Economic Analysis Based on Benefit Cost Ratio approach for Rice crop in combination with the bio-inoculants and chemical fertilizers

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ABSTRACT

A field experiment was conducted during kharif season of 2022 to evaluate the effect of different NPK levels and bio-inoculants on growth, yield and economics of NDR-2065. Factorial Experiment was laid out in completely randomized block design involving three NPK levels i.e. control, 60% RDF, 80% RDF and 100% RDF in combination with three levels of bio- organics viz. BGA + PSB, Azolla + PSB and BGA + Azolla + PSB along with seven treatment combinations replicated thrice. The total per ha^{-1} paddy and straw yield of rice varieties amounted a sum of ₹ 122721 for T_5 (80% RDF + 500kg Azolla ha^{-1} Soil application + PSB), ₹ 116048 for T_2 100% RDF (150, 60, 40 N_2, P_2O_5, K_2O kg ha^{-1}), ₹ 111108 for T_3 (80% RDF + 10 kg BGA ha^{-1} Soil application + PSB), ₹ 107709 for T_6 (60% RDF + 500kg Azolla ha^{-1} Soil application +PSB) and ₹ 86580 for T_1 under control. The Benefit Cost Ratio (BCR) was higher for T_5 having value of 2.0 and least for T_1 with a value of 1.3. The treatment combination T_2, T_6 and T_3 presented a close value of Benefit Cost Ratio (BCR) with respect to each other viz. 1.8, 1.7 and 1.7 respectively.

Keywords- NPK, BGA, PSB, Azolla

1. INTRODUCTION

Rice, scientifically known as *Oryza sativa* L., belongs to the Poaceae family and is an important cereal crop cultivated under aquatic (anaerobic) conditions. It is grown in diverse climatic conditions and is considered the second most important cereal crop world-wide, serving as a major food source for 50% of the global population due to its nutritional value [1]. The total cultivated area for rice globally in 2018 was approximately 164.19 million hectares, with a total annual grain production of 756.74 million tonnes and an average yield of 4.60 tonnes ha^{-1} [2]. The excessive intensification of land use without proper and equitable application of chemical fertilizers coupled with minimal or absent utilization of organic fertilizers, has led to significant degradation of soil fertility. Consequently, this has resulted in a plateauing or even reduction in agricultural outputs [3]. Exclusively relying on either organic manure or chemical fertilizers is insufficient to establish a sustainable production system within an intensive cropping regimen that can adequately meet the requirements of food demand [4]. Rice plants require N to promote growth and tillering, spikelet production during early panicle formation stage, grain filling, improving the photo-synthetic capacity and promoting carbohydrate accumulation in culms and leaf sheaths [5]. Phosphorus stimulates various physiological activities such as root and shoot growth, promotes vigorous seedling growth, advances crop maturity, and plays a vital role in plant metabolism such as cell division, breakdown of sugar, nutrient transport within the plant, regulation of metabolic pathways, and other biochemical characteristics [6]. Potassium plays an important role in physiology and metabolism of plant, not only because of its frequency in plant tissues, but also for its physiological and chemical duties [7].

Azolla recognized as a beneficial plant in agriculture, particularly in Southern China and Northern Vietnam, where it is used as a bio-fertilizer and green manure due to its nitrogen-fixing abilities [8]. By applying Azolla in every planting season, the need for artificial fertilizers can be significantly reduced as it directly provides nutrients to the soil [9]. Blue-green algae have a significant role in preserving and enhancing soil fertility, leading to improved growth and higher yields of rice, functioning as a natural fertilizer [10]. PSB (Phosphate-Solubilizing Bacteria) help dissolve immobilized soil phosphorus, enhancing the effectiveness of applied phosphates and ultimately leading to increased rice yields [11]. Due to financial constraints faced by a significant portion of Indian farmers, the expensive nature of chemical fertilizers poses a challenge. Nevertheless, it is crucial to employ integrated technologies to unlock the sustainable potential of wetland rice cultivation. This study aimed to evaluate the impact of varying NPK levels and bio-organic inputs on the growth, yield, and economic aspects of wetland rice in the conditions of eastern Uttar Pradesh. The objective was to recommend an effective integrated nutrient management approach for optimal results.

