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# Influence of Inorganic Fertilizers in Conjunction with Organic Manures on Growth, Yield and Quality of Broccoli (*Brassica oleracea* var. *Italica*)

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*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

A research work was conducted in the research farm of Nalanda College of Horticulture, Noorsarai, Nalanda (Bihar-803113) during Rabi season of academic year 2021-22 to study the Influence of Inorganic Fertilizers in conjunction with organic manures on growth, yield and Quality of Broccoli

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(*Brassica oleracea* var. *Italica*) in a randomized block design with 11 treatments. The Treatment, $T_5$ (50% RDN + 50% N as PM) recorded maximum values for plant height (37.41cm and 56.13 cm), number of leaves per plant (16.53 and 20.11), leaf area (749.51cm$^2$ and 949.57 cm$^2$) at 45 DAT and 60DAT respectively. The treatment, $T_5$ also recorded least days for head initiation (44.60 DAT) and highest value for diameter of head (15.93 cm), length of head (14.97 cm), wt. of head/plant (407.16 gm), wt. of head/plot (16.29Kg.), wt. of head/ha (150.65q.), vitamin C (92.43 mg/g), dry matter (11.57%), gross returns (Rs. 4,14,287.50/ha) and net returns (Rs. 3,19,448.00/ha) with B:C ratio of 3.36. This was followed by treatment $T_4$ (50% RDN + 50% N as VC). Among all the treatments, the Treatment $T_5$ (50% RDN + 50% N as PM) was found to be the best for obtaining better growth and optimum yield. Regarding qualitative characters and better soil health, treatment T4 (50% RDN + 50% N as VC) performed well.

*Keywords: Broccoli; FYM; VC; PM; yield; plant growth; quality; gross returns.*

## 1. INTRODUCTION

Broccoli (*Brassica olerasia* L. var. *Italica*) is a winter/cool season vegetable and belongs to family Cruciferae and commonly known as harigobi in hindi because. It is either consumed raw as a salad, cooked as a single or mixed vegetable with potato, and used in curries, soups, and pickles. There are two types of broccoli: heading and sprouting, sprouting broccoli is more widely consumed in India. Broccoli has anti-carcinogenic properties and reduce the risk of prostate cancer by up to 45 percent. It has about 130 times more Vitamin A contents than cauliflower and 22 times more than cabbage. Broccoli is also known as the "Crown of Jewel Nutrition" due to a rich source of vitamins, minerals, proteins etc [1]. In the global market approximately 40 percent is marketed as fresh and remaining 60 percent marketed as frozen. The exact data about the cultivable area and production of broccoli is currently unavailable in India. It was a rare cole crop in India, but it is now becoming more common in metropolitan's cities, hotels, and restaurants [1].

Many chemical fertilizers and just a little amount of organic fertilizers are used by various workers to enhance the production, which eventually has an impact on both human and soil health [2]. Integrated nutrient management is an essential need of the modern era since excessive use of chemical fertilizer has resulted in a pattern of declining soil fertility [3]. The basic goal of integrated nutrient management is to cultivate a piece of land so that the soil can support optimum crop quality production while remaining sustainable [4].

Organic manure plays a direct role in plant growth, as a supply of all essential macro and micronutrients in forms that are available during mineralization and increasing physical and chemical qualities of soils [5]. As a result, using locally produced manures in vegetable production operations may boost crop yield while requiring less chemical fertilizer. Consumers now expect veggies to be of higher safety and superior quality.

Hence, keeping in view of aforementioned facts, a research work entitled "Influence of Inorganic Fertilizers in conjunction with Organic Manures on Growth, Yield and Quality of Broccoli (*Brassica oleracea* var. *Italica*)" was conducted to determine the best inorganic fertilizer and organic manure combination for maximum growth, yield, quality and net profit in broccoli and for better soil health.

