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Economics of Cabbage Production Under Different Levels of Integrated Nutrient Management in Varanasi Region of Uttar Pradesh, India

Abhilash Singh [a++*], Narendra Pratap Verma [a++], Ankit Singh [a++], Shivani Sharma [a++] and Manjeet Kumar Singh [b#]

[a] School of Agriculture Science, LNCT University, Bhopal (M.P.), India.
[b] Agriculture Insurance Company Pvt. Ltd., Sirsa, Haryana, India.

Authors' contributions

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

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ABSTRACT

The excess use of chemical fertilizers is hazardous for soil and environmental health. To reduce the level of chemical fertilizers the field experiment was conducted during *Rabi* season of 2016-17 at horticulture research farm, Department of Horticulture, U. P. College, Varanasi (Uttar Pradesh). The experiment was laid out in a randomized block design (RBD) with nine treatments. These treatments were replicated thrice. The treatments included various levels of NPK, FYM, vermicompost, Phosphorus Solubilizing *Mycorrhiza.* Economic analysis of different treatments of

[++] *Assistant Professor;*
[#] *Field Supervisor;*
**Corresponding author: E-mail: abhilashsinghabhi4@gmail.com;*

cabbage production in Varanasi region (Uttar Pradesh) revealed variation in net capital investment. The results show that among different integrated nutrient management (INM) levels, half dose of NPK ha^{-1} + Vermicompost @ 2.5 tons ha^{-1} + *Azospirillum* @ 5kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} has highest net return followed by half dose of NPK ha^{-1} + FYM @ 15 tons ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}. Lowest net return was observed with half dose treatment of NPK ha^{-1} + FYM @ 15 t ha^{-1}. Cabbage crop nutrition by supplying recommended dose of NPK ha^{-1} (150 kg: 125 kg: 100 kg) recorded highest cost-benefit ratio (3.11) while, half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} gives lowest cost-benefit ratio (2.05) among the all INM levels.

Keywords: Cabbage; Bio-fertilizer; farmyard manure; phosphorus solubilizing mycorrhiza; vermicompost.

1. INTRODUCTION

The most important member of the *Brassica* genus cultivated throughout the world is cabbage (*Brassica oleracea* var *capitata* L.). The plant known as wild cabbage (*Brassica oleracea* var *sylvestris* L.) is the progenitor of cabbage. It was the first Cole crop to be cultivated is a biennial vegetable crop belongs to Cruciferae family. It is a temperate crop and originated from Mediterranean region. The edible part of cabbage is head. Cabbage is used as cooked, boiled, pickling, salad, *etc*. It has various medicinal properties and is also used for dehydration purpose. It helps in acidity neutralization and improvement of appetite and digestion [1]. The cabbage crops are grown in most states of Indian region but major growing states are U.P., West Bengal, Punjab, Orissa, Karnataka, Bihar, Gujrat, Maharashtra and Himachal Pradesh [2]. Uttar Pradesh ranked 8^{th} in the production of Cabbage in with production of 348,940 tonns and average productivity of 33.46 t/ha [3]. Rational use of plant nutrients in adequate quantities to increase yield and quality is a pre-requisite which can be met from both organic and inorganic sources. The use of chemical fertilizers increases after green revolution which ultimately affects the soil and environmental health. To mitigate this problem the concept of INM was introduced. The basic idea behind integrated nutrient management is to maintain plant nutrient availability and soil fertility at optimal levels to maintain targeted crop yields. Both organic and chemical fertilizers are important for the growth of vegetables. The system of nutrient provision is considered one of the fundamental elements in crop production. There is certainly evidence that fertilizer use and agricultural productivity are positively correlated [4]. Organic carbon declines day by day due to excess use of chemical fertilizers by farmers. Its excessive use causes bad effect on structure and texture of the soil. Therefore, use of these fertilizers alone to maintain productivity may not keep pace with time in soil health maintenance. The growth and quality of cabbage is significantly influenced by organic and inorganic nutrients. It is an established fact that use of inorganic fertilizers alone for the crop is not that good for the crop and soil health due to residual effect, but in case of organic fertilizers such problem does not arise and on the other hand it also improves the soil productivity results in improvement of crop growth, quality and yield. Many authors reported that the importance of organic and inorganic fertilizers on the growth and nutritional quality of cabbage. The cabbage cultivation is required adequate nutrients to better growth, yield and quality parameters. The requirements of these plant nutrients can be provide by applying inorganic fertilizers, organic manures and biofertilizer Use of different sources of nutrients such as inorganic fertilizers, FYM, vermicompost, biofertilizers in an integrated management to obtain good quality with timely growth and also maintain the soil health sustainably.

