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Economic assessment of organic manures and bio fertilizers on quality production in broccoli (*Brassica oleracea* var. *italica* Plenck)

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Abstract

A field experiment was conducted to assess the economic feasibility of organic manures, bio fertilizers along with chemical fertilizers on broccoli productivity and quality of broccoli (*Brassica oleracea* var. *italica* Plenck) during the year 2019-20 at Barhalganj, Gorakhpur region. A total of ten distinct treatments were administered by addition of manures (Farm Yard Manure and Vermicompost) and biofertilizers (Azotobacter and Phosphate-Solubilizing Bacteria). These treatments were applied to the test crop, broccoli. The experiment was laid out in randomized block design in three replications. The recommended dose of fertilizer (100 percent) used for broccoli was 120:60:60 kg NPK/ha. De Cicco variety of broccoli was transplanted at a spacing of 60 cm×45cm. Results revealed that the treatment T₇ (FYM 5 t/ha + VC @ 1.25 t/ha + 50% PSB) recorded maximum yield (17.06 t/ha) and quality parameters like Vitamin C (80.24 mg/g) and TSS (11.37 °Brix). The maximum uptake of Nitrogen (120 kg/ha), Phosphorous (60 kg/ha) and Potassium (60 kg/ha) was also observed in treatment T₇ (VC @ 1.25 t/ha + 75% PSB) followed by T₈ (FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% Azotobacter) and T₄ (VC @ 1.25 t/ha + 75% PSB). Gross returns (Rs. 2, 04,720/-), net returns (Rs. 1, 34,665/-) and benefit: cost ratio (2.92:1) was also found maximum in T₇. The results indicated that 50% of recommended dose of fertilizer along with vermicompost, was the best treatment for getting quality yield and return from broccoli.

Keywords: Broccoli, bio fertilizer, production, yield, quality

Introduction

Broccoli (*Brassica oleracea* var. *italica*), also known as "crown of jewel nutrition", is a high-value cash crop within the Brassicaceae family, offering substantial economic returns to growers. Broccoli is rich in vitamins such as A, B₁, B₂, minerals such as potassium, iron as well as bioactive compounds especially sulforaphane. Sprouting broccoli has recently gained popularity in India due to its loose cluster of green, immature buds as compared to heading broccoli which forms a compact curd-like structure along with nutritional and medicinal benefits.

Generally, broccoli is sown in September-October and harvested during the period of November to February in Northern India because its cultivation is best suited in cool climates. The seasonal adaptability and health benefits have made it a favoured crop for farming community and cultivated approximately 369 thousand hectares.

Despite the increasing demand for broccoli, the productivity remains low due to imbalance chemical fertilizer use, alongside their high costs, has been a significant barrier. To address these challenges, there is a shift towards sustainable farming practices, particularly integrated nutrient management (INM) which emphasizes the judicious use of organic, inorganic and microbial sources to maintain soil health and achieve sustainable crop productivity. Organic inputs such as vermicompost enrich the soil with a diverse microbial population, further supporting nutrient cycling and plant growth. Biofertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of produce. They contain microorganisms which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes. Thus, the present research has been conducted to assess the economic feasibility of various treatment

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combinations.

Materials and Methods

The experiment was carried out to assess the economic viability of the organic manures and biofertilizers for quality production in broccoli at the Research Farm, Department of Horticulture, National Post Graduate College, Barhalganj during Rabi season of 2019-20. The experimental site is located in the sub-tropical belt of Eastern Uttar Pradesh, experiences maximum temperature of 49 °C and minimum temperature of 2 °C. The annual rainfall ranges from 850 mm to 1100 mm, persists during the period of July-September. The initial value of soil chemical properties was recorded with 6.5 pH, 0.45 percent organic carbon and available nitrogen, phosphorus and potassium with 212.56 kg/ha, 37.32 kg/ha and 210.05 kg/ha, respectively.