## 2. MATERIALS AND METHODS

Present research work was conducted during Rabi season (2021-22) at research farm of Nalanda College of Horticulture, Noorsarai (Nalanda) with following objectives: (i) To find out the effect of inorganic fertilizers and organic manures on growth, yield and quality of broccoli, (ii) To find out nitrogen content and nitrogen use efficiency of broccoli, (iii) To find out effect of manures and fertilizers on properties of soil and (iv) To find out the economics. The soil condition of the research field was low in available nitrogen, medium in available phosphorus, potash and organic carbon while, good in pH and electrical conductivity. A randomized block design with three replications was used to apply eleven various treatments, including the use of organic manures (FYM, Vermicompost, and poultry manure) and inorganic fertilizers (Urea, SSP, and MOP). The treatments included $T_1$ (Control), $T_2$ (RDN= 150 Kg/Ha), $T_3$ (50% RDN + 50% N as FYM), $T_4$ (50% RDN + 50% N as VC), $T_5$ (50% RDN + 50% N as PM), $T_6$ (25% RDN +

75% N as FYM), $T_7$ (25% RDN + 75% N as VC), $T_8$ (25% RDN + 75% N as PM), $T_9$ (25% RDN + 25% N as VC + 50% N as FYM), $T_{10}$ (25% RDN + 25% N as VC + 50% N as PM), $T_{11}$ (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM). The crop was raised with a spacing of 60 cm × 45 cm and plot size of 4.5 m × 2.4 m. All of the experimental plots were maintained according to the standard cultural guidelines for broccoli. One month prior to transplanting (or during field preparation), organic manures (FYM, Vermicompost and Poultry Manure) were applied as per the requirement of treatments and mixed well with a spade. Inorganic fertilizer i.e., nitrogenous fertilizer was applied as per the selected treatments in which half dose of nitrogen through urea and common dosage of $P_2O_5$ and $K_2O$ @ 80 kg/ha each through SSP and MOP respectively during transplanting. The remaining half dose of nitrogen was given 30 DAT as per requirement of treatments. The observations like various growth parameters yield and yield attributing characteristics, qualitative characteristics and nutrient status of post harvested soil were noted. On the basis of current market pricing for inputs and outputs, the economics of the experiment were calculated.

## 3. RESULTS AND DISCUSSION

The purpose of the present research was to understand how integrated nutrient management affected broccoli. Observations on the characteristics of the plants were made to explore the impact of chemical fertilizers and various organic manures on growth parameters, yield parameters, qualitative features, soil characteristics and economics. Inorganic fertilizers alone or in combination with different organic manures were found to have a significant effect on growth parameters as compared to control (Table 1). The data was recorded on plant height (cm), number of leaves plant$^{-1}$, leaf area per plant (cm$^2$) of broccoli at 45 DAT and 60 DAT. The application of treatment $T_5$ (50% RDN + 50% N as PM) showed maximum plant height (37.41 cm and 56.13 cm, respectively), number of leaves plant$^{-1}$ (916.53 and 20.11, respectively) and leaf area (749.51cm$^2$ and 949.57 cm$^2$, respectively). The minimum values of growth characters were recorded in treatment $T_1$ (control). This variation might be caused by nutrient availability, the fact that organic manure improves soil aggregation, aeration, and water holding capacity while inorganic fertilizers provide more readily available forms of nutrients. As a result, mixing organic and inorganic nutrients gives superior results in better nutrient absorption and utilization by plants leading to better plant growth. Wani and Ahmed [6], Chetri et al. [7] and Mohanta et al. [8] all provided confirmation of the findings.

Nutrient application of inorganic fertilizers and organic manures alone or in combination significantly increased yield and yield attributing characters of broccoli as compared to control (Table 2). The application of treatment $T_5$ (50% RDN + 50% N as PM) was recorded minimum days for head initiation (44.60) and maximum values for diameter of head (15.93 cm), Length of head (14.97cm), Wt. of head/plant (407.16 gm), Wt. of head/Plot (16.29 Kg.) and Wt. of head/ha (150.65 q.). This might be as a result of the beneficial role of organic manures in improving physical, chemical and biological properties of soil, which result in better nutrient absorption by plants, which might account for increased carbohydrate accumulation due to increased photosynthesis and resulted in higher values for yield contributing characters. These results conform with the finding of Kumar et al. [9] in cauliflower, Chatterjee et al. [5] in cabbage, and Atal et al. [10] in broccoli. Maximum head weight in various combinations of organic and inorganic fertilizers observed by Choudhary et al. [11] in broccoli.