2. MATERIALS AND METHODS

The field experiments was carried out at Agronomy research field of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during Kharif, (2022) which is located on Ayodhya – Raebareli road about 43 km away from Ayodhya Headquarter. The experimental site falls under subtropical climatic zone of Indo Gangetic plains situated at 26.47 ^{0}N latitude, 82.12 ^{0}E longitudes and an altitude of 113 meters above mean sea level. The rice variety NDR-2065 was used as a test crop in the experiment. The experiment encompassed seven distinct treatments, each designed to investigate their impact on crop growth and yield enhancement. The first treatment, denoted as T_1, served as the control group, remaining unaffected by additional interventions. Treatment T_2 involved the application of 100% of the recommended dose of fertilizer (RDF), with specific nutrient proportions of 150 units, 60 units, and 40 units. In T_3, an 80% RDF was combined with the introduction of 10 kilograms of bio-growth agent (BGA) ha^{-1} and 3 kilograms of phosphorus-solubilizing bacteria (PSB) per hectare. Similarly, T_4 utilized a 60% RDF alongside 10 kilograms of BGA ha^{-1} and 3 kilograms of PSB ha^{-1}. Transitioning to T_5, this treatment incorporated 80% RDF, accompanied by the application of 500 kilograms of Azolla ha^{-1}, a water fern, and 3 kilograms of PSB ha^{-1}. In parallel, T_6 featured 60% RDF combined with 500 kilograms of Azolla ha^{-1} and 3 kilograms of PSB ha^{-1}. Lastly, T_7 encompassed the simultaneous introduction of 10 kilograms of BGA ha^{-1}, 500 kilograms of Azolla ha^{-1}, and 3 kilograms of PSB ha^{-1}. Each treatment was thoughtfully designed to explore diverse combinations of nutrient supplementation, organic inputs, and bacterial assistance, all aimed at optimizing crop productivity and nutrient utilization within the agricultural context.

An individual plot size of 20 m² (5 m x 4m) with a spacing of 20 cm x 10 cm (PP x RR) was maintained. The experiment was laid out in Randomized Block Design and replicated thrice. The recommended fertilizer dosage (RDF) for the Ayodhya region was applied to cultivate the experimental crop, with a composition of N-P_2O_5-K_2O (150-60-40 kg ha^{-1}). Half of the suggested nitrogen dose was administered as a basal application, while the remaining half was split equally into two parts during the active tillering and panicle initiation stages. The complete phosphorus and potassium doses were applied at the beginning in accordance with the treatments for their respective plots. Urea (46% N), di-ammonium phosphate (18% N and 46% P_2O_5), and muriate of potash (60% K_2O) were used as the sources for NPK fertilizers. The experimental field's soil was silty clay loam in texture and exhibited alkaline pH (8.62). It had low organic carbon content (0.42%) and available nitrogen (150.2 kg ha^{-1}), along with moderate levels of available phosphorus (13.8 kg ha^{-1}) and potassium (256.3 kg ha^{-1}).

Rice seedlings, aged four weeks, were transplanted onto a puddled field with a spacing of 20 cm × 10 cm, featuring two seedlings per hill. Azolla was applied five days after transplanting, and a powdered mixture of algal culture, at a rate of 10 kg ha^{-1}, was incorporated into the respective treatments using slurry made of soil, water, and cow dung. Liquid PSB culture was employed to create the solution needed for soil application. After 5 days of transplanting, the solution was applied to the soil around the base of the plants. This method ensured that the beneficial microorganisms from the PSB culture could establish contact with the root zone and promote nutrient availability and uptake for the growing plants. The application process involved treating the soil around the plants with the PSB solution, facilitating a symbiotic relationship between the microorganisms and the plant roots to potentially enhance nutrient acquisition and overall plant growth. Data collection from plots was facilitated through a well-organized questionnaire. The formula used for calculating the Benefit Cost Ratio (BCR) is as follows: BCR = VNR (Variety net revenue) / TC (Total cost of the variety). Notably, the Benefit Cost Ratio maintains a direct correlation with the net return. In simpler terms, a higher Cost Benefit Ratio signifies a greater net return.