2. MATERIALS AND METHODS

2.1 Experimental Site and Climatic Condition

This field experiment was conducted at the research farm of Horticulture Department, Udai Pratap Autonomous College, Bhojubir, Varanasi (UP) during Rabi season (2016-17). Varanasi is located in the Gangetic alluvial plain of eastern Uttar Pradesh at 25.21^0 north latitude and 82.58^0 east longitude, at an altitude of about 80.71

meters above sea level. The soil texture was sandy loam and had low to medium organic carbon content. The experimental site has a humid-subtropical climate, with summer maximum temperatures ranging from 29.6 ^{0}C to 40.3 ^{0}C and winter minimum temperatures ranging from 9.2 ^{0}C to 23.2 ^{0}C. The average annual rainfall in the Varanasi region was about 950 mm. The region receives its highest rainfall from mid-June to late September. However, occasional rainfall can also occur, while the summer months are extremely hot with westerly heat waves, locally called *Loo*, beginning in April and continuing until the onset of the monsoon in June.

2.2 Experimental Design and Treatment Details

The experiment was carried out using Randomised Block Design (RBD). This experiment was included nine treatments with three replications in "Sri Ganesh Gol" variety. The treatment details given in Table 1. There were nine treatments *i.e.* T_1 : recommended dose of NPK ha^{-1} (150 kg: 125 kg: 100 kg), T_2 : half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}, T_3 : half dose of NPK ha^{-1} + FYM @15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}, T_4 : half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}, T_5 : half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}, T_6 : half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}, T_7 : Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}, T_8 : half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} and T_9 : Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}. Before transplantation, FYM and vermicompost were mixed well before applying all the treatments in the soil. These treatments were replicated three times randomly. The powder of Phosphorus Solubilizing *Mycorrhiza* was mixed with some light as well as fine particles of soil and applied just before transplanting according to treatments. Before transplanting of seedlings were dipped into *Azospirillum* culture for 30 min. The five to six weeks old healthy and almost uniform seedlings were transplanted in November, 2016 at 60 x 45 cm distance. The crop was fertilized with chemical fertilizers according to treatments. The application of full dose of Phosphorus, Potassium and 1/3rd dose of Nitrogen as basal dose through urea, diammonium phosphate (DAP) and muriate of potash (MOP). Remaining 2/3rd dose were applied at two split doses *i.e.* 30 DAT and 45 DAT, respectively.

Table 1. Treatments detail [4]

S. No.	Treatments
T_1	Recommended dose of NPK ha^{-1} (150 kg: 125 kg: 100 kg)
T_2	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}
T_3	Half dose of NPK ha^{-1} + FYM @15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_4	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}
T_5	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_6	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}
T_7	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}
T_8	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}
T_9	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}

3. RESULTS AND DISCUSSION

Before transplanting, they were dipped in *Azospirillum* culture for 30 minutes. As per Table 2, the overall operations were normal in all treatments except the use of different nutrient sources and their distribution. The additional expenditure on this account was added to the total cost of all treatments. Cabbage cultivation became labour-demanding, resulting in employment of 184 labor days (hectares) from nursery rearing to soil preparation, as well as harvesting and marketing to disposal of the produce at high prices in the main market. In Table 2 compares common variable costs and fixed costs for cabbage production with added variable costs from nutrient sources to determine which nutrient source is less expensive for cabbage nutrition. The results demonstrated that crops fed solely with chemical fertilizers gained less cash than crops fed with a combination of chemical and organic fertilizers.

