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Impact of Biological Fertilizer Under Integrated Nutrient Management on Growth and Physiology of Rice (*Oryza sativa L.*)

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Abstract. To enhance the efficiency and productivity of rice seedlings, Post Harvest Lab., Department of Agriculture and Agribusiness Management, University of Karachi conducted a study to analyse the interactive effects of synthetic and biofertilizers on the physiology of rice seedlings. Individual and interactive effects of reclaimer (R), biozote (B), *Trichoderma* (T), urea and DAP on the productivity of rice seedlings were studied through a 5-inch pot on the open-pollinated, non-aromatic rice variety Pk-386. Different treatments of the individual biofertilizer and its mixture with synthetic fertilizers were used to assess the effects on germination, plant length, vigour, fresh weight, dry weight as well as moisture percentage. 3170.2 was the highest vigour recorded in the treatment of *Trichoderma* T with synthetic and biofertilizers. The highest moisture of 76.5% was calculated in the treatment of *Trichoderma* T with biofertilizers. Under the interactive combination of synthetic and biofertilizers, many treatments of biofertilizer mixture improved the major growth parameters of rice seedlings.

Keywords: rice, *Oryza sativa L*., integrated nutrient management, *Trichoderma*, biofertilizers, vigour

Introduction

In Pakistan, rice is the second most important cash crop Rehman *et al*. (2017). Because of population expansion, it has been thought that increasing rice (*Oryza sativa L.*) grain yield with chemical fertilizer is an effective strategy to address the problem of food safety Liu *et al*. (2019). The productivity of rice in farmers' fields is increased using improved varieties, prudent fertilizer use, irrigation and good management practices Gairhe *et al*. (2018). Grain yield and marginal net returns are reduced because of the nutritional imbalance Zafar *et al*. (2018). The application of fertilizer has been shown to be a major determinant of rice grain quality Dou *et al*. (2017).

Since the early 1950s, urea has been the main source of nitrogenous fertilizer worldwide. With about 46% nitrogen, it is well known to be the most concentrated source of nitrogen Swify *et al*. (2023). A vital component of several physiological processes, grain quality and biomass output are nitrogen Anas *et al*. (2020). Throughout the world, urea is a crucial source of nitrogen that is utilized to meet crop nitrogen requirements. However, applied nitrogen in the form of urea is usually lost in the soil creating significant problems for the environment and economy Mustafa *et al*. (2022).

DAP (diammonium phosphate) which contains both phosphate and nitrogen is the most widely used phosphate (P) fertilizer. Urea outperforms DAP as the recommended fertilizer for agriculture in several countries. Since only one-fifth of the P that is mined becomes available due to high losses from field to fork, P fertilizers are being used in an inefficient way globally. Therefore, a multi-criteria-based approach should be applied to create a sustainable agriculture system. Organic matter enhances soil structure, boosts water-holding capacity, lowers heavy metal toxicity, decreases soil-borne infections, supports microbial decomposition and makes mineral nutrients available to crops Scotti *et al*. (2015).

A biofertilizer is a substance that contains viable live microorganisms. In certain soil types and climate zones, *Azotobacter* and *Azospirillum* can improve plant development and increase the production of several agriculturally significant crops when the right circumstances are met Suhag (2016). Over time, significant progress has been made in the comprehension, investigation and formulation of various PGPRs as substitute crop fertilization techniques Bangash *et al*. (2021). Because they may produce and release phyto-

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hormones that change the chemistry of the rhizosphere to promote plant growth; microorganisms like Rhizobia are essential for promoting plant growth Jaiswal *et al.* (2021).

Trichoderma inoculation has been shown to have numerous positive effects on crop production including increased growth yield as well as the reduction of biotic and abiotic stresses. However, the benefits of these helpful fungi are limited because rice is typically grown in anaerobic soil conditions caused by constant flooding Khadka and Uphoff (2019). *Trichoderma* seed treatment has been shown to increase biomass production, improve seedling vigour and reduce the effects of biotic as well as abiotic stresses in a range of crops Rêgo *et al.* (2014).

An experiment was initiated to check the interactive effects of synthetic and biofertilizers on the seedlings of rice. The focus of the study was to check how balanced nutrients react to different growth parameters of rice seedlings. With the help of this, the productivity and efficiency of rice seedlings can be increased.