3. RESULTS AND DISCUSSIONS

3.1. Yield Attributes

3.1.1. Grain Yield

The perusal data presented in the table 1.0 showed that grain yield was influenced significantly with the application of different inorganic fertilizer in combination with Azolla PSB and BGA. The highest grain yield was observed in T_5, where 80% of the recommended dose of fertilizer (RDF) was combined with 500 kg of Azolla ha^{-1} and soil application of phosphate solubilizing bacteria (PSB), resulting in a remarkable yield of 56.8 q ha^{-1}. This treatment exhibited a substantial increase of approximately 43% in grain yield compared to the control (T_1), which yielded 39.5q ha^{-1}. Similarly, T_2, applying 100% RDF, showed a noteworthy enhancement in yield, producing 53.7 q ha^{-1}, a 36% increase over the control. However, T_3, T_4, T_6, and T_7 demonstrated moderate improvements in grain yield, compared to the control. The synergistic application of organic amendments, such as Azolla and BGA, along with PSB, can significantly enhance grain yield compared to conventional RDF application alone. Phosphate solubilizing bacteria solubilize insoluble phosphate to soluble forms and enhancing the supply of nutrient. The gradual release of nutrients resulting from the bio-inoculants such as of Azolla combined with BGA and PSB helps in supplementary nitrogen release from the breakdown of deceased algal cells and improved phosphorus availability in the soil, Azolla and BGA facilitated a more effective synchronization between the crop's nutrient requirements and the soil's nutrient provision. This, in turn, fostered enhanced production of carbohydrates and proteins, ultimately leading to the accumulation of dry matter. As a result, there was a positive impact on the characteristics influencing yield and the overall rice yield itself. The finding of the investigation confirms the observation of earlier workers [12, 13, 14, 15, 16, 17, and 18].

3.1.2. Straw Yield

Presented data in table No.1.0 explores the effects of various treatments on straw yield in a field experiment. The treatments encompass different combinations of nutrient inputs, bio-inputs, and microbial inoculants. The results and their implications depicts that T_1 control treatment, receiving no additional inputs, exhibited a straw yield of 60.00 q ha^{-1}. This baseline measurement provides a reference point for evaluating the impact of other treatments. Application of the recommended dose of fertilizers (RDF) led to a modest increase in straw yield, resulting in 65.00 q ha^{-1} in T_2. This suggests that adequate nutrient supply enhances straw production. A combination of T_3 (80% RDF + BGA + PSB) inoculation yielded a straw production of 66.60 q ha^{-1}. This treatment indicates that the synergistic effects of BGA and PSB, along with reduced chemical fertilizer, can enhance straw yield. The incorporation of Azolla along with 80% RDF and PSB led to a higher straw yield of 68.49 q ha^{-1} in T_5. Despite a lower RDF in T_4, the inclusion of BGA and PSB in the treatment resulted in a straw yield of 65.70 q ha^{-1}. This implies that the presence of beneficial microorganisms and growth agents can contribute positively to straw production. This treatment highlights the potential of Azolla as an organic nutrient source that enhances straw biomass. The results clearly demonstrate that the inclusion of bio-inputs (BGA and Azolla) and microbial inoculants (PSB) can significantly influence straw yield. Treatments with BGA and PSB (T_3 and T_4) indicate that the positive effects of these growth agents and microorganisms can complement and potentially offset the need for higher chemical fertilizer doses. The application of Azolla, a nitrogen-fixing aquatic fern, in combination with PSB (T_5 and T_6) showcases its potential as a sustainable and effective approach to boost straw production. Synergies between different interventions, such as those seen in treatments incorporating Azolla, BGA, and PSB, demonstrate the complexity of interactions in the soil-plant-microbe system. The finding of the investigation confirms the observation of earlier workers [14, 17, 19 and 20]