The experiment was laid out in Randomized Block Design with 10 treatments in three replications and 1.5 m² sized 30 plots. There were 6 plants per treatments. The treatments included various combinations of organic and biofertilizers, such as farmyard manure (FYM), vermicompost (VC), and biofertilizers like *Azotobacter* and phosphate-solubilizing bacteria (PSB). The treatment details included are: T₀ (Absolute control), T₁ (FYM @ 20 t/ha + VC @ 2.5 t/ha), T₂ (FYM @ 10 t/ha + 50% PSB), T₃ (FYM @ 10 t/ha + 50% Azotobacter), T₄ (VC @ 1.25 t/ha + 75% PSB), T₅ (VC @ 1.25 t/ha + 75% Azotobacter), T₆ (50% PSB + 50% Azotobacter), T₇ (FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% PSB), T₈ (FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% Azotobacter), T₉ (FYM @ 5 t/ha + VC @ 1.25 t/ha + 25% PSB + 25% Azotobacter).

Yield indicators with total yield per plot converted into yield per hectare for analysis. Moreover, economic analysis involved calculating the cost of cultivation, gross income, net income and benefit-cost ratio based on current market prices. The data collected were analyzed using analysis of

variance (ANOVA) to determine the economic significance of treatment effects by comparing the analysed data on yield, cost of production, net profit and cost: benefit ratio.

Results and Discussion

This study evaluated the economic viability of various treatments of integrated nutrient management including organic manure and biofertilizers for quality production of broccoli (*Brassica oleracea* var. *italica*) under the Gorakhpur region. The results highlighted the significant influence of INM treatments incorporated with organic fertilizers like farmyard manure (FYM), vermicompost (VC) and biofertilizers such as phosphate-solubilizing bacteria (PSB) and *Azotobacter*, the findings highlighted significant improvements in yield and quality with high cost: benefit ratio.

Yield parameters

The data on various yield attributing parameters are presented in Table-1 and showed the significant differences for number of days taken to harvest, average curd weight, yield per plot and yield per hectare. The significant variations were observed in the number of days taken to first harvest among all the treatments wherein the earliest curd formation (58 days) was recorded by the application of FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% PSB (T₇) followed by the treatment of 50% PSB + 50% Azotobacter in T₆ (59.67 days), while the control took 69 days to reach maturity. Increased phosphorus intake and nitrogen availability from PSB, which are essential for rapid vegetative growth and curd formation, have been associated with early maturity in T₇. This finding is in conformity with the results of Tripathi *et al.* (2012) [9] who were also observed that the use of balanced nitrogen and phosphorus led to quicker head formation in broccoli.

Table 1: Effect of various treatment combinations of FYM, VC, Azotobacter and PSB on yield attributing parameters of broccoli (*Brassica oleracea* var. *italica* Plenck).

Treatments	Days taken to harvest (days)	Curd weight (g)	Curd yield per plot (kg)	Curd yield (tonnes/ha)
T ₀ -Control (RDF)	69.00	288.60	1.44	9.60
T ₁ -50% FYM + 50%VC	68.33	343.13	1.71	11.39
T ₂ -50% FYM + 50% PSB	62.67	411.73	2.05	13.68
T ₃ -50% FYM + 50% Azotobacter	64.33	404.80	2.01	13.46
T ₄ -25% VC + 75% PSB	65.46	455.27	2.27	15.15
T ₅ -25% VC + 75% Azotobacter	60.33	434.33	2.17	14.46
T ₆ -50% PSB + 50% Azotobacter	59.67	415.40	2.08	13.88
T ₇ -25% FYM + 25% VC + 50% PSB	58.00	512.60	2.56	17.06
T ₈ -25% FYM + 25% VC + 50% Azotobacter	63.00	461.07	2.31	15.41
T ₉ -25% FYM + 25% VC + 25% PSB + 25% Azotobacter	67.17	358.67	1.79	11.90
F-test	S	S	S	S
C. D. at 0.05%	2.27	2.58	0.10	0.64
S.Ed (±)	1.08	1.23	0.05	0.30

The keen observations of the data presented in Table-1, revealed that there was highest curd weight (512.60 g) was recorded in FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% PSB (T₇). The significantly higher curd weight of 461.07 g and 455.27 g was also recorded with the application of 25% FYM + 25% VC + 50% Azotobacter (T₈) and 25% VC + 75% PSB (T₄), respectively whereas the lowest curd weight (288.60 g) was recorded in control (T₀). The improved curd weight in T₇ can be attributed through the synergistic effects of organic matter and biofertilizers, which improve nutrient

availability, water retention and soil microbial activity, leading to better nutrient assimilation and curd growth. Sharma (2000) [7] found similar results, indicating that integration of organic and inorganic fertilizers can substantially improve curd size and yield.