Materials and Methods

Individual and interactive effects of reclaimer (R), biozote (B), *Trichoderma* (T), urea and DAP on the productivity of rice seedlings in *vivo* conditions were observed to check how balanced nutrients react to different growth parameters of seedlings through a 5-inch pot in which reclaimer (R) is a liquid biofertilizer containing *Azotobacter*, *Azospirillum* and biozote (B) produced by Pakistan Agricultural Research Council (PARC), Islamabad. It contains living bacteria *Rhizobium* TAL169 in the carrier material Khan-Marwat *et al.* (2017). Experiment was executed on July 17th, harvested on August 25th on soil and compost media containing urea DAP and biofertilizer while comparing it with soil, compost and cocopeat with biofertilizers at the Post Harvest Lab., Department of Agriculture and Agribusiness Management, University of Karachi, Karachi, Pakistan.

The open-pollinated, non-basmati variety PK-386 of rice (*Oryza sativa L.*) cultivar was used in the experiments to examine the interaction between synthetic, biofertilizers (the plant growth-promoting rhizobacteria PGPR) and helpful fungi *Trichoderma* on growth characteristics. When seeds were sown, DAP (0.2 g) each pot was added to the soil. After fifteen days of sowing, urea (0.2 g) each pot was added and the seeds had been combined with a sucrose solution later Adam *et al.* (2020), the solid biofertilizer biozote (B) and *Trichoderma* (T) mixture was added as a seed coating. Seeds were then dried, sown and watered right away. In each pot, fifteen seeds were planted.

Treatments and study parameters. The subsequent blends were assessed: reclaimer (R), biozote (B), *Trichoderma* (T), reclaimer+biozote (RB), reclaimer+ *Trichoderma* (RT), biozote+*Trichoderma* (BT), reclaimer+ biozote+*Trichoderma* (RBT) and a control (C) replicate set were all biofertilizers that were individually applied in triplicate. A comparable set of identical biofertilizer blends were utilized along with the synthetic fertilizer *i.e*., urea and DAP (UAP). Among the characteristics that were measured were vigour index, fresh weight (mg), dry weight (mg), germination percentage, shoot length (cm), root length (cm) and moisture percentage.

Data collection. The collected data was evaluated statistically on an individual basis with SPSS software utilizing the mean standard deviation, analysis of variance ANOVA (one way-ANOVA) and Tukey's b tests.

Results and Discussion

The germination amongst the treatments was not significantly different with sig value of .242 at P<0.05 with Tukey's HSD value of 24.89. The highest germination percentage demonstrated in Fig. 1 was recorded in the biozote + *Trichoderma* (BT) treatment and the

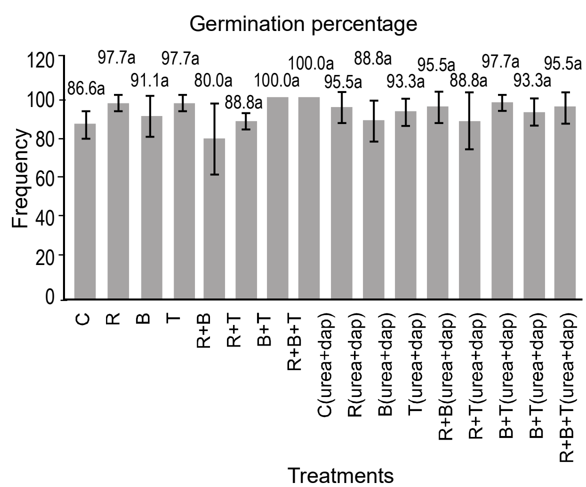

Fig. 1. Interactive effects of synthetic and biofertilizers on the germination of rice seedling of rice. Treatments were not significantly different at P<0.05 with sig value 0.242 and Tukey HSD 24.89.

reclaimer + biozote + *Trichoderma* (RBT) at (100%) in biofertilizers followed by the second highest in reclaimer R, *Trichoderma* (T) in biofertilizers and reclaimer + *Trichoderma* (RT) in synthetic with biofertilizer of (97.7%). The lowest germination percentage was recorded in the reclaimer+biozote treatment of biofertilizer (80.0%).

The shoot length amongst the treatments was significantly different with sign value of 0.010 at $P<0.05$ with Tukey's HSD value of 7.38 relcaimer + biozote (RB) treatment which used both synthetic and biofertilizers produced the highest plant shoot (18.5 cm) which can be seen in Fig. 2 with *Trichoderma* (T) of synthetic and biofertilizer coming in second (18.0 cm) 11.6 cm was the lowest shoot length measured in the biozote + *Trichoderma* treatment of biofertilizer.