3.1.3. Harvest Index

The data depicted in Table 1.0 evident that the effect of different treatments on harvest index. Critical examination of data revealed that maximum harvest index (45.33) was found under treatment T_5 and the minimum harvest index (39.30) was found under treatment T_7. Harvest index did not differ significantly by Chemical fertilizer in combination with other nutrient management practice such as Azolla PSB and BGA. The increased availability of nutrients and photosynthesis might have enhanced higher test weight resulting in higher grain yield (q ha^{-1}). Therefore, grain and straw yield of crop is a function of several yield components, which are dependent on complementary interaction between vegetative and reproductive growth of the crop. The biological yield under the influence of NPK ha^{-1} could be showed its positive influence on both vegetative and reproductive growth of crop which, led to increase in its grain and straw yield. The finding of the investigation confirms the observation of earlier workers [13].

Table & Fig No -1.0- Effect of Bio-Inoculant along with inorganic fertilizer on Grain yield, Straw yield, Biological yield and Harvest Index of rice crop.

Number	Treatment	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Biological Yield (q ha^{-1}	Harvest Index (%)
T_1	Control	39.5	60.00	99.60	39.76
T_2	100% RDF (150, 60, 40 N, P_2O_5, K_2O kg ha^{-1})	53.7	65.00	118.25	45.03
T_3	80% RDF + 10 kg BGAha^{-1}Soil application + PSB (Phosphate solubilizing bacteria)	51.2	66.60	117.80	43.46
T_4	60% RDF + 10kg BGA ha^{-1} Soil application + PSB	45.6	65.70	111.29	40.97
T_5	80% RDF + 500kg Azolla ha^{-1} Soil application +PSB	56.8	68.49	125.30	45.33
T_6	60% RDF + 500kg Azolla ha^{-1} Soil application +PSB	49.5	67.29	116.80	42.38
T_7	10kg BGA ha^{-1} Soil application + 500kg Azolla ha^{-1} Soil application + PSB	42.6	65.80	108.40	39.30
	SE(m)±	0.70	1.09	1.25	
	C.D. (p=0.05)	2.20	3.41	3.90	

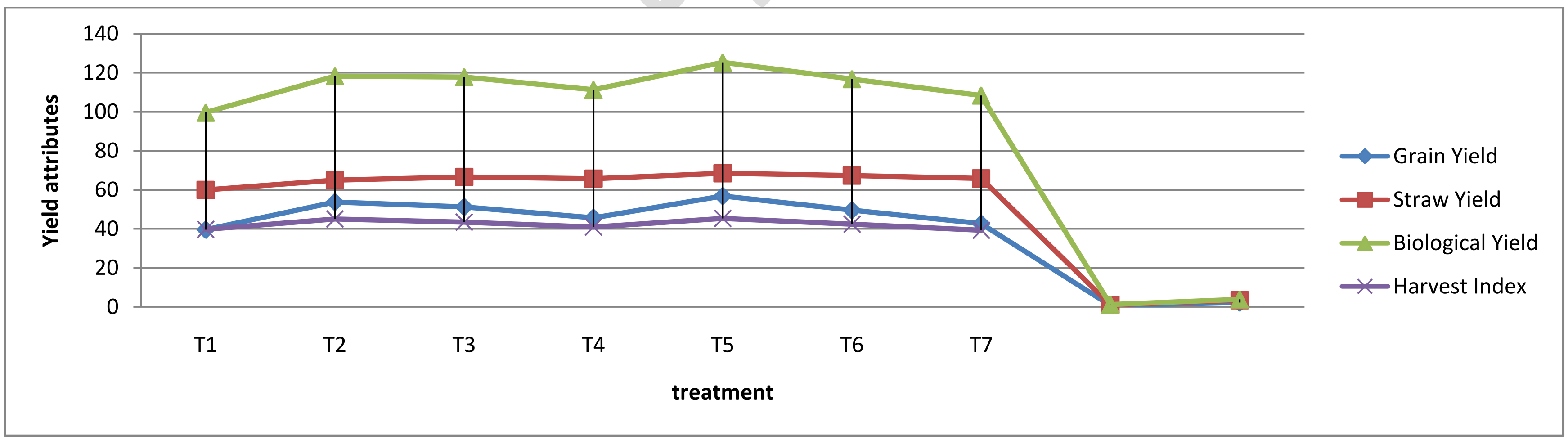

Fig No.1.0

Table & Fig. No.2.0- Effect of bio-inoculants along with inorganic fertilizer on cost of cultivation, gross yield, Net income Rs ha^{-1} of rice crop.

