**EFFECTS OF ORGANIC MANURES AND BIOFERTILIZERS ON YIELD AND ECONOMIC PERFORMANCE OF BROCCOLI IN KHIALA REGION, PUNJAB,INDIA**

**Abstract**

The field experiment was conducted during Rabi season 2023 and aimed to investigate the impact of organic manures and Bio-fertilizers on yield and economics analysis in broccoli. The experiment design has employed a Randomized Block Design with 8 treatments and three replications, comprising of T0- Control (No Organic Manure), T1- Farm Yard Manure (20 t/ha), T2- Vermicompost (5 t/ha), T3- Neem Cake (2 t/ha), T4-*Azotobacter* + *Phosphate Solubilizing Bacteria* (PSB), T5-Farm yard manure+ *Azotobacter* + PSB, T6- Vermicompost+ *Azotobacter* +PSB, T7- Neem cake + *Azotobacter* + PSB. It was observed that treatment T6 (Vermicompost+ Bio-fertilizers) shows a superior result recorded with other ones, weight of primary curd 412.0 g and secondary curd 156.3 g , yield per plant 568.3g, yield per plot 5.66 kg and yield per hectare 56.6 q ha-1 and minimum in under T0 Control. Overall combined application of organic manures and biofertilizers for better yield of broccoli crop. Economics returns of the same treatment were also found best in term of gross income Rs. 283000 ha-1, net returns Rs. 212450 ha-1 and benefit cost ratio is 3.01.

**Keywords:** *Biofertilizers Brassica oleracea* *var. italic, Economics, Organic manures, Yield parameter*

**INTRODUCTION**

Broccoli (*Brassica oleracea* L.), which is originated from the Mediterranean region commonly known as Hari Gobhi in Hindi and a member of Cole group, belongs to the family Brassicaceae or Cruciferae (Mustard family). Broccoli is an Italian vegetable which is cultivated in Italy in ancient roman times. Commercial cultivation of broccoli was started around 1923 [1]. Broccoli is classified into two types: heading and sprouting. Heading broccoli produces curd, whereas sprouting broccoli comprises a bunch of green immature buds and a thick fleshy flower stem that develops a head [2].Broccoli is called the "Crown of Jewel Nutrition" because to its high vitamin and mineral content. It has also had extra benefits, because broccoli is a great source of numerous vitamins and minerals. Approximately 130 times more vitamin A is present in it than Cabbage [3],[4]. Brassica vegetables possess both antioxidant and anti-carcinogenic properties [5] and it is well known that dietary intake of food containing antioxidants provides effective support for the body’ defensive systems and may prevent some diseases [6],[7].Broccoli is one of the most nutritious Cole crops and contains thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe. Broccoli is a cool-loving crop and very sensitive to high temperature which cause the heads to be distorted, making it a high-risk crop [8].

Organic manure and bio-fertilizers offer an alternative source of chemical fertilizers and being increasingly used in vegetable production. Bio-fertilizers are important beneficial microorganisms, which have ability to mobilize the nutritionally important elements from non-unstable to stable form through biological processes and are known to increase yield in several vegetables [9]. Bio-fertilizers are cost effective and renewable source of plant nutrient. Organic manure is a source of food for the innumerable number of microorganisms and creature like earthworms who breakdown these micronutrients, which are easily absorbed by the plants. Organic manures play major role in plant growth as sources of all necessary macro and micro nutrients in available from during mineralization and improving the physical and chemical properties of soil [10]. Organic such as Farm yard manure, Vermicompost and Neem cake are improve the soil structure, aeration, slow-release nutrient which support root development leading to higher yield of broccoli [11]. By adopting bio-fertilizers, farmers can transition towards a more sustainable and balanced approach to agriculture, minimizing the harm caused by chemical fertilizers and ensuring the well-being of both the ecosystem and human communities [12]. In order to increase productivity, chemical fertilizers and pesticides were used in the cultivation of vegetables with the development of new agricultural methods, which undoubtedly succeeded in feeding the world's largest population. On the other hand, overuse of chemical fertilizers harmed human health and contaminated the land, water, and atmosphere. As a result, focus is now being diverted from the organic sources of nutrition to other options. It is recommended to use crop residues, oil cakes, compost, organic manure, farm yard manure and other materials as nutrient sources to reduce the amounts of chemical fertilizers**.** Therefore, the purpose of this analysis is to determine how organic manures, bio-fertilizers and their combination affect the production and yield of broccoli.

