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EFFECT OF MIRACLE BIOFERTILIZER ON GROWTH AND YIELD OF ONION

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ABSTRACT

A field study was conducted during the Rabi season of 2025-26 at two distinct locations under the Bangladesh Agricultural Research Institute (BARI)-the Soil Science Division in Gazipur and the On-Farm Research Division (OFRD) in Rangpur. The primary objective was to evaluate the efficacy of Miracle Biofertilizer (MB) as a sustainable supplement to chemical fertilizers (CF) for onion (*Allium cepa* L.) cultivation. The experiment utilized five treatments: T_1 (100% CF), T_2 (75% CF + MB), T_3 (50% CF + MB), T_4 (MB alone), and T_5 (control). Results indicated significant variations in growth and yield parameters across both sites. In Gazipur, the highest onion yield was recorded in T_2 treatment (17.11 t ha^{-1}), which was statistically similar to T_1 treatment (16.51 t ha^{-1}). Similarly, in Rangpur, T_2 treatment produced the maximum yield of 12.68 t ha^{-1}, significantly outperforming the 100% CF treatment (11.37 t ha^{-1}). Growth attributes such as plant height and bulb dimensions followed a similar trend, with T_2 consistently performing as well as or better than the full chemical dose. Notably, the T_3 treatment (50% CF + MB) produced yields of 15.13 t ha^{-1} in Gazipur and 10.57 t ha^{-1} in Rangpur, suggesting that chemical inputs can be reduced by 50% with manageable yield impacts. The study concludes that integrating Miracle Biofertilizer with 75% of the recommended chemical fertilizer (T_2) is the most effective strategy for maximizing onion productivity.

Keywords: Growth; Sustainable; Yield; productivity; Gazipur; Rangpur

1 INTRODUCTION

Onion (*Allium cepa* L.), a member of the family Amaryllidaceae, is one of the most important vegetable and spice crops cultivated worldwide. It plays a significant role in human nutrition, culinary practices, agricultural trade, and rural livelihoods. Onion is widely used as a basic ingredient in various cuisines because of its distinctive flavour, aroma, and taste. In addition to its culinary importance, onion contains several bioactive compounds, including flavonoids, phenolic compounds, and organosulfur compounds, which are associated with antioxidant and other health-promoting properties (Pal et al., 2025). It also contributes dietary fibre and essential minerals to the human diet. Globally, onion is cultivated across diverse agro-climatic conditions and represents an important agricultural commodity in both domestic and international markets. Its substantial contribution to agricultural trade highlights its economic importance and relevance to global food and nutritional security.

In Bangladesh, onion is one of the most widely consumed spices and occupies a prominent position in the national agricultural economy. It is an essential ingredient in daily food preparation and is consumed by almost every household. The annual domestic demand for onion is estimated at approximately 3.5-3.6 million metric tons. To achieve self-sufficiency and reduce dependence on imported onion, Bangladesh has been making efforts to increase domestic production through the expansion of cultivated areas, improved varieties, and modern production technologies. For the 2025-26 fiscal year, the production target was reported to exceed 4.2 million metric tons from approximately 286,300 hectares of land. However, despite considerable production potential, the onion sector continues to face several challenges, including high production costs, fluctuating market prices, inadequate storage facilities, seasonal price instability, and substantial post-harvest losses. These constraints frequently affect farmers' profitability and the stability of domestic onion supplies. Therefore, increasing productivity through improved crop management practices and sustainable nutrient management is essential for strengthening onion production in Bangladesh.

