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IMPACT OF INORGANIC NUTRIENTS AND BIOFERTILIZERS ON ECONOMIC PERFORMANCE IN SPINACH BEET CULTIVATION

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ABSTRACT

A field study was conducted at the P.G. Research Farm, College of Horticulture, Rajendranagar, Hyderabad during Rabi season to evaluate the influence of inorganic nutrients and biofertilizers on the economic performance of spinach beet (*Beta vulgaris* var. *bengalensis*) cv. Pusa Bharati. Ten treatment combinations integrating various proportions of recommended dose of fertilizers (RDF), Arka Microbial Consortium (AMC), Potassium Solubilizing Bacteria (KSB), and foliar application of Arka Vegetable Special were tested in a randomized block design. The results revealed that combined application of inorganic fertilizers and biofertilizers significantly enhanced yield and profitability. The treatment T9 (50% RDF + AMC @ 5 kg/ha + KSB @ 2.5 kg/ha + foliar spray of Arka Vegetable Special @ 5 g/L) recorded the highest total yield (412.75 q/ha), gross return (Rs. 199,375/ha), net return (Rs. 103,214/ha), and benefit-cost (B:C) ratio (6.00). The lowest economic returns were obtained under T4 (25% RDF + Azotobacter + PSB + KSB each @ 3.75 kg/ha) with a B:C ratio of 3.50. The findings demonstrate the economic viability of integrating inorganic and biological nutrient sources for sustainable spinach beet production.

***Keywords* :** Spinach beet (*Beta vulgaris* var. *bengalensis*) cv. Pusa Bharati, Arka Microbial Consortium (AMC), Potassium Solubilizing Bacteria (KSB)

Introduction

Spinach beet (*Beta vulgaris* var. *bengalensis*), commonly known as Indian spinach or "Palak," is one of the most important leafy vegetables cultivated across India for its quick growth, high nutritional value, and market demand. It belongs to the family Chenopodiaceae and is rich in essential nutrients such as vitamin A (97,701 IU), vitamin C (70 mg 100 g^{-1}), iron, calcium, folic acid, and antioxidants like carotenoids and flavonoids (Thamburaj and Singh, 2015). Due to its soft, tender leaves and fast regeneration, it serves as a staple component of the daily diet, often termed as a "mine of minerals" for its exceptional nutritive composition.

India is the second-largest producer of vegetables globally, with an annual production of 185.8 million metric tonnes from 10.1 million hectares (NHB, 2019). In Telangana, leafy vegetables occupy 21,208 acres with a production of 89,577 metric tonnes. However, the average consumption of leafy vegetables remains far below the recommended daily intake only about 24 g per person per day compared to the 50 g recommended by ICMR (PJTSAU, 2019). Enhancing the productivity and profitability of leafy vegetables like spinach beet, therefore, holds great promise for improving both nutritional security and farmer income.

The extensive use of inorganic fertilizers such as urea, diammonium phosphate, and muriate of potash has significantly improved crop yields in the past decades. However, their indiscriminate use has led to declining soil fertility, reduced microbial activity, and increased production costs (Custic *et al.,* 1994; Mohandas, 1999). Moreover, excessive nitrogen application increases nitrate accumulation in leafy vegetables, adversely affecting human health and produce quality. Consequently, there is an increasing need to adopt eco-friendly nutrient management practices that maintain productivity while reducing chemical dependence.

Biofertilizers, which include beneficial microorganisms such as *Azotobacter*, phosphate solubilizing bacteria (PSB), and potassium solubilizing bacteria (KSB), are gaining attention as sustainable nutrient sources. They enhance soil fertility by fixing atmospheric nitrogen, solubilizing insoluble phosphates, and mobilizing potassium from minerals (Tilak and Singh, 1994; Etesami *et al.,* 2017). Among these, *Azotobacter* has been reported to save 10–20% of nitrogen fertilizer requirement (Mohandas, 1999). The use of Arka Microbial Consortium (AMC), a multi-strain biofertilizer developed by the Indian Institute of Horticultural Research (IIHR), further improves nutrient availability and promotes plant growth through synergistic microbial action (Sharma and Divakara, 2019).

In addition to microbial inoculants, the foliar application of micronutrient formulations such as Arka Vegetable Special Containing Zn, Fe, Mn, Cu, B, Mo, Ca, Mg, S, and K enhances the growth, colour, and shelf-life of leafy vegetables by correcting micronutrient deficiencies and improving photosynthetic efficiency (Diana and Nehru, 2014; Kisan *et al.,* 2015). The combined application of inorganic fertilizers, biofertilizers, and foliar micronutrients is thus recognized as an integrated nutrient management (INM) approach that enhances nutrient use efficiency and sustains long-term soil fertility (Kanaujia *et al.,* 2010; Yadav *et al.,* 2019).