The data presented in the Table-1 showed that the yield per plot as well as yield per hectare was found significantly higher (2.56 kg and 17.06 tonnes/ha) due to the application of FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% PSB (T₇), followed by T₈ (2.31 kg and 15.41 tonnes) and T₄ (2.27 kg

and 15.15 tonnes/ha). The lowest yield per plot and yield per hectare was observed in control (1.44 kg and 9.60 tonnes), respectively. The significantly increase in yield by the application of FYM @ 5 t/ha + VC @ 1.25 t/ha + 50% PSB is due to the enhanced nutrient supply from FYM, VC and PSB, which promotes better vegetative growth and curd formation. The similar result was also reported by Bahadur *et al.* (2004) ^[1] which showed that the combination of organic amendments and recommended dose of NPK leading to significant yield improvements in cole crops like broccoli.

Quality parameters

The data recorded on quality parameters were presented in

Table 2: Effect of various treatment combinations of FYM, VC, Azotobactor and PSB on quality parameters of broccoli (*Brassica oleracea* var. *italica* Plenck).

Treatments	Ascorbic acid (mg/100 g of edible portion)	Total Soluble Solid (°Brix)
T ₀ -Control (RDF)	65.28	7.40
T ₁ -50% FYM + 50%VC	70.76	8.63
T ₂ -50% FYM + 50%PSB	73.86	9.58
T ₃ -50% FYM + 50% Azotobactor	72.24	9.36
T ₄ -25% VC + 75% PSB	77.90	10.42
T ₅ -25% VC + 75% Azotobactor	76.44	10.14
T ₆ -50% PSB + 50% Azotobactor	75.40	9.78
T ₇ -25% FYM + 25% VC + 50% PSB	80.24	11.37
T ₈ -25% FYM + 25% VC + 50% Azotobactor	79.47	10.82
T ₉ -25% FYM + 25% VC + 25% PSB + 25% Azotobactor	71.48	8.84
F-test	S	S
C. D. at 0.05%	2.85	0.45
S.Ed (±)	1.36	0.21

The effect of various combination of FYM, Vermicompost and biofertilizers on total soluble solids is also presented in Table-2. The observations on TSS showed significant variations among all the treatments in which highest value (11.37 °Brix) was recorded due to the application of T₇ (25% FYM + 25% VC + 50% PSB), indicating better flavour and sugar content, while the control had the lowest TSS (7.40 °Brix). The increased TSS level in T₇ is probably the result of better sugar synthesis and plant metabolism, which are made possible by increased nutrient intake and photosynthetic efficiency from vermicompost and biofertilizers. This finding is in line with Padamwar and Dakore (2010) ^[4], who reported that the use of vermicompost increases sugar content in cole crops.

Economic Analysis

The cost of cultivation, gross return, net return and benefit: cost ratio was calculated on the basis of existing price and presented in Table-3. The maximum cost of cultivation (Rs. 71830/-per ha) was calculated in the T₁ i.e. recommended dose of fertilizer (120:60:60 kg of NPK per hectare). It was due to the extensive use of chemical fertilizers whereas the control (T₀) had the lowest cost of cultivation (Rs. 67,080/-per ha) due to zero fertilizer use. But, the treatment

Table-2. The keen observation of the data showed that the significant variations were found among the various treatments. Ascorbic acid levels were significantly higher (80.24 mg/100 g) in T₇ (25% FYM + 25% VC + 50% PSB), followed closely by the treatment combination of 25% FYM + 25% VC + 50% Azotobactor (T₈) i.e. 79.47 mg/100 g. The control had the lowest ascorbic acid content (65.28 mg/100 g). The higher ascorbic acid levels in T₇ among all the treatments can be due to improvement in micronutrient availability from organic matter and biofertilizers, which are critical for vitamin C synthesis. Upadhyay *et al.* (2007) ^[10] was also found similar increase in ascorbic acid content with the use of organic and bio fertilizers in cabbage.

combination of 25% FYM + 25% VC + 50% PSB i.e. T₇ had a moderate cost of cultivation (Rs. 70,055/-per ha) owing to combined use of organic and biofertilizers, which, despite the initial investment, proved more cost-effective in the long run due to higher yields.