Among the various production constraints, soil fertility management is one of the most important factors influencing onion growth, bulb development, and final yield. Onion is a relatively shallow-rooted crop with a limited root system, making it particularly sensitive to nutrient availability in the soil. Adequate and balanced supplies of essential plant nutrients, particularly nitrogen (N), phosphorus (P), potassium (K), and sulfur (S), are necessary for proper vegetative growth, photosynthetic activity, bulb initiation, bulb enlargement, and quality development. Nitrogen promotes leaf development and vegetative growth, phosphorus supports root development and energy transfer, potassium regulates physiological processes and improves crop performance, while sulfur contributes to the formation of characteristic flavour compounds in onion. An inadequate or imbalanced supply of these nutrients may adversely affect plant growth, bulb size, marketable yield, and overall productivity.Traditionally, onion cultivation in Bangladesh has relied heavily on inorganic fertilizers to achieve higher yields. Although chemical fertilizers provide readily available nutrients and can significantly improve crop productivity, their continuous and imbalanced application may contribute to soil degradation, nutrient imbalance, changes in soil reaction, declining soil organic matter, and disruption of beneficial soil microbial communities. Long-term dependence on excessive chemical fertilizer inputs may also reduce nutrient-use efficiency and increase production costs (Gnanasundari et al., 2023; Pal et al., 2025). Consequently, sustainable nutrient management strategies are increasingly important for maintaining soil fertility, improving crop productivity, and reducing the environmental impacts associated with intensive agricultural production.

Integrated Nutrient Management (INM) has emerged as an effective approach to addressing these challenges. INM involves the balanced and judicious integration of chemical fertilizers, organic manures, and biological nutrient sources to maintain soil fertility and improve nutrient-use efficiency. The approach aims to synchronize nutrient availability with crop demand while supporting beneficial soil biological processes. Biofertilizers are an important component of INM because they contain beneficial microorganisms capable of improving nutrient availability, promoting plant growth, and enhancing soil biological activity. Depending on their microbial composition, biofertilizers may contribute to biological nitrogen fixation, phosphorus solubilization, nutrient mobilization, and the production of plant-growth-promoting substances (Vessey, 2003; Bhattacharyya & Jha, 2012).

Biofertilizers can improve plant nutrient acquisition through several mechanisms, including atmospheric nitrogen fixation, solubilization of insoluble phosphorus, mineralization of organic nutrients, and stimulation of root growth. Certain beneficial microorganisms also produce phytohormones, such as auxins, gibberellins, and cytokinins, which promote root development, nutrient absorption, and plant growth. Furthermore, microbial inoculants may improve plant tolerance to environmental stresses and contribute to a favourable rhizosphere environment (Bhattacharyya & Jha, 2012; Vessey, 2003). Therefore, the integration of biofertilizers with chemical fertilizers offers an opportunity to improve crop productivity while reducing excessive dependence on inorganic nutrient sources.Several studies have demonstrated the potential of microbial inoculants to improve fertilizer-use efficiency and crop productivity. Adesemoye et al. (2009) reported that the combined application of plant growth-promoting rhizobacteria (PGPR) and reduced chemical fertilizer rates could maintain plant growth, yield, and nutrient uptake comparable to those obtained with full recommended fertilizer application in tomato. Similarly, Adesemoye and Kloepper (2009) highlighted the

importance of plant–microbe interactions in improving nutrient-use efficiency and developing sustainable integrated nutrient management systems. These findings indicate that biofertilizers can serve as valuable components of sustainable crop production systems. However, their effectiveness depends on several factors, including microbial composition, inoculant quality, soil properties, climatic conditions, crop species, and fertilizer management practices.

In onion production, the use of suitable biofertilizers may contribute to improved root development, nutrient availability, vegetative growth, bulb formation, and final yield. Since onion has a relatively shallow root system, improved nutrient mobilization and uptake in the rhizosphere may be particularly beneficial for maintaining adequate plant nutrition throughout its growing period. Nevertheless, the response of onion to biofertilizer application may vary depending on the soil environment and the interaction between beneficial microorganisms and applied chemical fertilizers. Consequently, evaluating biofertilizers under different agro-ecological conditions is necessary to identify appropriate nutrient management combinations for sustainable onion production.

Bangladesh has considerable agro-ecological diversity, and differences in soil characteristics, climatic conditions, and nutrient availability may influence the performance of biofertilizers. Gazipur, located in the central region of Bangladesh, represents an important research environment for evaluating agricultural technologies under the conditions of the Madhupur Tract. On the other hand, Rangpur, situated in the northern region, represents another important agricultural environment with distinct soil and climatic characteristics. Evaluating the performance of biofertilizers at these two locations can provide useful information about their consistency and adaptability under different field conditions. Such multi-location research is particularly important for developing location-responsive fertilizer recommendations and promoting the wider adoption of sustainable nutrient management technologies.