The results obtained during the investigation in respect to quality parameters viz., Dry matter percentage, T.S.S vitamin C content and nitrogen percentage in head present in Table 3. Different treatment organic manure and inorganic fertilizer was found to influence significantly. Treatments $T_5$ (50% RDN + 50% N as PM) recorded highest value (11.56$^o$B) for dry matter percentage followed by treatment $T_4$ (50% RDN + 50% N as VC). While, the maximum T.S.S. (12.1$^o$B) is found in treatment $T_4$ (50% RDN + 50% N as VC) and which is followed by treatments $T_5$ (50% RDN + 50% N as PM) with (11.96$^o$B).

The maximum vitamin-C content (92.42 mg/100g) was recorded under treatment $T_4$ (50% RDN + 50% N as VC) followed by $T_5$ (50% RDN + 50% N as PM) with 89.21 mg/100 g. Meaning that the combined application of various fertilizer and manure played a major contribution to the higher total soluble solids in the broccoli heads. Similar observations were also noted by Upadhyay et al. [12] in cabbage, Kumar et al. [13] in broccoli and Chatterjee et al. [5] in

**Table 1. Growth parameters of broccoli**

| Treatments | Plant Height at 45 DAT (cm) | Plant Height at 60 DAT (cm) | No. of leaves at 45 DAT | No. of leaves at 60 DAT | Leaf area at 45 DAT ($Cm^2$) | Leaf area at 60 DAT ($Cm^2$) |
|---|---|---|---|---|---|---|
| **$T_1$ (**Control) | 22.63 | 32.70 | 9.33 | 14.30 | 388.72 | 597.10 |
| **$T_2$** (RDN = 150 Kg/Ha) | 30.23 | 45.37 | 14.28 | 17.97 | 634.44 | 867.33 |
| **$T_3$** (50% RDN + 50% N as FYM) | 35.34 | 49.90 | 14.43 | 18.73 | 691.10 | 907.70 |
| **$T_4$** (50% RDN + 50% N as VC) | 35.80 | 52.37 | 14.77 | 19.37 | 725.40 | 919.83 |
| **$T_5$** (50% RDN + 50% N as PM) | 37.41 | 56.13 | 16.53 | 20.11 | 749.51 | 949.57 |
| **$T_6$** (25% RDN + 75% N as FYM) | 30.29 | 45.37 | 13.66 | 17.57 | 579.60 | 808.07 |
| **$T_7$** (25% RDN + 75% N as VC) | 32.19 | 46.60 | 14.30 | 18.32 | 605.57 | 765.07 |
| **$T_8$ (**25% RDN + 75% N as PM) | 32.83 | 47.40 | 13.20 | 17.03 | 523.74 | 739.83 |
| **$T_9$ (**25% RDN + 25% N as VC + 50% N as FYM) | 28.73 | 44.90 | 12.97 | 17.01 | 517.47 | 733.62 |
| $T_{10}$ (25% RDN + 25% N as VC + 50% N as PM) | 26.40 | 43.60 | 12.47 | 16.17 | 474.47 | 714.17 |
| **$T_{11}$** (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM) | 27.95 | 44.03 | 12.63 | 16.33 | 487.57 | 735.97 |
| **Grand Mean** | **30.89** | **46.22** | **13.51** | **17.54** | **558.84** | **794.39** |
| **S.Em±** | **1.69** | **1.99** | **0.41** | **0.78** | **70.64** | **19.85** |
| **CD (5%)** | **4.87** | **5.74** | **1.18** | **2.23** | **203.48** | **57.19** |