**2. MATERIAL AND METHODS**

The experimental area is situated at longitude 75° 81`E, latitude 31°42`N and an elevation of 228 meters above mean sea level in the central plains of Punjab. Climate is subtropical, with abundant rainfall during the Kharif season and little precipitation the rest of the year (*Rabi* season). The mean high temperature was 24.2°C to 31°C, while the mean minimum temperature was 5°C to 11.5°C. The Rabi season is distinguished by an abundance of sunlight. The ideal temperature for broccoli production is 18 - 22°C. The humidity recorded 89% during November month when sowing of broccoli is done in field. The experiment was laid out in Randomized Block Design (RBD) with 8 treatments and three replications. Welcome-141 broccoli variety was used in the study as a planting material. The total area of the plot 234m2. The size of each plot was

2.5m X 4.0m. The experimental field was ploughed completely before transplantation of seedlings. Debris of previous crop should be removed. The field was properly leveled and adequate drainage was provided [4].The plots were made and treatments were assigned as per the layout. Healthy seedlings that were one month old were placed in the experimental plots on October 2023, with a distance of 60 cm × 45 cm between each transplant. The measured data, at 90 days after transplanting were calculated yield attributes and yield *viz.* weight of primary curd (g), weight of secondary curd (g), yield per plant (g), and yield per plot (kg). The yield per plant and yield per plot was calculated by adding the weight of main curds and the weight of secondary curds of all the plants of each unit plot and expressed in kilogram (kg).The yield per hectare (q/ha) In order to compute and express yield per hectare in q/ha, yield data related to central head and secondary heads were recorded on all plants (q/ha). The yield economics *viz.* Gross returns (Rs/ha) was calculated on the basis of minimum support price (MSP) of broccoli and Net returns (Rs/ha) were calculated by formula given below.

**Net returns = Gross returns – Cost of cultivation**

The Benefit cost ratio was calculated by given formula.

**Benefit cost ratio =** $\frac{Net return}{Cost of cultivation}$

The Statistical analysis was performed on the data gathered from the experiment at various growth and yield points. The average or mean of five plants from each net plot was used in the experiment, and comparisons were done at the five percent significance level. p=0.05 was the significance employed in the "F" and "t" tests, and the treatment mean under the F-test of one-way ANOVA was calculated along with the crucial difference between the various variables by using OPSTAT[13].

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 **a) b) c)**

 **Fig.1 a) Measuring the diameter of curd b) Weighing the curd c) Yield of broccoli**

 **RESULTS AND DISCUSSION**

The weight of primary and secondary curd were significantly affected by different applications of organic manures and bio-fertilizers. The maximum weight of primary curd was recorded as 412.0 g with treatment T6, which was statistically at par with treatment T5 (366.6 g), T7 (275.6 g), T2 (269.0 g) and treatment T4 (226.9 g) respectively. The minimum weight of primary curd 168.6 g was recorded under T0 Control, then followed by treatment T1(171.5 g) and T3 (224.9 g) respectively. A rise in head weight be brought about by longer-term, increased nutritional accessibility from organic inputs at various growth stages [14]. Vermicompost holds onto nutrients for an extended period of time, but ordinary compost is usable to provide plants with the necessary quantity of macro and micronutrients, including the essential NPK, in a shorter length of time. Vermicompost is proven to be a very nutrient dense organic fertilizer and a more potent growth stimulator than traditional composts [15] [16],[17]. The maximum secondary weight of curd was 156.3 g recorded with treatments T6, which is statistically at par with treatments T5 (143.3 g), T7 (136.3 g), T2 (134.9 g) and treatment T4 (137.8 g) respectively. The minimum weight of secondary curd 99.7 g was found under T0 Control where no application of organic manures and use of biofertilizers, which is significantly followed by treatment T1 (118.4 g) and T3(105.4 g) respectively. The increase in weight of secondary head is due to combine application of FYM, Vermicompost with biofertilizers. Micro and macronutrients that are essential are provided by vermicompost. The physical and chemical qualities of soil are enhanced by organic manure, while simultaneously balancing the supply of nutrients supply and demand. Bio fertilizers are made up of microorganisms that may mobilize nutrients through biological processes from an unusable state to a useable one [17]. The present results have close resemblance with the findings of [18], [19].