3.1 Cost of Cultivation (₹/ha)

Data presented in Table 3 is clearly indicated that the maximum cost of cultivation was calculated under treatment T_5 (Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}) with an expenditure of (118283 Rs/ ha.). The minimum cost of cultivation (89900 Rs/ ha.) was recorded by the use of treatment T_1 (Recommended dose of NPK ha^{-1} (150 kg: 125 kg: 100 kg). This may because of Chemical fertilizers required in low amount in comparison to organic manures, low cost of fertilizers, transportation and application charges. Similar finding are also showed by Singh et al. [5] in broccoli and Kumar et al. (2019) in Cabbage.

Table 2. Treatment wise comparative economics of cost of cultivation of Cabbage

Treatments	Common Fixed Cost (₹ ha^{-1})	Added Variable cost (₹ ha^{-1})	Total cost of cultivation (₹)
T_1: Recommended dose of NPK ha^{-1} (150 kg :125 kg : 100 kg)	79065	10835	89900
T_2: Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}	79065	34518	113583
T_3: Half dose of NPK ha^{-1} + FYM @15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	79065	38318	117383
T_4: Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	79065	38418	117483
T_5: Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	79065	39218	118283
T_6: Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}	79065	29018	108083
T_7: Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	79065	30018	109083
T_8: Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	79065	29918	108983
T_9: Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}.	79065	30718	109783

Table 3. Economics of cabbage production under different treatments involved in cultivation

Symbol	Treatments	Cost of cultivation (₹/ha.)	Yield (q/ha.)	Gross income (₹ /ha.)	Net income (₹/ha.)	Benefit: Cost Ratio
T_1	Recommended dose of NPK ha^{-1} (150 kg : 125 kg : 100 kg)	89900	369.42	369420	279520	3.11
T_2	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1}.	113583	346.21	346210	232627	2.05
T_3	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	117383	382.01	382010	264627	2.25
T_4	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}	117483	405.96	405960	288477	2.46
T_5	Half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	118283	445.47	445470	327187	2.77
T_6	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1}	108083	378.55	378550	270467	2.50
T_7	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1}	109083	394.36	394360	285277	2.62
T_8	Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} +Phosphorous Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}`	108983	435.59	435590	326607	3.00
T_9	: Half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}.	109783	447.69	447690	337907	3.08

The maximum gross income of (₹ 447690/ ha.) was calculated from half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}while the minimum gross income (₹ 346210/ ha.) was calculated under half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} during experimental period.

Net profit is calculated by deducting the cost of farming from gross income. It found the maximum net profit (₹ 337907/ ha.) with usage of half dose of NPK ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* @ 5 kg ha^{-1} + Phosphorus Solubilizing *Mycorrhiza* @ 5 kg ha^{-1}. was obtained which is the best from other treatments. However, the minimum net income (232627 Rs/ ha.) was showed in half dose of NPK ha^{-1} + FYM @ 15 t ha^{-1} during 2016-17.

The maximum cost-benefit ratio (1:3.11) was noted under recommended dose of NPK ha^{-1} (150 kg :125 kg: 100 kg). However, minimum cost: benefit ratio (1:2.05) was recorded from Half dose of NPK ha^{-1} + FYM @ 15 t ha. It is clearly indicated that treatment Recommended dose of NPK ha^{-1} (150 kg :125 kg: 100 kg) was found to be superior to other treatments, and this ratio is also beneficial for farmers in making crop production decisions for the cabbage crop.