**Table 2. Yield parameters of broccoli**

| Treatments | Days taken to head initiation (DAT) | Diameter of Head (cm) | Length of head (cm) | Wt. of Head/Plant (gm) | Wt. of Head/Plot (Kg.) | Wt. of Head/Ha (q.) |
|---|---|---|---|---|---|---|
| $T_1$ (Control) | 48.70 | 8.70 | 8.07 | 167.03 | 6.68 | 61.80 |
| $T_2$ (RDN = 150 Kg/Ha) | 47.00 | 14.10 | 13.33 | 353.58 | 14.14 | 130.82 |
| $T_3$ (50% RDN + 50% N as FYM) | 45.83 | 14.83 | 13.60 | 375.83 | 15.03 | 139.06 |
| $T_4$ (50% RDN + 50% N as VC) | 45.37 | 15.60 | 14.23 | 394.57 | 15.78 | 145.99 |
| $T_5$ (50% RDN + 50% N as PM) | 44.60 | 15.93 | 14.97 | 407.16 | 16.29 | 150.65 |
| $T_6$ (25% RDN + 75% N as FYM) | 46.73 | 14.17 | 12.57 | 337.72 | 13.51 | 124.96 |
| $T_7$ (25% RDN + 75% N as VC) | 46.93 | 14.67 | 13.30 | 328.99 | 13.16 | 121.73 |
| $T_8$ (25% RDN + 75% N as PM) | 46.40 | 14.78 | 12.43 | 313.17 | 12.53 | 115.87 |
| $T_9$ (25% RDN + 25% N as VC + 50% N as FYM) | 47.17 | 13.87 | 12.10 | 305.08 | 12.20 | 112.88 |
| $T_{10}$ (25% RDN + 25% N as VC + 50% N as PM) | 47.43 | 13.27 | 10.33 | 277.58 | 11.10 | 102.70 |
| $T_{11}$ (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM) | 47.30 | 13.83 | 10.90 | 288.57 | 11.54 | 106.77 |
| **Grand Mean** | **46.68** | **13.98** | **13.26** | **322.66** | **12.91** | **119.38** |
| **S.Em±** | **0.33** | 0.23 | **0.42** | **6.68** | **0.27** | **2.47** |
| **CD (5%)** | **0.96** | 0.68 | **1.21** | **19.25** | **0.27** | **7.12** |

**Table 3. Quality parameters of broccoli**

| Treatments | Dry matter % of head | TSS ($^{o}$B ) | Vit. C content (mg/100 gm) | Nitrogen % in head |
|---|---|---|---|---|
| $T_1$ (Control) | 7.43 | 8.36 | 65.31 | 3.08 |
| $T_2$ (RDN = 150 Kg/Ha) | 9.78 | 11.16 | 81.25 | 3.44 |
| $T_3$ (50% RDN + 50% N as FYM) | 10.26 | 11.3 | 86.61 | 3.74 |
| $T_4$ (50% RDN + 50% N as VC) | 11.07 | 12.1 | 92.42 | 3.82 |
| $T_5$ (50% RDN + 50% N as PM) | 11.56 | 11.96 | 89.21 | 3.75 |
| $T_6$ (25% RDN + 75% N as FYM) | 10.6 | 10.93 | 85.53 | 3.59 |
| $T_7$ (25% RDN + 75% N as VC) | 8.46 | 11.53 | 85.13 | 3.72 |
| $T_8$ (25% RDN + 75% N as PM) | 7.63 | 11.03 | 81.06 | 3.66 |
| $T_9$ (25% RDN + 25% N as VC + 50% N as FYM) | 9.35 | 10.7 | 80.35 | 3.60 |
| $T_{10}$ (25% RDN + 25% N as VC + 50% N as PM) | 8.16 | 10.4 | 73.53 | 3.57 |
| $T_{11}$ (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM) | 8.17 | 10.63 | 79.76 | 3.41 |
| **Grand mean** | **9.32** | **10.92** | **81.84** | **3.58** |
| **S.Em±** | **0.13** | **0.12** | **0.77** | **0.05** |
| **CD (5%)** | **0.36** | **0.35** | **2.23** | **0.16** |

broccoli. The maximum nitrogen percentage (3.82%) in head was recorded in treatment $T_4$ (50% RDN + 50% N as VC) followed by $T_5$ (50% RDN + 50% N as PM) (3.75%). However minimum value for these qualitative parameters was recorded in treatment $T_1$ (Control). Similar findings were made by Ouda and Mahadeen [14], who found that the control treatment resulted in the lowest leaf N content (3.18%), whereas the maximum leaf N content (3.87%) was obtained when both inorganic fertilizer and organic manure was applied in appropriate dosages. Findings of Shalini et al. [15] in knol-khol, Sharma et al. [16] in sprouting broccoli and Mohanta et al. [8] also came to same conclusion. Effect on soil property after harvest presented in Table 4. Treatment $T_5$ (50% RDN + 50% N as PM) recorded the highest amount of available nitrogen (220.4 kg/ha) in soil after harvest, which was significantly higher than treatment $T_1$ (Control). Sharma et al. [16] claimed that the reason for the increase in nitrogen concentration in soil is that organic manures and chemical fertilizers increase the direct supply of nitrogen and promote the growth of microorganisms, which may be related to the conversion of organically bound nitrogen to inorganic and usable forms. Kumar et al. [17] observed that availability of NPK in soil was increased with integrated application of organic manures and synthetic fertilizers. They also noted that the addition of organic manure reduced the C:N ratio, which further sped up mineralization and led to an immediate release of nitrogen into the soil. Sreenivasa et al. [18] and Devakumar et al. [19] came to same conclusion.