Root length of (14.9 cm) was the highest recorded in *Trichoderma* (T) of synthetic and biofertilizer being (14.8 cm) from relcaimer + biozote (BT) treatment used both synthetic and biofertilizer is demonstrated in Fig. 3. The lowest root length of (6.5 cm) was recorded in *Trichoderma* (T) of biofertilizer. The root length amongst the treatments was significantly different with sig value of 0.002 at $P<0.05$ with Tukey's HSD value of 7.03.

Rice seedling vigour index amongst the treatments was also significantly different with sign value of 0.002 at $P<0.05$ with Tukey's HSD value of 1268.04. The highest vigour was recorded (3170.2) in the treatment of *Trichoderma* (T) in synthetic and biofertilizers followed by (2927.1) in the treatment of reclaimer + biofertilizer (RB) of synthetic and biofertilizer and the lowest (1653.5) was recorded in reclaimer + biofertilizer (RB) of biofertilizer which can be seen in Fig. 4.

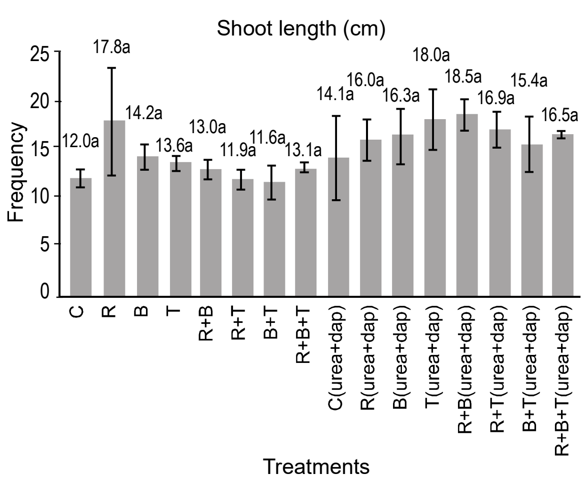

Fig. 2. Interactive effects of synthetic and biofertilizers on the shoot length of rice seedling of rice. Treatments were significantly different at $P<0.05$ with sig. value of 0.010 and Tukey HSD 7.38.

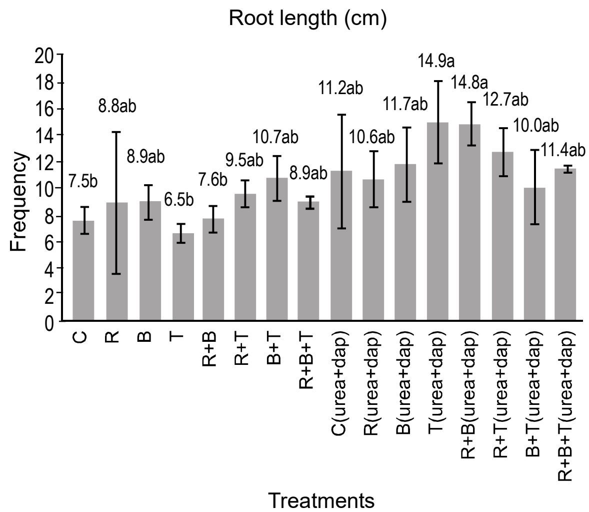

Fig. 3. Interactive effects of synthetic and biofertilizers on the root length of rice seedling of rice. Treatments were significantly different at $P<0.05$ with sig. value of 0.002 and Tukey HSD 7.03.

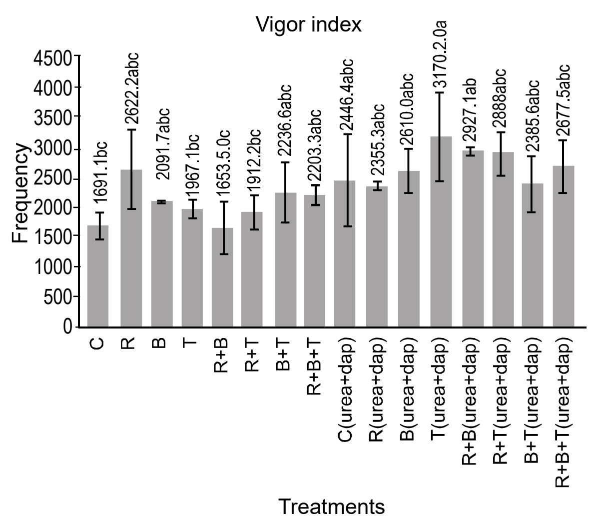

Fig. 4. Interactive effects of synthetic and biofertilizers on the vigor index of rice seedling of rice. Treatments were significantly different at $P<0.05$ with sig. value of 0.002 and Tukey HSD 1268.04.

