao L. Application of Salicylic Acid Improves Filling of Inferior Grains of Rice during Late Maturity under Mild Cold Stress. Crop Science. 2017; 57: 2130-2142.
29. Bala R, Kalia A, Dhaliwal SS. Evaluation of Efficacy of ZnO Nanoparticles as Remedial Zinc Nanofertilizer for Rice. Journal of Soil Science and Plant Nutrition. 2019; 1-12.
30. Singh J, Sing M, Jain A, Bhardwaj S, Singh A, Singh DK, Bhushan B, Dubey SK. An Introduction of Plant Nutrients and Foliar Fertilization: A Review. Precision Farming. 2014; 259-320.
31. Raghunath MP, Beena R, Mohan V, Viji MM, Manju RV, Stephen R. High temperature stress mitigation in rice (*Oryza sativa* L.): Foliar application of plant growth regulators and nutrients. Journal of Crop and Weed. 2021; 17(1): 34-47.
32. Deus ACF, Prado RM, Alvarez RCF, Oliveira RLL, Felisberto G. Role of Silicon and Slicylic Acid in the Mitigation of Nitrogen Deficiency Stress in Rice Plants. Silicon. 2019; 1-9.

33. Zulkarami B, Panhwar QA, Ismail MR, Saud HM, Mondal MMA, Naher UA, Islam MR. Rice yield improvement by foliar application of phytohormone. Journal of Food, Agriculture and Environment, 2014; 12(2): 399-404.
34. Amin NSM, Uchida N, Masumoto C, Hatanaka T, Tsugawa H. Partitioning of Absorbed Nitrogen to Chloroplast, Soluble Protein and Rubisco in Rice Leaves under Low Nitrogen Supply. Environmental Control in Biology. 2002; 40(2): 201-206.
35. Li Y, Zhang L, Yu Y, Deng L, Chen G, Wang Y. Melatonin-Induced Resilience Strategies against the Damaging Impacts of Drought Stress in Rice. Agronomy. 2022; 12: 813-827.
36. Asma, Hussain I, Ashraf MY, Saleem MH, Ashraf MA, Ali B, Shereen A, Farid G, Ali M, Shirazi MU, Saleem A, Mostafa YS, Hashem M, Yasin G. Alleviating effects of salicylic acid spray on stages-based growth and antioxidative defence system in two drought-stressed rice (*Oryza sativa* L.) cultivars. Turkish Journal of Agriculture and Forestry. 2023; 47: 79-99.
37. Ram US, Srivastava VK, Hemanataranjan, Sen A, Singh RK, Bohra JS, Shukla U. Effect of Zn, Fe, FYM application on growth, yield and nutrient content of rice. ORYZA. 2013; 351-357.
38. Ramesh S, Sudhakar P, Elankavi S, Suseendran K, Jawahar S. Effect of Gibberellic Acid (GA_3) on Growth and Yield of Rice (*Oryza sativa* L.). Plant Archives. 2019; 19: 1369-1372.
39. Singh V, Virendra S, Singh S, Khanna R. Effect of Zinc and Silicon on Growth and Yield of Aromatic Rice (Oryza sativa) in North-Western Plains of India. Journal of Rice Research and Developments. 2020; 3(1): 82-86.
40. Liu Y, Han J, Liu D, Gu D, Wang Y, Liao Y. Effect of Plastic Film Mulching on the Grain Filling and Hormonal Changes of Maize under Different Irrigation Conditions. PLOS ONE. 2015; 10(4): 1-17.
41. Pan S, Rasul F, Li W, Tian H, Mo Z, Duan M, Tang X. Roles of plant growth regulators on yield, grain qualities and antioxidant enzyme activities in super hybrid rice (*Oryza sativa* L.). Rice. 2013; 6(9): 1-10.
42. Singh VJ, Gampala S, Ravat VK, Chakraborti SK, Basu A. Effect of foliar spray of salicylic acid on sheath infecting pathogen and yield attributes in hybrid rice. Journal of Environmental Sciences. 2015; 9(1): 507-512.
43. Golada S, Debbarma V. Influence of Varieties and Foliar Application of Zinc on Growth, Yield and Economics of Rice (*Oryza sativa* L.). International Journal of Plant and Soil Science. 2023; 35(13): 33-42.
44. Saikh R, Murmu K, Sarkar A, Mondal R, Jana K. Effect of foliar zinc application on growth and yield of rice (Oryza sativa) in the Indo-Gangetic Plains of India. Nusantara Bioscience. 2022; 14(2): 182-187.
45. Singh AK, Singh V. Effect of Foliar Application of Iron, Zinc and Age of Seedlings on Growth and Yield of Rice (*Oryza sativa* L.). International Journal of Current Microbiology and Applied Sciences. 2018; 7(8): 1062-1068.
46. Pal R, Mahajan G, Sardana V, Chauhan BS. Impact of sowing date on yield, dry matter and nitrogen accumulation, and nitrogen translocation in dry-seeded rice in North-West India. 2017; 138-148.