From an economic standpoint, fertilizer inputs constitute a major portion of production costs in leafy vegetables. Integrating biofertilizers with inorganic fertilizers can reduce chemical fertilizer dependency, lower input costs, and improve the benefit-cost (B:C) ratio while maintaining or even enhancing yields (Patel *et al.,* 2010; Aisha *et al.,* 2013). Such integration also improves the quality and marketability of produce, extending shelf life and consumer appeal (Raut *et al.,* 2006; Phandis *et al.,* 2007).

Given these considerations, it becomes essential to identify the most efficient combination of inorganic and biological nutrient sources for sustainable spinach beet production. The present investigation was therefore undertaken to evaluate the impact of inorganic nutrients and biofertilizers on the growth, yield, quality, and particularly the economic performance of spinach beet under Telangana conditions.

Materials and Method

The experimental site is located at an altitude of 542.3 meters above mean sea level, at 17°19′ N latitude and 79°23′ E longitude, and falls under the semi-arid tropical climate of the Deccan Plateau region. Meteorological data during the cropping season (December 2020 to March 2021) recorded mean maximum and minimum temperatures of 31.8°C and 17.2°C, respectively, with moderate rainfall and relative humidity ranging from 52–76% and was laid out in a Randomized Block Design (RBD) with ten treatments and three replications. Each plot measured 2 m × 2 m (4 m²) with an inter-plot spacing of 0.4 m and replication spacing of 2.0 m and covered a total area of approximately 120 m^2.

Treatments	Treatment Details
T_1	100% RDF (100:25:50 kg NPK ha^{-1})
T_2	75% RDF + *Azotobacter* + PSB + KSB (Each @ 1.25 kg/ha)
T_3	50% RDF + *Azotobacter* + PSB + KSB (Each @ 2.5 kg/ha)
T_4	25% RDF + *Azotobacter* + PSB + KSB (Each @ 3.75 kg/ha)
T_5	75% RDF + Arka Microbial Consortium (AMC) @ 2.5 kg/ha + KSB @ 1.25 kg/ha
T_6	50% RDF + AMC @ 5.0 kg/ha + KSB @ 2.5 kg/ha
T_7	25% RDF + AMC @ 7.5 kg/ha + KSB @ 3.75 kg/ha
T_8	T_5 + Arka Vegetable Special @ 5 g/L (foliar spray)
T_9	T_6 + Arka Vegetable Special @ 5 g/L (foliar spray)
T_{10}	T_7 + Arka Vegetable Special @ 5 g/L (foliar spray)

Note: Arka Vegetable Special was applied as a foliar spray at 15, 30, and 45 days after sowing (DAS).

The field was ploughed and harrowed twice to achieve fine tilth, followed by levelling. Farmyard manure (FYM) was uniformly incorporated before sowing. The seeds were sown directly in rows at the recommended spacing (30 cm × 10 cm) and covered lightly with soil. Thinning was done at 15 DAS to maintain uniform plant population.

Nutrient Application

Inorganic fertilizers were applied as per the treatment combinations using urea (46% N), single superphosphate (16% P_2O_5), and muriate of potash (60% K_2O) as nutrient sources.

- **Nitrogen** was applied in three equal splits ¼ as basal and the remaining in two equal splits after each cutting.
- **Phosphorus and potassium** were applied as basal doses before sowing.
- Biofertilizers such as *Azotobacter*, PSB, and KSB were mixed with well-decomposed FYM and applied to the soil before sowing according to treatment rates.
- **Arka Microbial Consortium (AMC)**, a multi-strain formulation containing N-fixing, P- and Zn-solubilizing, and plant growth-promoting rhizobacteria, was applied to the soil before sowing as per treatment.
- **Arka Vegetable Special**, a micronutrient formulation containing Zn, B, Fe, Cu, Mn, Mo, Ca, Mg, and S, was sprayed thrice during the crop growth period.

Irrigation and Intercultural Operations

Immediately after sowing, the crop was irrigated to ensure proper germination. Subsequent irrigations were given at 7-day intervals throughout the crop growth period, maintaining optimum soil moisture. Regular weeding and hoeing were carried out to keep the field weed-free. Thinning and gap-filling were done at 15 DAS to maintain uniform plant stands.

Observations Recorded

Observations on growth, yield, quality, and economic parameters were recorded at different growth stages (15, 30, 45, and 60 DAS).

Economic Parameters

- **Cost of Cultivation (Rs./ha)**: Computed based on input costs including fertilizers, biofertilizers, labour, irrigation, and plant protection.
- **Gross Return (Rs./ha)**: Calculated by multiplying total yield (q/ha) with the market price of spinach beet.
- **Net Return (Rs./ha)**: Obtained by subtracting total cost of cultivation from gross return.
- **Benefit-Cost Ratio (B:C)**: Determined by dividing gross returns by the total cost of cultivation.