The highest fresh weight of (907.0 mg) was observed in the synthetic and biofertilizer treatment of recalimer + *Trichoderma* (RT). The second highest shown in Fig. 5 of 837.0 mg was from biozote + *Trichoderma* (BT) treatment and the lowest (318.3 mg) was measured in biozote + *Trichoderma* (BT) treatment of biofertilizer. Rice seedling fresh weight amongst the treatments was recorded significantly different with sign value of 0.009 at P<0.05 with Tukey's HSD value of 598.56.

The highest dry weight of (226.0 mg) was calculated in the treatment of synthetic and biofertilizer treatment of reclaimer + *Trichoderma* (RT), second highest in biozote and *Trichoderma (BT)* treatment of synthetic and biofertilizer treatment with (222.3 mg) and the lowest shown in Fig. 6 was (97.3 mg) from the treatment of *Trichoderma* T of biofertilizer. Rice seedling dry weight amongst the treatments was recorded significantly different with sig value of 0.001 at P<0.05 with Tukey's HSD value of 131.26.

The lowest moisture percentage was recorded in the treatment biozote + *Trichoderma* of 66.3% shown in Fig. 7. The highest moisture percentage of 76.5% was calculated in the treatment of *Trichoderma* T with biofertilizer and the second highest in reclaimer + *Trichoderma* treatment of synthetic and biofertilizer of 75.2%. Rice seedling exhibited no significant variation amongst the treatments with sig value of 0.71 at P<0.05 with tukey's HSD value of 15.21.

Different biofertilizer rates in this study had a noticeable impact on growth. However, biofertilizers and synthetic biofertilizers had better germination rates. Auxin, ethylene, gibberellins and other plant hormones are

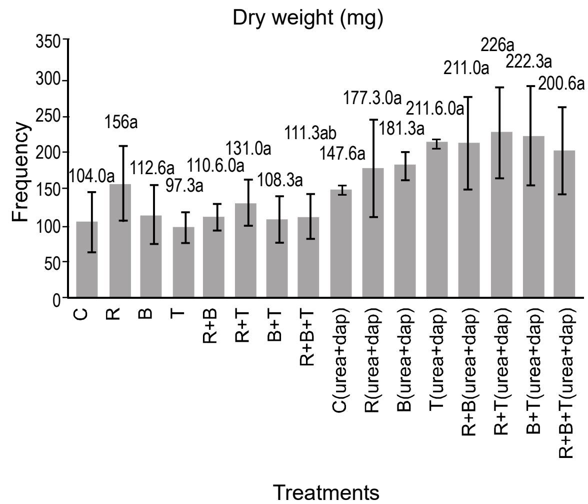

Fig. 6. Interactive effects of synthetic and biofertilizers on the dry weight of rice seedling of rice. Treatments were significantly different at P<0.05 with sig, value of 0.001 and Tukey HSD 131.26.

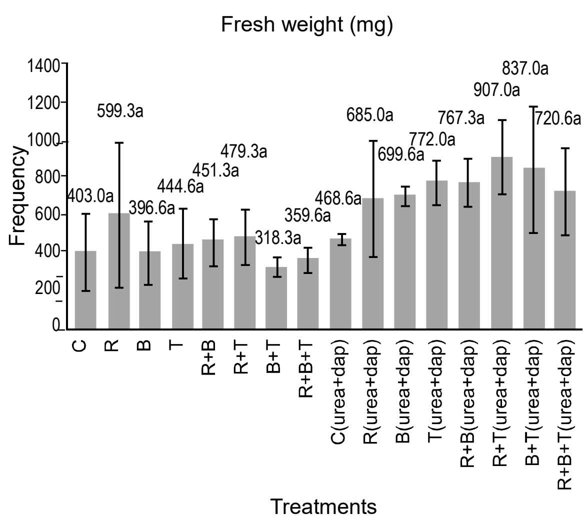

Fig. 5. Interactive effects of synthetic and biofertilizers on the fresh weight of rice seedling of rice. Treatments were significantly different at P<0.05 with sig, value of 0.009 and Tukey HSD 598.56.