**Table 1. Effect of organic manures and biofertilizers on weight of primary and secondary curd (g) of broccoli**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Weight of primary curd (g)** | **Weight of secondary curd (g)** |
| T0 Control (no organic manure) |  168.6 ± 0.722 | 99.7 ± 0.872 |
| T1 Farm yard manure (20 t/ha) |  171.5 ± 0.757 | 118.4 ± 0.330 |
| T2Vermicompost (5t/ha) |  269.0 ± 0.819 | 134.9 ± 0.577 |
| T3 Neem cake (2 t/ha) |  224.9 ± 0.590 | 105.4 ± 0.318 |
| T4 *Azotobacter* + PSB | 226.9 ± 0.580 | 137.8 ± 1.126 |
| T5 Farm yard manure + *Azotobacter* + PSB | 366.6 ± 0.721 | 143.6± 0.512 |
| T6 Vermicompost + *Azotobacter* + PSB | 412.0 ± 0.451 | 156.3 ± 0.319 |
| T7 Neem cake + *Azotobacter* + PSB | 275.6 ± 0.578 | 136.3 ± 0.781 |
| **SE(m)±** | 0.617 | 0.627 |
| **CD (p=0.05)** | 0.873 | 1.921 |

 PSB: Phosphate solubilizing bacteria

Fig.2 Effect of organic manures and bio-fertilizers on weight of primary and secondary curd (g)

**Yield per plant**

Yield per plant is most crucial parameters for enhancing the total yield. The maximum yield per plant was 568.3 g recorded with treatment T6, which is statistically at par with treatment T5 (510.2 g), T7 (411.9 g), T2 (403.9 g) and T4 (364.7 g) respectively. While minimum yield per plant 268.3 g was recorded under T0 Control, which was followed by treatment T1 (289.9 g) and T3 (330.4 g) respectively.

The enhancement in yield per plant is due to the right amount of nitrogen, which is essential for the synthesis of many different substances, such as enzymes that help plants utilize carbohydrates and chlorophyll. Furthermore, ATP and ADP both include phosphorus, which is crucial for the intake of nutrients. Similar to how potassium promotes starch synthesis, photosynthesis, sugar translocation, and eventually plant development in broccoli, it also activates a variety of enzymes and alters energy metabolism [20]. In addition to releasing nutrients gradually, organic fertilizers are additionally utilized to enhance the foundation and equilibrium of the soil and to increase crop plant output and quality. These fertilizers are created from animal excrement or other agricultural wastes [21]**.**

 **Table 2. Effect of organic manures and bio-fertilizers on yield per plant (g) and per plot (kg) of broccoli**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Yield per plant (g)** | **Yield per plot (kg)** |
| T0 Control (no organic manure) | 268.3± 0.96 | 2.65 ± 0.49 |
| T1 Farm yard manure (20 t/ha) | 289.9 ± 0.52 | 3.23 ± 0.18 |
| T2Vermicompost (5t/ha) | 403.9 ± 1.09 | 3.76 ± 0.37 |
| T3 Neem cake (2 t/ha) | 330.4± 0.69 | 3.31 ± 0.42 |
| T4 *Azotobacter* + PSB | 364.7± 0.86 | 3.67 ± 0.38 |
| T5 Farm yard manure + *Azotobacter* + PSB | 510.2± 0.59 | 5.53 ± 0.29 |
| T6 Vermicompost + *Azotobacter* + PSB | 568.3± 0.57 | 5.66 ± 0.17 |
| T7 Neem cake + *Azotobacter* + PSB | 411.9 ± 0.60 | 4.09 ± 0.09 |
| **SE(m)±** | 0.61 | 0.29 |
| **CD (p=0.05)** | 1.76 | 0.90 |