Among the available biological nutrient management products, Miracle Biofertilizer (MB) has potential for evaluation as a component of integrated nutrient management in onion cultivation. Its combined application with chemical fertilizers may improve nutrient availability and plant growth while potentially reducing the requirement for higher levels of inorganic fertilizer inputs. However, the agronomic effectiveness of Miracle Biofertilizer needs to be scientifically assessed under local field conditions rather than assumed from its commercial claims. In particular, determining its contribution to vegetative growth, bulb development, and total bulb yield is essential for establishing its practical value in onion production systems.

Considering these aspects, the present study was conducted during the Rabi season of 2025-26 at the Soil Science Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, and the On-Farm Research Division, BARI, Rangpur. The experiment aimed to evaluate the effect of Miracle Biofertilizer in combination with different levels of chemical fertilizers on the growth and yield of onion. Important growth and yield attributes, including plant height, bulb dimensions, and total bulb yield, were assessed to determine the effectiveness of different nutrient management treatments. The study was also intended to identify an appropriate combination of Miracle Biofertilizer and chemical fertilizers for improving onion productivity under the agro-ecological conditions of Gazipur and Rangpur. The findings are expected to contribute to the development of sustainable and economically viable nutrient management practices, improve fertilizer-use efficiency, support soil fertility management, and strengthen domestic onion production in Bangladesh.

2 MATERIALS AND METHODS

The experiment was conducted during the Rabi season of 2025-26 to evaluate the synergistic effects of microbial inoculants and inorganic fertilizers. The trials were established at two distinct locations: the Soil Science Division, BARI, Gazipur and OFRD, BARI, Rangpur. The study was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each experimental unit (plot) measured 2m x 2m. BARI Onion- 4 was used as the test crop. The standard recommended fertilizer dose for the regions was 70-25-50-20-1.5-0.8 kg N-P-K-S-Zn-B ha^{-1}, supplemented with 3 t ha^{-1} of organic fertilizer. The experiment evaluated five nutrient management strategies: T_1 (100% CF), T_2 (75% CF + MB), T_3 (50% CF + MB), T_4 (MB alone), and T_5 (control). Miracle Biofertilizer (MB), was applied at a rate of 2 L ha^{-1}. For the specific plot sizes, the dose was calibrated accordingly. Application occurred in two stages: 1) At Planting: Onion seedlings were treated with MB during transplanting. 2) Top Dressing: A second application was performed 20 days after seedling planting. Plant growth and yield attributes were recorded. Statistical analysis was performed using ANOVA, and means were compared using the Least Significant Difference (LSD) test at a 5% level of significance. The precision of the experiment was monitored via the Coefficient of Variation (CV%).

3 RESULTS AND DISCUSSION

Table 1: Yield and yield attributes of onion as affected by different fertilizer treatments at Soil Science Division, BARI, Gazipur during rabi season of 2025-26

Treatment	Plant Height (cm)	Bulb Length (cm)	Bulb Breadth (cm)	Yield (t ha^{-1})
T_1=100% Chemical Fertilizer (CF)	51.46a	5.63a	4.55a	16.51a
T_2=75% Chemical Fertilizer (CF) + MB	52.10a	5.91a	4.42a	17.11a
T_3= 50% CF + Miracle Biofertilizer (MB)	46.06b	4.97b	4.06ab	15.13a
T_4= Miracle Biofertilizer (MB)	43.96b	5.36a	4.29ab	9.82b
T_5=Control	37.70c	4.99b	3.84	8.27b
LSD (0.05)	4.07	0.43	0.54	2.91
CV (%)	4.68	4.27	6.85	11.59