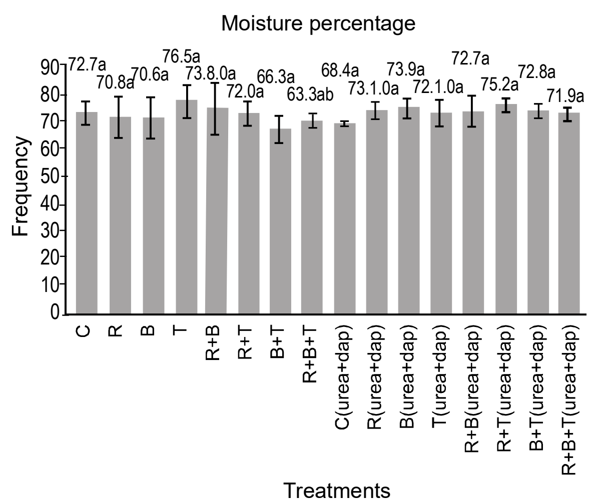

Fig. 7. Interactive effects of synthetic and biofertilizers on the moisture percentage of rice seedling of rice. Treatments were not significantly different at P<0.05 with sig, value of 0.709 and Tukey HSD 15.21.

produced by PGPRs which has been shown to improve seed germination, soil fertility and plant growth Tahir *et al*. (2017). According to Singh *et al*. (2015), due to the consistent nutrient delivery during all growth phases and the advantageous interaction between chemical fertilizers and biofertilizers (*Azotobacter* and phosphobacteria), the treated plants reached their highest height.

According to a study by Ajeng *et al*. (2020), adding biofertilizers in addition to chemical fertilizers has been shown to improve plant uptake of nutrients and increase plant growth in terms of height, girth size and chlorophyll. The application rates and types of fertilizers used determine how organic fertilization or chemical and organic fertilizer used together affect crop growth as well as soil fertility Saba *et al*. (2013). Noraida and Hisyamuddin (2021) also observed the highest fresh weight of plant in synthetic and biofertilizers. The moisture percentages of both synthetic and biofertilizers are the same.

Azospirillum and *Azotobacter* are the two species of bacteria frequently found in biofertilizers which can boost crop biomass and productivity by fixing nitrogen in the crop rhizosphere by producing phytohormones. Applying *Azospirillum* biofertilizer with 80% inorganic N can effectively increase rice crop productivity. Singh (2014) documented *Azospirillum's* efficacy in several rice cultivars.

According to Siddique *et al*. (2014), co-inoculation of *Rhizobium* and *Azotobacter chroococcum* increases nodulation, nitrogen content and grain yield in chickpeas (*Cicer aeritinum*). The results of Shrivastava *et al*. (2015), were also related to this experiment. According to his study, plant development was enhanced by co-inoculation of *Azotobacter chroococcum* with urea. In black gram (*Vigna mungo*), Tiwari *et al*. (2017) also reported that the co-inoculation of *Azotobacter* and *Rhizobium* resulted in increased length of shoots.

A crop's ability to photosynthesize is correlated to its yield, even with a lower dose of inorganic N, the plants inoculated with *Trichoderma* had noticeably higher chlorophyll levels. According to Doni *et al*. (2017), rice plants that have received a *Trichoderma* inoculation exhibit improved stomatal conductivity, photosynthetic rate and specific as well as relative chlorophyll concentrations. Chlorophyll content is a sign of a healthier and more functional root system which enables plants to absorb nutrients and water more effectively.

The production of sorghum crops increased when chemical and biofertilizer were applied simultaneously Akhtar *et al*. (2020). The soil's bacterial variety and enzyme activity increased due to the balanced fertilization Ling *et al*. (2014). An agricultural practice that uses balanced fertilization is profitable and long-lasting. Fertilizer application is essential for increasing rice output and has a significant impact on rice quality Liu *et al*. (2019). Additionally, it boosts protein contents, essential amino acids, vitamins, and nitrogen fixation which can increase crop yield by up to 40% Daniel *et al*. (2022).