PSB: Phosphate solubilizing bacteria mean of three replications

Fig. 3 Effect of organic manures and bio-fertilizers on yield per plant (g) and (kg)

**Yield per plot**

The maximum yield per plot was recorded with treatment T6 (5.66 kg), which was statistically at par with treatment T5 (5.53 kg), T7 (4.09 kg), T2 (3.76 kg) and treatment T4 (3.67 kg) respectively. The minimum yield per plot was 2.65 kg found under T0 Control, which was followed by treatment T1 (3.23 kg) and treatment T3 (3.31 kg) respectively. Because farmyard manure and vermicompost have a positive impact on the physical, chemical, and biological properties of soil, which in turn aid in enhancing plant absorption of nutrients, higher values for yield contributing characteristics have been achieved [22]. The application of organic materials led to improved broccoli plant growth and yield, which may have been caused by the availability of a more readily available kind of fertilizer for plants. It also improved the soil's ability to store water and other plant nutrients, such as micronutrients. Organic material provides a favorable environment for the growth of broccoli plants' root systems., applying organic materials enhanced soil organic C and considerably reduced exchangeable aluminum (Al) in acid soil at varied levels, regardless of the type of organic material applied. Greater nutrient availability and ideal soil conditions for plant growth led to the establishment of healthy vegetative plants, which in turn produced a larger yield [23].

**Yield per hectare**

One of the most important factors to take into account when evaluating the efficacy of different treatments and looking at a number of factors is yield per hectare. The maximum yield per hectare was 56.6 q ha-1 was obtained with treatment T6, which was statistically at par with treatment T5 (55.3 q ha-1), T7 (40.9 q ha-1), T2 (37.6 q ha-1) and treatment T4 (36.7 q ha-1) respectively. The minimum yield per hectare 26.5 q ha-1 was recorded under T0 Control Plot, which was then followed by treatment T1 (32.3 q ha-1) and T3 (33.1q ha-1) respectively. It is well known that *Azotobacter* produces antifungal and antibiotic compounds that suppress a range of soil fungus. Additionally, it is capable of synthesizing and secreting gibberellins, or compounds that resemble gibberellins, thiamine, riboflavin, pyridoxine, cyanocobalamin, nicotinic acid, pentatonic acid, Indole acetic acid, and gibberellins, which promote strong plant development and dry matter.

It improved head development, fertilization, and yield in the end. Phosphorus solubilizing bacteria (PSB) release growth-promoting chemicals and vitamins into the soil, which feeds the crops. After PSB was injected, broccoli sprouts showed improved yield characteristics. This might be because the phosphorus that was previously insoluble or otherwise fixed became more soluble and more available to the plants. When combined with other nutrients, the favorable benefits of PSB may have enhanced agricultural productivity. This might have happened because various reproductive structures partitioned more quickly, leading to a larger crop yield overall [24],[32].

**Table 3. Effect of organic manures and biofertilizers on yield per hectare (q/ha) of broccoli**

|  |  |
| --- | --- |
| **Treatments** | **Yield per hectare (q/ha)** |
| T0 Control (no organic manure) | 26.5 ± 0.35 |
| T1 Farm yard manure (20 t/ha) | 32.3 ± 0.39 |
| T2Vermicompost (5t/ha) | 37.6 ± 0.88 |
| T3 Neem cake (2 t/ha) | 33.1 ± 0.60 |
| T4 Biofertilizers (*Azotobacter* + PSB) | 36.7 ± 0.41 |
| T5 Farm yard manure + *Azotobacter* + PSB | 55.3 ± 0.46 |
| T6 Vermicompost + *Azotobacter* + PSB | 56.6 ± 0.52 |
| T7 Neem cake + *Azotobacter* + PSB | 40.9 ± 0.99 |
| **SE(m)±** | 0.53 |
| **CD (p=0.05)** | 1.06 |

 PSB: Phosphate solubilizing bacteria mean of three replications

Fig. 4 Effect of organic manures and bio-fertilizers on yield per hectare (q/ha)

**4. ECONOMIC ANALYSIS**

The economics of different treatments viz., yield, cost of cultivation, gross return, net return and benefit cost ratio.