Table 1: Effect of different Nutrients and Plant growth hormones on Leaf area of rice genotypes.

Treatments	Leaf Area (cm^2)			
	1st Spray		2nd Spray	
	CO 55	ADT 57	CO 55	ADT 57
T_1- Control (water spray)	1306.28	1396.40	1579.89	1626.70
T_2- Nutrio-hormonal consortia 1	1403.93	1500.72	1652.60	1703.88
T_3- Nutrio-hormonal consortia 2	1559.93	1603.98	1756.42	1817.60
T_4- Rice booster 1	1617.68	1710.28	1810.78	1893.29
T_5- Rice booster 2	1695.47	1813.99	1932.53	2059.78
	SEd	**CD (P=0.05)**	**SEd**	**CD (P=0.05)**
V	**21.39**	**43.89****	**31.97**	**65.61***
T	**33.82**	**69.41****	**50.55**	**103.73****
VxT	**47.84**	**98.07 NS**	**71.50**	**146.57 NS**

Table 2: Effect of different Nutrients and Plant growth hormones on Leaf area index and Crop growth rate of rice genotypes.

Treatments	Leaf Area Index				Crop Growth Rate (g/m^2/day)			
	1st Spray		2nd Spray		1st Spray		2nd Spray	
	CO 55	ADT 57	CO 55	ADT 57	CO 55	ADT 57	CO 55	ADT 57
T_1- Control (water spray)	3.27	3.49	3.95	4.07	23.91	23.91	27.60	27.97
T_2- Nutrio-hormonal consortia 1	3.51	3.75	4.13	4.26	24.68	26.72	29.47	30.73
T_3- Nutrio-hormonal consortia 2	3.90	4.01	4.39	4.54	27.00	28.83	30.08	33.35
T_4- Rice booster 1	4.04	4.28	4.53	4.73	28.14	31.72	32.08	35.33
T_5- Rice booster 2	4.24	4.53	4.83	5.15	30.91	32.07	34.32	37.89
	SEd	**CD (P=0.05)**	**SEd**	**CD (P=0.05)**	**SEd**	**CD (P=0.05)**	**SEd**	**CD (P=0.05)**
V	**0.054**	**0.110****	**0.080**	**0.164***	**0.356**	**0.731****	**0.264**	**0.542****
T	**0.085**	**0.174****	**0.127**	**0.260****	**0.563**	**1.156****	**0.418**	**0.857****
VxT	**0.120**	**0.246 NS**	**0.179**	**0.366 NS**	**0.796**	**1.631***	**0.591**	**1.212****

Table 3: Effect of Nutrients and Plant growth hormones on Number of spikelet/panicle and Spikelet fertility of rice genotypes.

Treatments	Number of Spikelet per panicle		Spikelet fertility (%)	
	CO 55	ADT 57	CO 55	ADT 57
T_1- Control (water spray)	124.75	128.50	85.58	86.64
T_2- Nutrio-hormonal consortia 1	128.25	135.25	87.67	89.30
T_3- Nutrio-hormonal consortia 2	134.50	147.25	88.63	91.50
T_4- Rice booster 1	142.50	157.25	90.88	93.32
T_5- Rice booster 2	147.50	165.50	93.57	95.48
	SEd	CD (P=0.05)	SEd	CD (P=0.05)
V	1.525	3.130**	0.670	1.375**
T	2.412	4.949**	1.060	2.174**
VxT	3.411	6.999*	1.499	3.072 NS

Table 4: Effect of Nutrients and Plant growth hormones on 1000 Grain weight and Harvest Index of rice genotypes.