Conclusion

The findings from a recent study on rice seedlings indicate that a balanced approach to fertilization can be achieved using both synthetic and biofertilizers. The combination of these two types of fertilizers can lead to healthier seedlings and improved growth. The study suggests that utilizing a combination of fertilizers can benefit overall rice crop yields. As a result, farmers need to be made aware of the advantages in combining synthetic and biological fertilizers to maintain high productivity, promote good soil health and increase yield.

Conflict of Interest. The authors declare that they have no conflict of interest.

References

Anas, M., Liao, F., Verma, K.K., Sarwar, M.A., Mahmood, A., Chen, Z., Li, Q., Zeng, X., Liu, Y., Li, Y. 2020. Fate of nitrogen in agriculture and environment: agronomic, eco-physiological and molecular approaches to improve nitrogen use efficiency. *Biological Research*, **53:** 2-20.

Adam, A.H., Adam, A., Magid, F.M. 2020. Efficacy of bat guano on growth and yield of some hybrid sunflower (*Helianthus annus L.*) cultivars in Sudan. *Agronomy Research*, **3:** 28-38.

Akhtar, S., Bashir, S., Khan, S., Iqbal, J., Gulshan, A.B., Irshad, S., Batool, S., Ahmad, N., Rizwan, M.S. 2020. Integrated usage of synthetic and biofertilizers: an environment friendly approach to improve the productivity of sorghum. *Cereal Research Communications*, **48:** 247-253.

Ajeng, A.A., Abdullah, R., Malek, M.A., Chew, K.W., Ho, Y., Ling, T.C., Lau, B.F., Show, P.L. 2020. The effects of biofertilizers on growth, soil fertility and nutrients uptake of oil palm (*Elaeis Guineensis*) under greenhouse conditions. *Processes*, **8:** 2-16.

Bangash, N., Mahmood, S., Akhtar, S., Hayat, M.T., Gulzar, S., Khalid, A. 2021. Formulation of biofertilizer for improving growth and yield of wheat in rain dependent farming system. *Environment Technology and Innovation*, **24:** 101806.

Daniel, A.I., Fadaka, A.O., Gokul, A., Bakare, O.O., Aina, O., Fisher, S., Burt, A.F., Mavumengwana, V., Keyster, M., Klein, A. 2022. Biofertilizer: the future of food security and food safety. *Microorganisms*, **10:** 1220.

Doni, F., Zain, C.R., Isahak, A., Fathurrahman, F., Anhar, A., Mohamad, W.N., Yusoff, W.M., Uphoff, N. 2017. A simple, efficient and farmer-friendly *Trichoderma*-based biofertilizer evaluated with the SRI rice management system. *Organic Agriculture*, **8:** 207-223.

Dou, Z., Tang, S., Li, G., Liu, Z., Ding, C., Chen, L., Wang, S., Ding, Y. 2017. Application of nitrogen fertilizer at heading stage improves rice quality under elevated temperature during grain-filling stage. *Crop Science*, **57:** 2183-2192.

Gairhe, S., Shrestha, H.K., Timsina, K. 2018. Dynamics of major cereals productivity in Nepal. *Journal of Nepal Agricultural Research Council*, **4:** 60-71.

Jaiswal, S.K., Mohammed, M., Ibny, F.Y., Dakora, F.D. 2021. *Rhizobia* as a source of plant growth-promoting molecules: potential applications and possible operational mechanisms. *Frontiers in Sustainable Food Systems*, **4:** 1-14.

Khadka, R.B., Uphoff, N. 2019. Effects of *Trichoderma* seedling treatment with system of rice intensification management and with conventional management of transplanted rice. *The Journal of Life and Environmental Sciences* (*PeerJ*), **7:** e5877.

Khan Marwat, M.N., Shah, H., Qureshi, A.H., Abbasi, S. 2017. Biozote performance on wheat in on-farm trials: farmers' perceptions. *Science, Technology and Development*, **36:** 147-151.

Liu, Q., Ma, H., Lin, X., Zhou, X., Zhao, Q. 2019. Effects of different types of fertilizers application on rice grain quality. *Chilean Journal of Agricultural Research*, **79:** 202-209.

Ling, N., Sun, Y., Ma, J., Guo, J., Zhu, P., Peng, C., Yu, G., Ran, W., Guo, S., Shen, Q. 2014. Response of the bacterial diversity and soil enzyme activity in particle-size fractions of Mollisol after different fertilization in a long-term experiment. *Biology and Fertility of Soils*, **50:** 901-911.