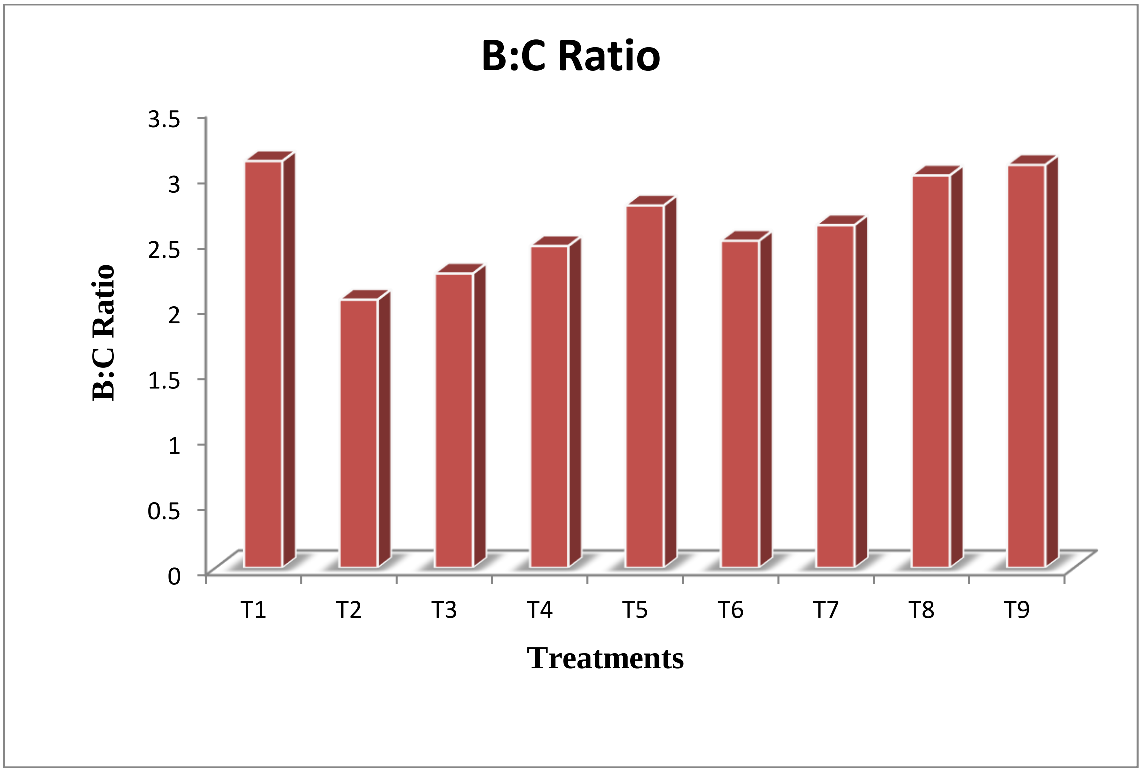

Fig. 1. Effect of INM on benefit cost ratio of Cabbage

Almost Similar findings were also reported by the researchers like Thronsbug et al. [6], Magray et al. [7] and Meena et al. [8] in broccoli**.** The highest Cost Benefit ratio with the application of 100% RDF of NPK is due to the low cost of cultivation (low cost of fertilizers, transportation and application charges) which ultimately increase the cost benefit ratio [9,10,11].

4. CONCLUSION

This study demonstrates that, when compared to integrated nutrient management, the sole use of chemical fertilizers for nutrient management in the cabbage variety Sri Ganesh gol (f1) produced the most lucrative results. For the purpose of feeding cabbage crops, it is more productive and profitable to use NPK at 100% of RDF. However, the constant application of chemical fertilizers alone may have detrimental effects on the soil and the environment around it. Chemical waste may even enter the food chain and endanger human health. According to the study, using fertilizers and organic manures in tandem not only helps to sustain yield but also helps to minimize the issues described above.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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