Similarly, the treatment T₇ (25% FYM + 25% VC + 50% PSB) provided the highest gross return (Rs. 2,04,720/-per ha) and net return (Rs. 1,34,665/-per ha), while the control had the lowest gross return (Rs. 1,15,200/-per ha) and net return (Rs. 48,120/-per ha). These results demonstrate that the use of integrated nutrient management practices can significantly enhance economic returns for farmers. Dubey *et al.* (2009) ^[2] reported the similar results by integrating organic and biofertilizers with reduced chemical inputs leads to increased profit by the cultivation of broccoli.

The highest benefit: cost ratio (2.92:1) was observed due to the treatment combination T₇ (25% FYM + 25% VC + 50% PSB) indicating that the investment in organic and biofertilizer treatments yields substantial economic benefits. This finding is supported by Ola *et al.* (2019) ^[3], who emphasized the economic advantages of integrating organic and inorganic inputs in increasing yield, quality and profitability.

Table 3: Economic assessment of various treatment combinations of FYM, VC, Azotobactor and PSB for broccoli (*Brassica oleracea* var. *italica* Plenck).

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Curd yield (t ha ⁻¹)	Selling rate (Rs. t ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	Benefit cost ratio
T ₀ -Control (RDF)	67,080	9.6	12,000	115200	48,120	1.71:1
T ₁ -50% FYM + 50%VC	71,830	11.39	12,000	136680	64,850	1.90:1
T ₂ -50% FYM + 50% PSB	69,930	13.68	12,000	164160	94,230	2.34:1
T ₃ -50% FYM + 50% Azotobactor	69,630	13.46	12,000	161520	91,890	2.31:1
T ₄ -25% VC + 75% PSB	69,230	15.15	12,000	181800	1,12,570	2.62:1
T ₅ -25% VC + 75% Azotobactor	68,780	14.46	12,000	173520	1,04,740	2.52:1
T ₆ -50% PSB + 50% Azotobactor	67,980	13.88	12,000	166560	98,580	2.45:1
T ₇ -25% FYM + 25% VC + 50% PSB	70,055	17.06	12,000	204720	1,34,665	2.92:1
T ₈ -25% FYM + 25% VC + 50% Azotobactor	69,755	15.41	12,000	184920	1,15,165	2.65:1
T ₉ -25% FYM + 25% VC + 25% PSB + 25% Azotobactor	69,905	11.9	12,000	142800	72,895	2.04:1

Conclusion

The results of this study demonstrate that treatment T₇ (25% FYM + 25% VC + 50% PSB) significantly enhances quality production in broccoli cultivation. The improved nutrient availability from organic matter and biofertilizers supports larger curd size, higher ascorbic acid content and greater yield. These findings align with previous studies by Singh *et al.* (2000) [8] and Rani *et al.* (1997) [6], highlighting the benefits of balanced nutrient management for sustainable agriculture. Implementing these practices can ensure higher productivity, improved quality, better economic returns and long-term soil health in the Gorakhpur region.

In order to maintain quality and production of broccoli in India, integrated and sustainable agricultural practices must be adopted. Farmers may maximise nutrient use, enhance soil health, and increase yields while reducing their negative effects on the environment by implementing INM. This all-encompassing strategy guarantees that broccoli farming continues to be both economically and environmentally sustainable, meeting the dietary demands of India's expanding population. Promoting sustainable production methods will be essential to preserving broccoli's position as a significant crop in India's agricultural landscape as its health advantages continue to grow in popularity.

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