**Gross returns**

The maximum gross return Rs. 283000 ha-1 was obtained with treatment T6, which was statistically at par with treatment T5 (Rs. 276500 ha-1), T7 (Rs. 204500 ha-1), T2 (Rs.188000 ha-1) and treatment T4 (Rs.183500 ha-1) respectively. The minimum gross return Rs. 132500 ha-1 was recorded under T0 Control t, which was then followed by treatment T1 (Rs. 164500 ha-1) and T3 (Rs. 165500 ha-1) respectively. The Combined application of vermicompost and biofertilizers recorded to have more gross returns as compared to other treatment [25]and [26].

**Net return**

The maximum net return (Rs. 212450 ha-1) was obtained with treatment T6, which was statistically at par with treatment T5 (Rs. 194050 ha-1), T7 (Rs. 129950 ha-1), T2 (Rs. 109044 ha-1) and treatment T4 (Rs. 103045 ha-1) respectively. The minimum gross return Rs. 57045 ha-1 was recorded under T0 Control Plot, which was then followed by treatment T1 (Rs. 84608 ha-1) and T3 (Rs. 85270 ha-1) respectively. The treatment T6 recorded to have more net returns as compared to other treatment [27] and [28]**.**

**Benefit cost ratio**

The maximum benefit cost ratio (3.01) was obtained with treatment T6, which was statistically at par with treatment T5 (2.35), T7 (1.74), T2 (1.38) and treatment T4 (1.28) respectively. The minimum benefit cost ratio (0.75) was recorded under T0, which was then followed by treatment T3 (1.06) and T1 (1.10) respectively. The use of vermicompost and biofertilizers recorded to have more benefit cost ratio as compared to other treatment [29], [30] and [31].

**Table 4. Effect of organic manures and biofertilizers on gross return, net return and benefit cost ratio of broccoli**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Cost of cultivation****(Rs ha-1)** | **Total yield** **(q ha-1)** | **Gross return (Rs ha-1)** | **Net return (Rs ha-1)** | **B:C ratio** |
| **a** | **b** | **c= b X MSP** | **d= c-a** | **e= d/a** |
| T0 Control (no organic manure) | 75455 | 26.5 | 132500 | 57045 | 0.75 |
| T1 Farm yard manure (20 t/ha) | 76892 | 32.3 | 161500 | 84608 |  1.10 |
| T2Vermicompost (5t/ha) | 78956 | 37.6 | 188000 | 109044 | 1.38 |
| T3 Neem cake (2 t/ha) | 80230 | 33.1 | 165500 | 85270 | 1.06 |
| T4 *Azotobacter* + PSB | 80455 | 36.7 | 183500 | 103045 | 1.28 |
| T5 Farm yard manure + *Azotobacter* + PSB | 82450 |  55.3 | 276500 | 194050 | 2.35 |
| T6 Vermicompost + *Azotobacter* + PSB | 70550 | 56.6 | 283000 | 212450 | 3.01 |
| T7 Neem cake + *Azotobacter* + PSB | 74550 | 40.9 | 204500 | 129950 | 1.74 |

B:C: benefit cost ratio, PSB: Phosphate solubilizing bacteria

 Fig .5 Effect of organic manures and biofertilizers on gross returns and net returns of broccoli

**Conclusion and Recommendation**

The findings of the study experiment revealed that the combination of vermicompost and biofertilizers have shown positive results on yield parameters as well as productivity of broccoli with maximum net returns across the other parameters. The combination enhances soil fertility, promotes healthy plant growth, reduces the need for chemical fertilizers and pesticides, and improves the sustainability of farming systems. The combination of both have shown ecofriendly and sustainable response to environment. By development a more resilient and balanced ecosystem, organic manures and biofertilizers not only improve crop yields and quality but also contribute to environmental conservation and long-term soil health.

**COMPETING INTERESTS**- Authors have declared that no competing interests exist.

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