The experiment evaluated the response of Miracle Biofertilizer (MB) in combination with chemical fertilizers (CF) on the growth and yield of onion (*Allium cepa* L.) during the Rabi season of 2025-26 at two locations under Bangladesh Agricultural Research Institute, namely Gazipur and Rangpur. The results revealed significant variation among treatments for growth and yield parameters. At Gazipur (Table 2**)**, the tallest plants were observed in T_2 (75% CF + MB) with 52.10 cm, which was statistically similar to T_1 (100% CF, 51.46 cm). Bulb length and breadth were also highest in T_2 (5.91 cm and 4.42 cm, respectively), though statistically similar to T_1. The highest yield (17.11 t ha^{-1}) was recorded in T_2, followed closely by T_1 (16.51 t ha^{-1}), indicating that MB can effectively supplement chemical fertilizers and even enhance yield. Treatment T_3 (50% CF + MB) produced comparable yield (15.13 t ha^{-1}), suggesting that chemical fertilizer use can be reduced up to 50% with minimal yield reduction. In contrast, T_4 (MB alone) and T_5 (control) produced significantly lower yields (9.82 and 8.27 t ha^{-1}, respectively), highlighting the importance of balanced nutrient supply.

Table 2: Yield and yield attributes of onion as affected by different fertilizer treatments at OFRD, BARI, Rangpur during rabi season of 2025-26

Treatment	Plant Height (cm)	Bulb Length (cm)	Bulb Breadth (cm)	Yield (t ha^{-1})
T_1=100% Chemical Fertilizer (CF)	62.87ab	4.94a	4.62a	11.37b
T_2=75% Chemical Fertilizer (CF) +(MB	62.73ab	4.82ab	4.49b	12.68a
T_3= 50% CF + Miracle Biofertilizer (MB)	63.07ab	4.68ab	4.44b	10.57c
T_4= Miracle Biofertilizer (MB)	61.33a	4.62b	4.57a	5.75d
T_5=Control	57.40c	4.92a	4.22c	5.57d
LSD (0.05)	3.85	0.32	0.28	1.12
CV (%)	5.82	6.45	5.90	8.96

Similarly, at Rangpur (Table 2**)**, T_2 again produced the highest yield (12.68 t ha^{-1}), significantly outperforming T_1 (11.37 t ha^{-1}). Although plant height was highest in T_3 (63.07 cm), it was statistically similar to T_1 and T_2. Bulb size parameters showed minor variation, but T_2 maintained superior performance in yield. The lowest yield was observed in the control (5.57 t ha^{-1}), followed by MB alone (5.75 t ha^{-1}), reinforcing the need for integrated nutrient management. The superior performance of T_2 across both locations can be attributed to the synergistic effects of biofertilizer and chemical fertilizers. Biofertilizers enhance nutrient availability through mechanisms such as biological nitrogen fixation, phosphorus solubilization, and secretion of growth-promoting hormones (Vessey, 2003). These processes improve root development and nutrient uptake, resulting in better plant growth and bulb formation. Similar findings have been reported by J. K. Vessey and Adesemoye *et al*. (2009), who observed increased crop productivity with reduced chemical fertilizer input when combined with plant growth-promoting rhizobacteria. The moderate performance of T_3 indicates that partial substitution of chemical fertilizers with MB is feasible, though site-specific factors such as soil fertility and

climate influence the extent of reduction. The relatively lower yield in MB-only treatment (T_4) suggests that while biofertilizer improves soil biological activity, it cannot fully meet the high nutrient demand of onion as a bulb crop when applied alone.

Statistical analysis confirmed that treatment effects were significant at the 5% level, as indicated by LSD values. The coefficient of variation (CV%) was within acceptable ranges, indicating good experimental precision. The yield increase observed in integrated treatments can also be linked to improved soil microbial activity and nutrient cycling, which enhance overall soil health and sustainability (Bhattacharyya and Jha, 2012). From a practical perspective, the use of MB with reduced chemical fertilizer (T_2) offers an economically viable and environmentally sustainable option for onion production. It reduces dependency on chemical fertilizers, lowers production costs, and promotes eco-friendly agriculture.