Statistical Analysis

Data recorded for different parameters were statistically analyzed using Analysis of Variance (ANOVA) as per the Randomized Block Design procedure (Panse and Sukhatme, 1967). The level of significance was tested at p = 0.05, and the Critical Difference (CD @ 5%) values were calculated for comparison of treatment means

Results and Discussion

Higher money value and less cost of cultivation are desirable for getting higher returns the economics of different treatment combinations consisting of land configuration and fertilizer level worked out by considering the prevailing market price of produce and input is furnished. Hence economics of the treatments was worked out and the data pertaining to economics of different treatments are depicted in Table 1 and Fig.1 The treatment application of T_9 (T_6 + Arka vegetable special @ 5 g L^{-1}) recorded highest benefit cost ratio (6.00) whereas, the minimum benefit cost ratio (3.50) recorded in treatment T_4 (25 % RDF + Azotobacter + PSB+ KSB (Each @ 3.75 kg ha^{-1}). The benefit cost ratio under each treatment was worked out to judge the feasibility of its implementation. The data indicated that maximum profit could be realized under treatment combination with 50 % inorganic nutrients with integration of 50 % biofertilizers which was the highest among all treatments. This might be due to the fact that 50 % inorganic and 50 % organic sources enhance the nutrient availability resulting in vigorous plant growth and dry matter production which in turn resulted in giving higher yields and economics over other treatments. These results are very close to the findings of (Chaudhary *et al.*, 2011) in fenugreek and reported that maximum net return and B: C ratio with integration of 50% RDF through vermicompost + 50% RDF through inorganic sources and also for realizing good soil health and sustainable production.

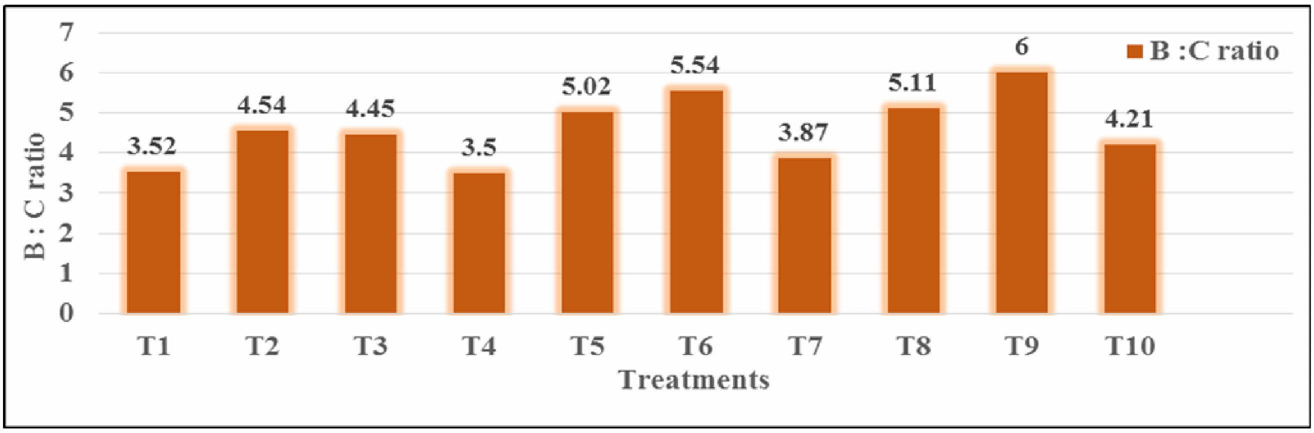

Fig. 1 : Benefit cost ratio as influenced by inorganic nutrients and biofertilizers in spinach beet Cv. Pusa Bharati.

Table 1 : Gross returns, net returns Rs. ha^{-1} and benefit cost ratio as influenced by inorganic nutrients and biofertilizers in spinach beet Cv. Pusa bharati

Treatment details	Total yield (q/ha)	Cost of cultivation Rs. ha^{-1}	Gross return Rs. ha^{-1}	Net returns Rs. ha^{-1}	Benefit Cost ratio
T_1	296.19	20979	148095	53069	3.52
T_2	330.75	18209	165375	64478	4.54
T_3	318.25	17859	159125	61704	4.45
T_4	235.88	16828	117940	42142	3.50
T_5	347.50	17291	173750	69584	5.02
T_6	388.25	17491	194125	79571	5.54
T_7	265.57	17129	132785	49264	3.87
T_8	363.25	17759	181625	73054	5..11
T_9	412.75	20611	199375	103214	6.00
T_{10}	284.26	20249	142130	65030	4.21

Conclusion

The study concludes that integrating 50% RDF with biofertilizers (AMC @ 5 kg/ha + KSB @ 2.5 kg/ha) and foliar application of Arka Vegetable Special (5 g/L) significantly enhances both yield and economic performance in spinach beet cultivation. This integrated nutrient management practice provides a cost-effective and sustainable alternative to complete reliance on chemical fertilizers while improving soil health and productivity.

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