Treatments	1000 Grain weight (g)		Harvest Index (%)	
	CO 55	ADT 57	CO 55	ADT 57
T_1- Control (water spray)	18.84	18.14	32.98	35.07
T_2- Nutrio-hormonal consortia 1	19.01	19.50	34.78	40.73
T_3- Nutrio-hormonal consortia 2	19.55	20.06	36.57	42.55
T_4- Rice booster 1	19.98	20.50	38.22	44.34
T_5- Rice booster 2	20.50	21.35	42.52	45.44
	SEd	CD (P=0.05)	SEd	CD (P=0.05)
V	0.161	0.331*	0.462	0.948**
T	0.255	0.523**	0.730	1.499**
VxT	0.360	0.740*	1.033	2.119*

Fig. 1. Effect of different Nutrients and Plant Growth Hormones on Chlorophyll index of rice genotypes

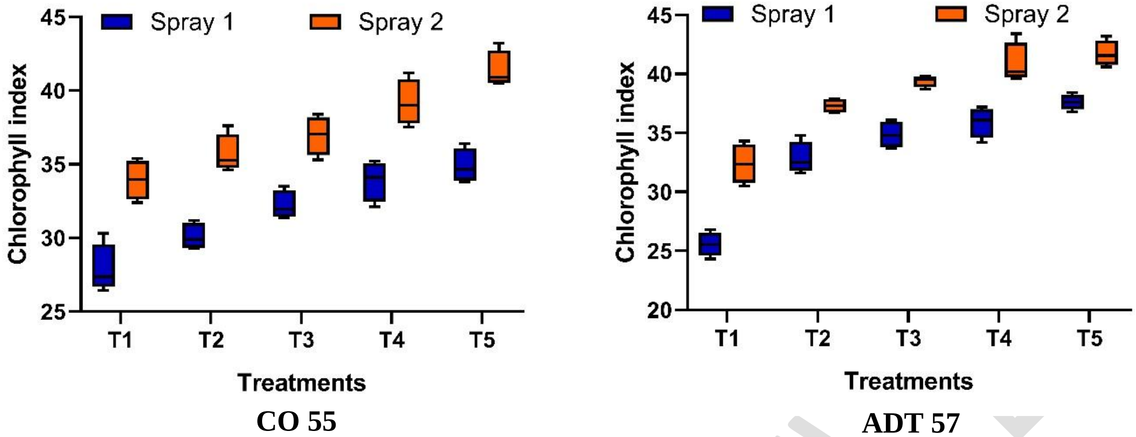


Fig. 2. Effect of different Nutrients and Plant Growth Hormones on Photosynthetic rate of rice genotypes