Number	Treatment	Cost of Cultivation (Rs ha^{-1})	Gross Return (Rs ha^{-1})	Net Return (Rs ha^{-1})	B:C Ratio
T_1	Control	37375	86580	49205	1.3
T_2	100% RDF (150, 60, 40 N, P_2O_5, K_2O kg ha^{-1})	41017	116048	75031	1.8
T_3	80% RDF + 10 kg BGAha^{-1}Soil application + PSB (Phosphate solubilizing bacteria)	41869	111108	69239	1.7
T_4	60% RDF + 10kg BGA ha^{-1} Soil application + PSB	41221	99594	58373	1.4
T_5	80% RDF + 500kg Azolla ha^{-1} Soil application +PSB	40957	122721	81764	2.0
T_6	60% RDF + 500kg Azolla ha^{-1} Soil application +PSB	40341	107709	67368	1.7
T_7	10kg BGA ha^{-1} Soil application + 500kg Azolla ha^{-1} Soil application + PSB	39498	93484	53986	1.4
	SE(m)±	4.8	0.44	1.93	0.28
	C.D. (p=0.05)	15.1	1.39	6.03	0.89

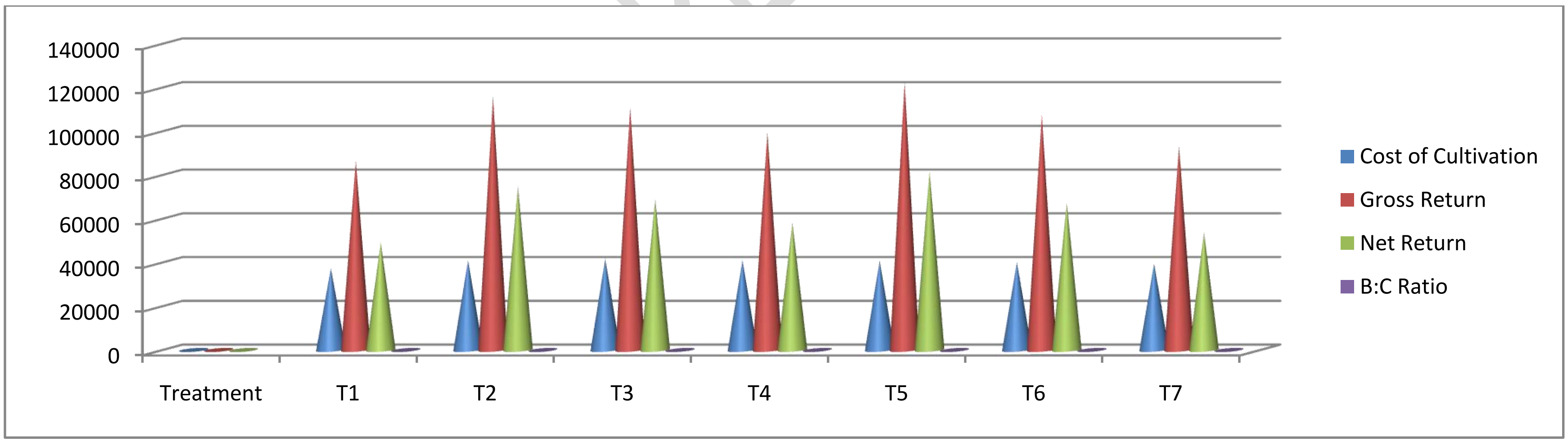

Fig No. 2.0

3.2. Economics of inputs and returns

3.2.1. Cost of cultivation (₹ ha^{-1})

The presented data in Table No 2.0 outlines the cost of cultivation for the rice crop, providing a detailed breakdown of expenditures across various key activities. Land preparation, including ploughing, puddling, and bunding, constitutes an initial investment of ₹ 7,410. Nursery raising, involving seed procurement, bed preparation, and labor, contributes ₹ 10,490 to the total cost. Water management costs, encompassing irrigation charges and labor, amount to ₹ 4,610. Weed management and harvest-related expenses, including manual weeding and harvesting processes, add up to ₹ 7,035. Additionally, the rental value of land is accounted for at ₹ 500 per hectare per annum. The interest on working capital at a rate of 12% per annum sums up to ₹ 2,104. Consequently, the comprehensive common cost of cultivation is estimated at ₹ 37,174. This detailed breakdown highlights the significance of each component in the cultivation process, emphasizing the financial commitment required at different stages. Efficient resource allocation and cost-effective strategies are essential for ensuring economic viability and sustainable agricultural practices.

The data in the table provides an insightful overview of the total cost of cultivation associated with different treatments for the rice crop. These treatments encompass a range of interventions, including varying levels of recommended dose of fertilizers (RDF), bio-inputs (such as BGA and Azolla), and microbial inoculants (PSB). Notably, the results demonstrate a progressive increase in total cost across the treatments. The control treatment (T_1) incurs the lowest cost at 37,375 kg ha^{-1}, while the introduction of RDF and additional bio-inputs leads to higher costs in subsequent treatments. For instance, the application of 100% RDF (T_2) results in a total cost of 41,017 kg ha^{-1}, followed by further increases with the incorporation of BGA and PSB (T_3), Azolla (T_5 and T_6), or a combination of BGA, Azolla, and PSB (T_7). These escalating costs highlight the financial implications of adopting different agricultural strategies. A comprehensive cost-benefit evaluation would aid in determining the most economically viable and sustainable approach to crop cultivation.

3.2.2. Gross return (₹ ha^{-1})

The gross return of rice cultivation was evaluated under various treatments, each involving different nutrient management practices and soil amendments. The results revealed notable variations in gross returns across the treatments. The highest gross return was recorded in T_5, where 80% recommended dose of fertilizer (RDF) was combined with the application of 500 kg of Azolla per hectare along with phosphate solubilizing bacteria (PSB). This treatment resulted in a remarkable 41.6% increase in gross return compared to the control (T_1), indicating the positive impact of integrated nutrient management. Another treatment that displayed a substantial increase in gross return was T_2, involving the application of 100% RDF. This treatment exhibited a 33.8% rise in gross return over the control, highlighting the significance of adequate nutrient supplementation. Conversely, treatments with reduced fertilizer inputs, such as T_3 (80% RDF + 10 kg BGA ha^{-1} Soil application + PSB) and T_4 (60% RDF + 10 kg BGA ha^{-1} Soil application + PSB), demonstrated lower gross returns compared to the control, with percentage reductions of 21.6% and 13.3%, respectively. Interestingly, the combination of bio-fertilizers like Azolla and PSB in T_5 and T_6 (60% RDF + 500 kg Azolla ha^{-1} Soil application + PSB) contributed to enhanced gross returns by 41.5% and 22.7% compared to T_4, respectively. Notably, the treatment T_7 (10 kg BGA ha^{-1} Soil application + 500 kg Azolla ha^{-1} Soil application + PSB) displayed a gross return reduction of 7.8% compared to T_6. All the organic inputs with chemical fertilizer recorded significantly higher gross return than T_1 (control) which had recorded minimum gross return (86580 ₹). Kikuchi *et al*. (1984) reported similar findings.