Maximum phosphorus (18.25 kg $ha^{-1}$) and potash (280.36 kg $ha^{-1}$) availability in soil was found in treatment $T_4$ (50% RDN + 50% N as VC) whereas minimum available phosphorus and potash was noted in treatment $T_1$ (Control). Pawar et al. [20] noted that the causes of the increased availability of phosphorus in soil might be due to the decomposition of organic matter and the solubilization of phosphorus from the native soil pool. Similar observations were recorded by Narayanamma et al. [21] and Sarangthem et al. [22]. The probable reason for high potash availability is due to the improvement of potassium (K) status in soil accounts to reduced fixation rate and release of K as a result of the interaction of organic sources with clay particles. The above outcomes are corresponding with the findings of Kumar P et al. [13] and Das et al. [23] in sprouting broccoli.

The data pertaining to pH, electrical conductivity and organic carbon in Table 4 clearly indicates that the difference between the treatments was found to be non-significant. After termination of research work, highest pH (7.11) was recorded in $T_9$ **(**25% RDN + 25% N as VC + 50% N as FYM**)** whereas, minimum (6.83) was recorded in $T_1$ (Control). Similar result was observed by Ouda and Mahadeen [14]. They also pointed that application of organic, inorganic manures and their interaction had no significant effect on soil

**Table 4. Effect on soil property after harvesting of crop**

| Treatments | N (kg/ha) | P (kg/ha) | K (kg/ha) | pH | EC (dS $m^{-1}$) | OC (%) |
|---|---|---|---|---|---|---|
| **$T_1$ (**Control) | 180.35 | 13.12 | 232.45 | 6.83 | 0.35 | 0.64 |
| **$T_2$** (RDN = 150 Kg/Ha) | 211.6 | 16.84 | 272.62 | 6.8 | 0.37 | 0.66 |
| **$T_3$** (50% RDN + 50% N as FYM) | 218.04 | 17.35 | 274.23 | 7.05 | 0.38 | 0.74 |
| **$T_4$** (50% RDN + 50% N as VC) | 218.13 | 18.25 | 280.36 | 6.84 | 0.4 | 0.75 |
| **$T_5$** (50% RDN + 50% N as PM) | 220.4 | 18.15 | 277.22 | 7.05 | 0.38 | 0.78 |
| **$T_6$** (25% RDN + 75% N as FYM) | 215.75 | 17.56 | 274.82 | 7.08 | 0.37 | 0.69 |
| **$T_7$** (25% RDN + 75% N as VC) | 217.8667 | 18.05 | 276.65 | 7.06 | 0.39 | 0.7 |
| **$T_8$ (**25% RDN + 75% N as PM) | 214.4833 | 17.92 | 275.72 | 6.97 | 0.36 | 0.72 |
| **$T_9$ (**25% RDN + 25% N as VC + 50% N as FYM) | 214.66 | 17.22 | 273.66 | 7.11 | 0.35 | 0.67 |
| **$T_{10}$** (25% RDN + 25% N as VC + 50% N as PM) | 212.88 | 16.62 | 274.47 | 6.87 | 0.37 | 0.71 |
| **$T_{11}$** (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM) | 213.55 | 16.51 | 275.41 | 7.09 | 0.38 | 0.68 |
| **Grand Mean** | **212.52** | **17.05** | **271.60** | **6.97** | **0.37** | **0.70** |
| **S.Em±** | **0.52** | **0.17** | **1.34** | **0.04** | **0.01** | **0.02** |
| **CD (5%)** | **1.50** | **0.51** | **3.86** | **0.12** | **0.04** | **0.06** |