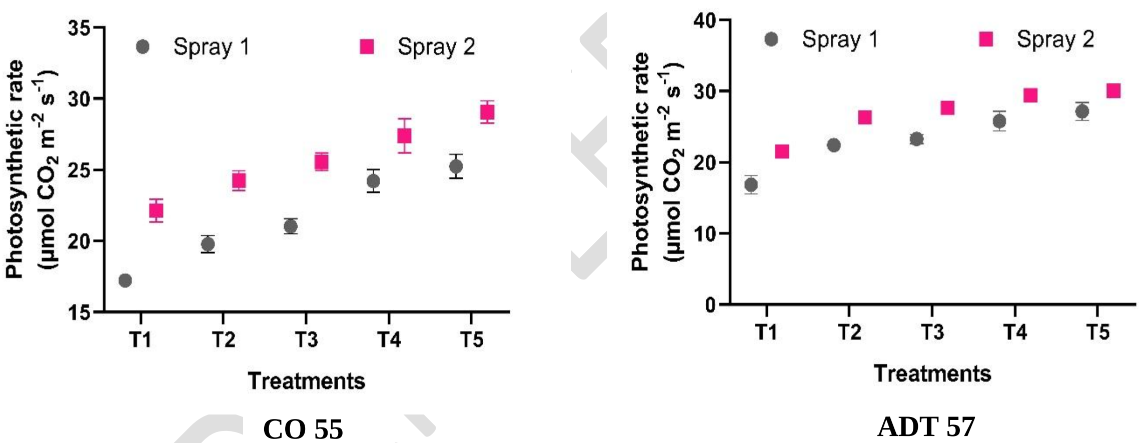
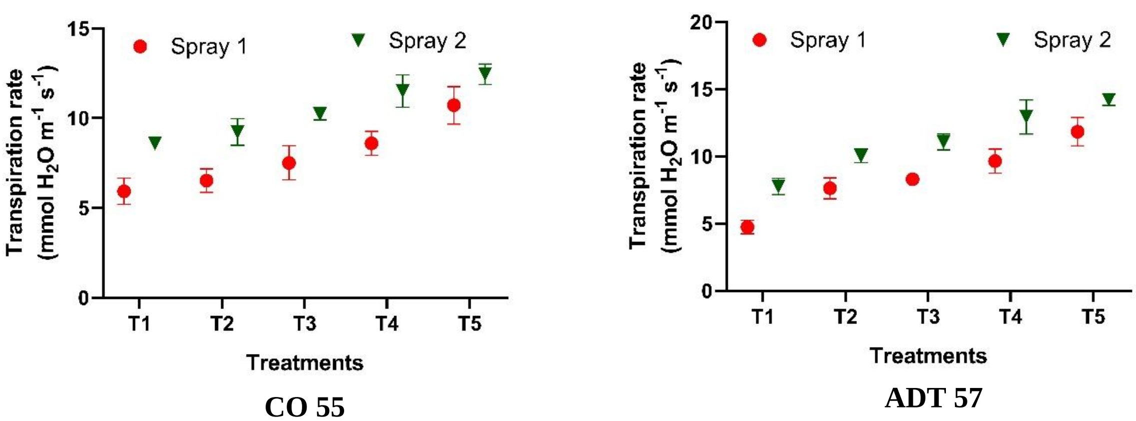


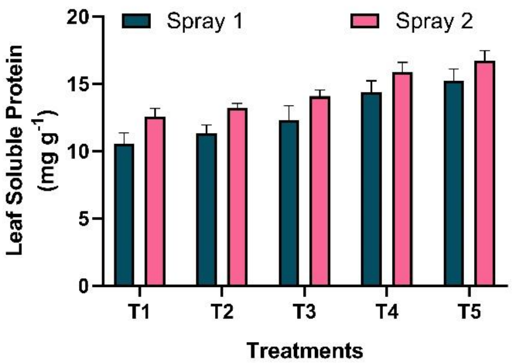
Fig. 3. Effect of different Nutrients and Plant Growth Hormones on Transpiration rate of rice genotypes



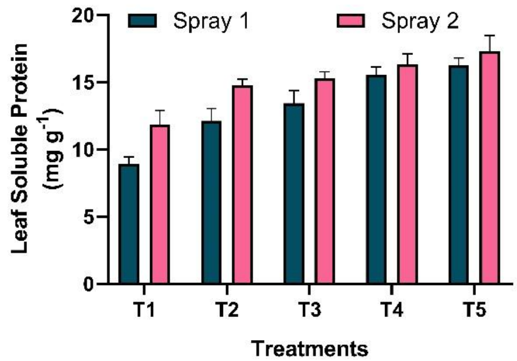
T_1- Control (Water Spray) T_3- Nutrio-hormonal Consortia 2 T_5- Rice Booster 2

T_2- Nutrio-hormonal Consortia 1 T_4- Rice Booster 1

Fig. 4. Effect of different Nutrients and Plant Growth Hormones on Leaf Soluble Protein of rice genotypes