3.2.3. Net return (₹ ha^{-1})

The provided data furnishes a comprehensive insight into the net returns associated with various treatments applied to a rice crop. These treatments encompass diverse combinations of nutrient inputs, bio-inputs, and microbial inoculants. Among the treatments, the control (T_1) yields a net return of ₹ 49,205 per hectare, which sets the baseline for comparison. With the application of the recommended dose of fertilizers (T_2), the net returns substantially increase to ₹ 75,031, indicating a positive correlation between higher input levels and increased returns. This translates to a percentage increase of approximately 52%. Moreover, the ratio of net returns between T_2 and T_1 is approximately 1.53, underscoring the economic advantage of using the full RDF. Interestingly, the treatment involving a combination of 80% RDF, BGA, and PSB (T_3) results in a net return of ₹ 69,239, represent a percentage increase of about 40% over the control. The corresponding ratio of net returns is approximately 1.40, indicating a favorable economic outcome from this combination of interventions. However, variations in net returns are observed among the treatments incorporating Azolla. For instance, T_5, which applies 80% RDF with 500kg Azolla and PSB, yields a substantial net return of ₹ 81,764, representing a percentage increase of around 66% over the control. The ratio of net returns between T_5 and T_1 is approximately 1.66, highlighting the substantial economic benefit of this treatment. On the other hand, T_6, applying 60% RDF with 500kg Azolla and PSB, yields a net return of ₹ 67,368.7, showcasing a percentage increase of about 37% and a ratio of approximately 1.37. Intriguingly, the treatment involving both BGA and Azolla, alongside PSB (T_7), produces a net return of ₹ 53,986, reflecting a percentage increase of around 9% compared to the control. The ratio of net returns between T_7 and T_1 is approximately 1.09. The results clearly showed that the application of bio-inoculants increased net return and benefit cost ratio of rice.

Conclusion:

The findings underscore the critical importance of informed decision-making in modern agriculture to maximize both economic returns and sustainability. Firstly, the breakdown of cultivation costs highlights the financial commitments associated with different stages of rice farming. Efficient resource allocation and cost-effective strategies are pivotal in ensuring economic viability, especially in the face of fluctuating market conditions. The analysis of treatment effects on cultivation costs demonstrates the financial implications of adopting different agricultural strategies. The progressive increase in costs with the introduction of recommended doses of fertilizers (RDF), bio-inputs, and microbial inoculants emphasizes the need for farmers to carefully consider their investment choices. A comprehensive cost-benefit evaluation becomes essential to determine the most economically viable and sustainable approach to rice cultivation. Moving to the gross returns, the data reveals substantial variations across treatments, with integrated nutrient management practices leading to significant increases. This highlights the potential for optimizing crop yields and income through judicious nutrient supplementation. Notably, treatments involving Azolla and phosphate solubilizing bacteria (PSB) exhibit remarkable boosts in gross returns, underlining the positive impact of these interventions. The net return analysis provides a crucial measure of profitability, and the results are striking. Treatments with higher input levels, particularly the application of full RDF, consistently result in significantly higher net returns. This underscores the economic advantage of using recommended doses of fertilizers and bio-inoculants, emphasizing the importance of nutrient management.

References

1 Baroudy, Ahmed A. El, Abdelraouf. M. Ali, Elsayed Said Mohamed, Farahat S. Moghanm, Mohamed S. Shokr, Igor Savin, Anton Poddubsky, Zheli Ding, Ahmed M.S. Kheir, Ali A. Aldosari, and *et al*. (2020). "Modeling Land Suitability for Rice Crop Using Remote Sensing and Soil Quality Indicators: The Case Study of the Nile Delta" Sustainability 12, no. 22: 9653. https://doi.org/10.3390/su12229653

2 Food and Agriculture Organization of the United Nations. (2021). FAOSTAT. http://www.fao.org/faostat/en/

3 Shormy SAS, Chowdhury MAH, Saha BK, Haque MA (2013) Effects of different sources of organic materials on nutrient contents and their uptake by T. aman rice. *J Agrofor Environ* 7: 37—40

4 Garai TK, Datta JK, Mondal NK (2014) Evaluation of integrated nutrient management on boro rice in alluvial soil and its impact upon growth, yield attributes yield and soil nutrient status. *Arch in Agron and Soil Sci* 60 : 1—14.