Table 3: Economic analysis and MBCR of onion at Soil Science Division, BARI, Gazipur during rabi season of 2025-26

Treatment	Yield (t ha^{-1})	Gross Return (Tk. ha^{-1})	Variable Cost (Tk. ha^{-1})	Common Cost (Tk. ha^{-1})	Total Cost (Tk. ha^{-1})	Net Return (Tk. ha^{-1})	BCR	MBCR
T1 = 100% CF	16.51	495,300	15,743	161,500	177,243	318,057	2.79	14.70
T2 = 75% CF + MB	17.11	513,300	15,308	161,500	176,808	336,492	2.90	16.32
T3 = 50% CF + MB	15.13	453,900	11,372	161,500	172,872	281,028	2.63	17.10
T4 = MB	9.82	294,600	3,500	161,500	165,000	129,600	1.79	12.29
T5 = Control	8.27	248,100	0	161,500	161,500	86,600	1.54	—

Urea=27 tk/kg, TSP=27 tk/kg, MoP=22 tk/kg, Gypsum=16 tk/kg, Zinc Sulphate=350 tk/kg, Boric Acid=600 tk/kg, Onion=30 tk/kg and Rate of applied Miracle biofertilzer = Tk. 3500 ha^{-1}

Table 4: Economic analysis and MBCR of onion at OFRD, BARI, Rangpur during rabi season of 2025-26

Treatment	Yield (t ha^{-1})	Gross Return (Tk. ha^{-1})	Variable Cost (Tk. ha^{-1})	Common Cost (Tk. ha^{-1})	Total Cost (Tk. ha^{-1})	Net Return (Tk. ha^{-1})	BCR	MBCR
T1 = 100% CF	11.37	341,100	15,743	161,500	177,243	163,857	1.92	10.05
T2 = 75% CF + MB	12.68	380,400	15,308	161,500	176,808	203,592	2.15	12.93
T3 = 50% CF + MB	10.57	317,100	11,372	161,500	172,872	144,228	1.83	12.19
T4 = MB	5.75	172,500	3,500	161,500	165,000	7,500	1.01	0.54
T5 = Control	5.57	167,100	0	161,500	161,500	5600	1.03	—

Urea=27 tk/kg, TSP=27 tk/kg, MoP=22 tk/kg, Gypsum=16 tk/kg, Zinc Sulphate=350 tk/kg, Boric Acid=600 tk/kg, Onion=30 tk/kg and Rate of applied Miracle biofertilzer = Tk. 3500 ha^{-1}

The growth, yield and economic performance of onion were significantly affected by different fertilizer treatments at both Gazipur and Rangpur during the rabi season of 2025-26. Among the treatments, T_2 (75% Chemical Fertilizer + Miracle Biofertilizer) produced the highest bulb yield at both locations, yielding 17.11 t ha^{-1} at Gazipur and 12.68 t ha^{-1} at Rangpur. In contrast, the control treatment produced the lowest yields. Improved growth and yield under integrated nutrient management might be due to enhanced nutrient availability, better root development and increased microbial activity in the soil. Biofertilizers help improve nutrient uptake and stimulate plant growth through biological nitrogen fixation and nutrient solubilization. The findings are consistent with the reports of Vessey (2003) and Subba Rao (2014), who observed positive effects of biofertilizers on crop productivity and soil fertility. Economic analysis also revealed that T_2 was the most profitable treatment, providing the highest gross return, net return and benefit-cost ratio (BCR) at both locations. The results indicate that integrated application of Miracle Biofertilizer with 75% recommended chemical

fertilizer can enhance onion productivity and profitability while reducing dependence on chemical fertilizers, contributing to sustainable onion cultivation in Bangladesh.

4 CONCLUSION

The study revealed that Miracle Biofertilizer combined with 75% recommended chemical fertilizer significantly improved onion yield and profitability at both Gazipur and Rangpur. The treatment produced the highest yield (up to 17.11 t ha^{-1}), indicating that chemical fertilizer use can be reduced by 25% through sustainable integrated nutrient management.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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