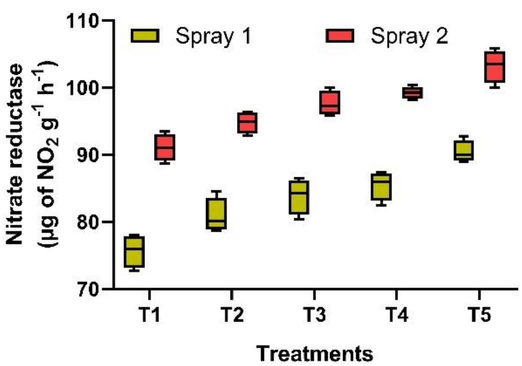


CO 55

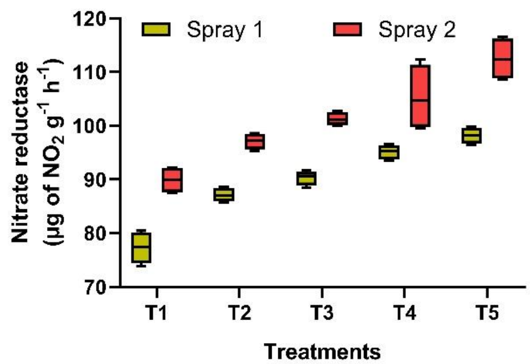


ADT 57

Fig. 5. Effect of different Nutrients and Plant Growth Hormones on Nitrate Reductase of rice genotypes



CO 55



ADT 57

T_1- Control (Water Spray)
T_2- Nutrio-hormonal Consortia 1
T_3- Nutrio-hormonal Consortia 2
T_4- Rice Booster 1
T_5- Rice Booster 2

Fig. 6. Effect of different Nutrients and Plant Growth Hormones on Number of productive tillers of rice genotypes

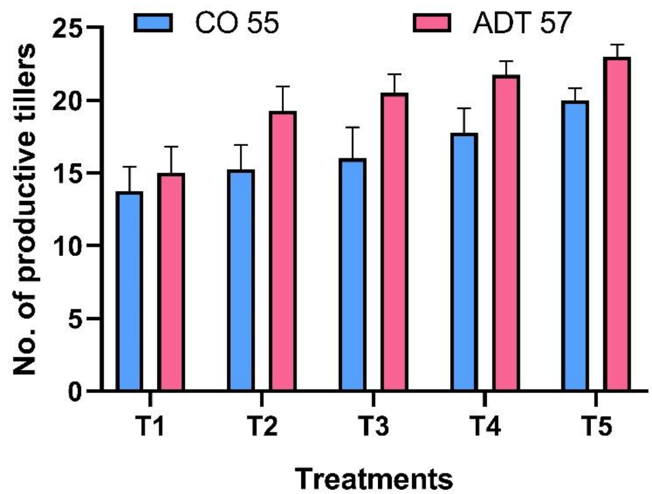
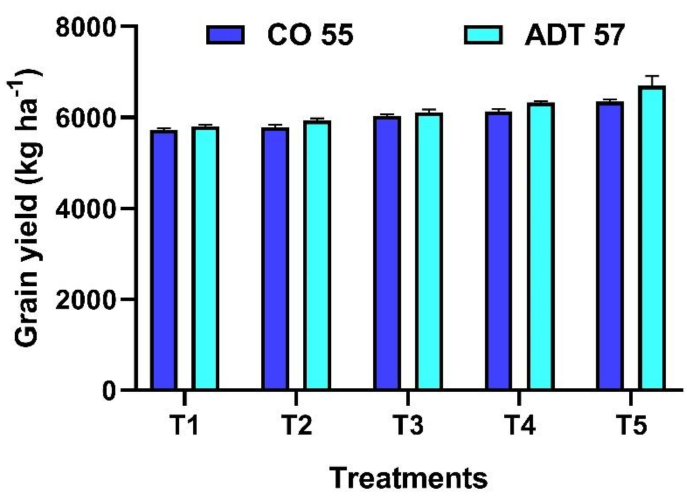


Fig. 7. Effect of different nutrients and plant growth hormones on Grain yield per hectare of rice genotypes



T_1- Control (Water Spray)

T_2- Nutrio-hormonal Consortia 1

T_3- Nutrio-hormonal Consortia 2

T_4- Rice Booster 1

T_5- Rice Booster 2