Liu, X., Li, M., Guo, P., Zhang, Z. 2019. Optimization of water and fertilizer coupling system based on rice grain quality. *Agricultural Water Management*, **221:** 34-46.

Mustafa, A., Athar, F., Khan, I., Chattha, M.U., Nawaz, M., Shah, A.N., Mahmood, A., Batool, M., Aslam, M.T., Jaremko, M., Abdelsalam, N.R., Ghareeb, R.Y., Hassan, M.U. 2022. Improving crop productivity and nitrogen use efficiency using sulphur and zinc-coated urea: a review. *Frontiers in Plant Science*, **13:** 1-19.

Noraida, M.R., Hisyamuddin, M.R. 2021. The effect of different rate of biofertilizer on the growth performance and yield of rice. IOP Conference Series: *Earth and Environmental Science*, **757:** 012050.

Rehman, A., Jingdong, L., Chandio, A.A., Shabbir, M., Hussain, I. 2017. Economic outlook of rice crops in Pakistan: a time series analysis (1970-2015). *Financial Innovation*, **3:** 2-9.

Rêgo, M.C., Ilkiu-Borges, F., Filippi, M.C., Gonçalves, L.A., Silva, G.B. 2014. Morpho-anatomical and biochemical changes in the roots of rice plants induced by plant growth-promoting microorganisms. *Journal of Botany*, **14:** 1-10.

Singh, R.K., Kumar, P., Prasad, B., Singh, S. 2015. Effect of biofertilizers on growth, yield and economics of rice (*Oryza sativa L.*). *International Research Journal of Agricultural Economics and Statistics*, **6:** 386-391.

Saba, S., Awan, I.U., Baloch, M.S., Shah, I.H., Nadin, M.A., Qadir, J. 2013. Improving synthetic fertilizer use efficiency through bio-fertilizer application in rice. *Gomal University Journal of Research*, **29:** 32-38.

Scotti, R., Bonanomi, G., Scelza, R., Zoina, A., Rao, M. 2015. Organic amendments as sustainable tool to recovery fertility in intensive agricultural systems. *Journal of Soil Science and Plant Nutrition*, **15:** 333-352.

Singh, M.K. 2014. Evaluation of *Azospirillum* strains as biofertilizers for rice. *International Journal of Farm Sciences*, **74:** 15-18.

Swify, S., Mažeika, R., Baltrusaitis, J., Drapanauskaitë, D., Barèauskaitë, K. 2023. Review, modified urea fertilizers and their effects on improving nitrogen use efficiency (NUE). *Sustainability*, **16:** 188. DOI:10.3390/su16010188

Siddique, A., Shivle, R., Magodiya, N., Tiwari, K. 2014. Mixed effect of *Rhizobium* and *Azotobacter* as biofertilizer on nodulation and production of chick pea, *cicer arietinum. Biosciences, Biotechnological Research Communications*, **7:** 46-49.

Shrivastava, R., Shrivastava, A.K., Dewangan, N. 2015 Combined application of *Azotobacter* and urea to improve growth of rice (*Oryza sativum*). IOSR *Journal of Environment Science, Toxicology and Food Technology*, **1:** 67-72.

Suhag, M. 2016. Potential of biofertilizers to replace chemical fertilizers. *International Advanced Research Journal in Science, Engineering and Technology*, **3:** 163-167.

Tahir, H.A., Gu, Q., Wu, H., Raza, W., Hanif, A., Wu, L., Colman, M.V., Gao, X. 2017. Plant growth promotion by volatile organic compounds produced by bacillus subtilis SYST2. *Frontiers in Microbiology*, **8:** 1-11.

Tiwari, S., Chauhan, R.K., Singh, R., Shukla, R., Gaur, R. 2017. Integrated effect of *Rhizobium* and *Azotobacter* cultures on the leguminous crop black gram (*Vigna Mungo*). *Advances in Crop Science and Technology*, **5:** 2-9.

Zafar, S.A., Noor, M.A., Waqas, M.A., Wang, X., Shaheen, T., Raza, M., Rahman, M.U. 2018. *Temperature extremes in cotton production and mitigation strategies*. *Past, Present and Future Trends in Cotton Breeding*, 184 pp., Pakistan. Doi:105772/ Intechopen.7464.