5 Mae, T, (1997) Physiological nitrogen efficiency in rice: nitrogen utilization, photosynthesis and yield potential. *Plant and Soil* 196:201-210

6 Theodorou ME, Plaxton WC. (1993) Metabolic Adaptations of Plant Respiration to Nutritional Phosphate Deprivation. Plant Physiol. Feb;101(2):339-344. doi: 10.1104/pp.101.2.339. PMID: 12231689; PMCID: PMC160576.

7 Mengel, K., & Kirkby, E. A. (1987). Principles of plant nutrition. *Bern. International Potash Institute*, 687-695.

8 Van Hove, C., Lejeune, A. (1996). Biological Nitrogen Fixation Associated with Rice Production. *Developments in Plant and Soil Sciences*, vol 70. Springer, Dordrecht. https://doi.org/10.1007/978-94-015-8670-2_10

9 Maftuchah, D., Wahyudi, A., Zainudin, A., & Budiyanto, M. A. (1998). Association of

Azolla sp. with Microalga Anabaena azollae as a Natural Nitrogen Source and Its Utilization as Raw Material for Protein. Competitive Grant Research Project VI–First Year, DP3M, *Directorate General of Higher Education, Ministry of National Education*

10 Song T, Martensson L, Eriksson T, Zheng W, Rasmussen U (2005) Biodiversity and seasonal variation of the cyanobacterial assemblage in a rice paddy field in Fujian, China. *The Federation of European Materials Soc Microbiol Ecol* 54 : 131—140.

11 Gull M, Hafeez FY, Saleem M, Malik KA (2004) Phos- phorus uptake and growth promotion of rice by co- inoculation of mineral phosphate solubilizing bacteria and mixed rhizobial culture. *Aust J Experim Agric* 44 : 623—628.

12 Begum, Z.N.T., Mandal, R., Islam, S. (2011). Effect of cyanobacterial biofertilizer on the growth and yield components of two HYV of rice. *J. Algal Biomass Util*. 2: 1–9.

13 Yousaf, M., Li, J., Lu, J. *et al.*, (2017) Effects of fertilization on crop production and nutrient-supplying capacity under rice-oilseed rape rotation system. *Sci Rep* 7, 1270. https://doi.org/10.1038/s41598-017-01412-0

14 Baktash, A. M., Datt, N., Suri, D., Choudhary, D., & Thakur, A. (2021). Integrated effect of azolla in combination with graded doses of nitrogen on growth and agronomic parameters of rice crop. *Indian Journal of Ecology*, 48(5), 1435-1437.

15 Biswakarma, B., Verma, H., & Sarkar, N. C. (2018). Effect of phosphate solubilizing bacteria on yield of transplanted rice under lateritic belt of West Bengal, India. *International journal of current microbiology and applied sciences*, 7(2), 3192-3204.

16 Ojha, S. K., Benjamin, J. C., & Singh, A. K. (2018). Role on biofertilizer (Blue green algae) in paddy crop. *Journal of Pharmacognosy and Phytochemistry*, 7(4), 830-832.

17 Paudel, Y. P., Pradhan, S., Pant, B., & Prasad, B. N. (2012). Role of blue green algae in rice productivity. *Agriculture and Biology Journal of North America*, 3(8), 332-335.

18 Chinnusamy, M., Kaushik, B. D., & Prasanna, R. (2006). Growth, nutritional, and yield parameters of wetland rice as influenced by microbial consortia under controlled conditions. *Journal of plant nutrition*, 29(5), 857-871.

19 Abbas, H., Ali, M., Mohammed, M., Ghazal, F, M., El-Gaml, N.M,. (2015). Impact of cyanobacteria Inoculation on rice (*Oriza sative*) yield cultivated in saline soil. *Journal of American Science*. 11. 11-19.

20 Maurya, R., & Singh, M., & Singh, N., & Singh, M., & Singh, A., (2021). Effect of Nitrogen Levels on Growth Attributes, Yield and Nutrient Uptake of Different Rice (*Oryza Sativa* L.) Varieties under the Transplanted Condition. *Journal of Experimental Biology and Agricultural Sciences*. 9. S336-S342. 10.18006/2021.9 (Spl-3-NRMCSSA_2021).S336.S342.