**Table 5. Economics of treatments**

| Treatments | Treatment costs Rs./ha | Fixed input Rs./ha | Total input costs (Rs./ha) | Yield (q/ha) | Gross income (Rs.) | Net income (Rs.) | B:C |
|---|---|---|---|---|---|---|---|
| **$T_1$ (**Control) | 0 | 68,210 | 68,210 | 61.79 | 1,69,922.5 | 1,01,713 | 1.49 |
| **$T_2$** (RDN = 150 Kg/Ha) | 10740 | 68,210 | 78,950 | 130.82 | 3,59,755 | 2,80,805 | 3.56 |
| **$T_3$** (50% RDN + 50% N as FYM) | 45245 | 68,210 | 1,13,455 | 139 | 3,82,250 | 2,68,795 | 2.37 |
| **$T_4$** (50% RDN + 50% N as VC) | 42345 | 68,210 | 1,10,555 | 145.9 | 4,01,225 | 2,90,670 | 2.63 |
| **$T_5$** (50% RDN + 50% N as PM) | 26630 | 68,210 | 94,840 | 150.65 | 4,14,287.5 | 3,19,448 | 3.36 |
| **$T_6$** (25% RDN + 75% N as FYM) | 62497 | 68,210 | 1,30,707 | 124.95 | 3,43,612.5 | 2,12,906 | 1.62 |
| **$T_7$** (25% RDN + 75% N as VC) | 58147 | 68,210 | 1,26,357 | 121.73 | 3,34,757.5 | 2,08,401 | 1.65 |
| **$T_8$ (**25% RDN + 75% N as PM) | 34575 | 68,210 | 1,02,785 | 115.87 | 3,18,642.5 | 2,15,858 | 2.10 |
| **$T_9$ (**25% RDN + 25% N as VC + 50% N as FYM) | 61047 | 68,210 | 1,29,257 | 112.88 | 3,10,420 | 1,81,163 | 1.40 |
| **$T_{10}$** (25% RDN + 25% N as VC + 50% N as PM) | 42432 | 68,210 | 1,10,642 | 102.8 | 2,82,700 | 1,72,058 | 1.55 |
| **$T_{11}$** (25% RDN + 25% N as VC + 25% N as PM + 25% as FYM) | 51740 | 68,210 | 1,19,950 | 110.7 | 3,04,425 | 1,84,475 | 1.53 |

pH. There was minute increase EC value in treatment $T_4$ (50% RDN + 50% N as VC) over rest of the treatments and it might be due to large amounts of soluble salts and $HCO^{-3}$ contained in organic manures may be the cause of the small rise in EC value. Singh et al. [24] noticed that the use of organic manures may enhance the amount of organic carbon and organic matter in vegetable crops because less fossil fuel energy is consumed, which results in lower emissions of carbon dioxide and nitrous dioxide, which raise soil carbon concentration [25-27].

The economics of different treatments *viz.,* yield (t/ha), cost of cultivation, gross return and benefit cost ratio has been worked out and presented in Table 5. Treatment $T_5$ (50% RDN + 50% N as PM) recorded maximum gross return of Rs, 4,14,287 $ha^{-1}$ and maximum net return Rs. 3,19,448 $ha^{-1}$ followed by treatment $T_4$ (50% RDN + 50% N as VC) with Rs, 4,01,225 $ha^{-1}$ and Rs. 2,90,670 $ha^{-1}$, respectively whereas the cost benefit ratio of treatment $T_2$ (RDN= 150 Kg/Ha) i.e. (3.56) was found to be the best treatment combinations terms of economics returns.

## 4. CONCLUSION

Based upon the results recorded during research, it could be concluded that the treatment T5 (50% RDN + 50% N as PM) was shown to be the best treatment with regard to growth, yield, and yield attributing features in broccoli as compared to control and other treatments followed by treatment T4 (50% RDN + 50% N as VC). Regarding qualitative characters and for better soil health, treatment T4 (50% RDN + 50% N as VC) performed well. The noteworthy results of economic return with B:C ratio of 3.36 was also given with an application of treatment T5 (50 percent RDN + 50 percent N as PM) followed by treatment T4 (50% RDN + 50% N as VC).

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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