

**“Response of various organic manures and bio-fertilizers on
growth, yield and quality of
broccoli (*Brassica oleracea* var. *italica* Plenck.)”**

Thesis

Submitted to the

College of Horticulture

VCSG Uttarakhand University of Horticulture and Forestry

Bharsar-246123, Pauri Garhwal (Uttarakhand) India



By

Ekta Negi

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

Master of Science

Horticulture (Vegetable Science)

September, 2016

CERTIFICATE

This is to certify that the thesis entitled "**Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck)**" submitted in partial fulfilment of the requirements for the degree of Master of Science (Horticulture) with major in Vegetable Science of the College of Horticulture, VCSG Uttarakhand University of Horticulture & Forestry, Bharsar, is a record of *bona fide* research carried out by **Ms. Ekta Negi Id. No. 13121**, under my supervision and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been acknowledged.



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We, the undersigned, members of the Advisory Committee of Ms. Ekta Negi . Id. No. 13121, a candidate for the degree of Master of Science Horticulture with major in Vegetable Science agree that the thesis entitled “**Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck)**” may be submitted in partial fulfilment of the requirements for the degree.

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Acknowledgements

I am most indebted to the grace of one Universal Being. His image of universal teacher, who constantly inspire entire humanity towards the knowledge, truth and eternal place. So, I would like to consecrate myself before the Supreme Being for the mental strength. He bestowed on me to go through the ups and downs of my life.

Every effort is motivated by an ambition and all ambitions have inspirations behind. I owe this pride place to my ever loving papa (Sh. Jagmohan Singh Negi), Mummy (Smt. Dhaneshwari Negi), Brother (Alok Negi) and dii, jijaji (Alka Bhandari and Sanjeet Bhandari) for their oceans of love and moral support bestowed upon me which steered the life of this cipher to the present shape.

It is my profound privilege to express deep sense of gratitude and regards of my esteemed teacher and my Advisor Dr. Shailaja Punetha (Department of Vegetable Science) for his inspiring guidance, constant encouragement, valuable suggestions, logical and necessary criticism, innovative ideas, indefatigable supervision throughout the course of this investigation and preparation of manuscript which made this endeavor a complete success.

I emphatically extend my heartiest thanks to the worthy members of my Advisory Committee Dr. B. P. Nautiyal (Chairman), Dr. Shailaja Punetha (Assistant Professor), Dr. S. C. Pant (Assistant Professor), Dr. Sandeep Upadhyay (Assistant Professor) and Dr. Pankaj Bahuguna (Assistant Professor) for their valuable suggestions and guidance with their scientific acumen during the investigation and manuscript preparation.

Nevertheless, my successful accomplishment of the tasks at hand also owes much to the cooperation, personal inspiration, unfailing encouragement and moral support of Dr. B. P. Nautiyal and Dr. Shailaja Punetha. I cordially acknowledge the assistance extended by faculty members, office, and lab staff of Department of Food Technology for timely and sincere help during the course of experimentation.

It's my fortune that I have been blessed with long lasting memorable company my friends and classmate Mekap, Pankaj, Sunil, Chinmaya, Maboji, Pragya, Sarita, Tanuja, Neema, Madhuri, Beena, Deeplata, Neelam, Kanchan, Sonam, Suyanka, Kulveer, Yashwant, Rajesh and Prem who made my every moment enjoyable.

I emphatically extend my heartiest thanks to Dr. Sandeep Dhatwalia, Dr. Parul Punetha and worthy members of Vegetable Science Pradeep Bhaiya.

I shall always remember the jovial company of my juniors for boosting up my spirits.

Library will always remain a luscious remembrance for furnishing my studies with endless and invaluable information.

I own entire responsibility for all the errors and omissions.

Place: Bharsar, Pauri Garhwal.

Date: September 2016.

(Ekta Negi)

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ABBREVIATIONS

%	:	per cent
@	:	at
Cm	:	Centimeter
Cv	:	Cultivar
<i>et al.</i>	:	co- workers
FYM	:	farmyard manure
VC	:	vermicompost
NM	:	neem manure
G	:	Gram
GA	:	gibberellic acid
Ha	:	Hectare
IAA	:	indole 3-acetic acid
K	:	Potassium
Kg	:	Kilogram
L	:	Liter
ml	:	Milliliter
Mm	:	millimeter
km	:	kilometer
Mt	:	metric tones
N	:	Nitrogen
Fig	;	figure
nm	;	nanometer
PSB	;	phosphate solubilizing bacteria

pH	:	puissance d' hydrogen
kg/ha	:	kilogram per hectare
HP	:	Himachal Pradesh
CAN	:	calcium ammonium nitrate
m ²	:	meter square
cm ²	:	centimeter square
IU	:	international unit
Zn	:	zinc
Cu	:	copper
Mn	:	managnese
Fe	:	iron
HCl	:	hydrochloric acid
HNO ₃	:	nitric acid
CD	:	critical difference
B:C	:	benefit cost ratio
S	:	sulphur
B	:	boron
Na	:	sodium
PM	:	poultry manure
TSS	:	total soluble solids
VA	:	vesicular arbuscular mycorrhiza



CHAPTER-1

INTRODUCTION



CHAPTER 1

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica* Plenck.) is one of the most nutritious vegetable amongst the cole crops grown for its tender heads. It belongs to the family brassicaceae and originated from the Mediterranean region (Thamburaj and Singh, 2001). United States of America is the largest producer of sprouting broccoli in the world. Broccoli is available in three different colours *viz.*, green, yellow and purple, out of which green colour type is generally preferred.

In India, the cultivation of sprouting broccoli is gaining popularity among the growers for the last few years obviously due to increasing demand in cosmopolitan cities and awareness of its high nutritive values. Sprouting broccoli is occupying an important place as cool season vegetable. In Himachal Pradesh, it is an important vegetable crop and farmers are getting lucrative returns by selling their produce in nearby markets.

Broccoli contains indole-3-carbinol, which helps to fight breast and lung cancer. Its sprouts are rich source of glucosinolate, particularly glucoraphanin, the substance associated with reducing of cancer (Maurya *et al.*, 2008). Besides its anticarcinogenic properties, broccoli is a rich source of vitamins, minerals and proteins. It has about 130 times more vitamins A content than cauliflower and 22 times more than cabbage. It is richest source of sulphoraphane, a compound associated with reducing risk of cancer in human beings (Thamburaj and Singh, 2001). Consumption of 150 gm of broccoli helps in fulfilling the requirement of adult's for vitamins E, A, B1 and C and enhances the immune system (Michaud *et al.*, 2002). Consumption of broccoli has been steadily increased due to its health promoting properties and conscious of human towards health.

In recent years its cultivation has gained momentum in India. It is grown in an area of 3,776 acre with annual production of 26,612(000 lbs) and productivity of 7.04000 lbs per acre. (Anonymous, 2015)

The introduction of improved agriculture technologies in vegetable cultivation emphasized the use of chemical fertilizers and pesticides to enhance productivity, which has no doubt succeeded in feeding the vast population. However, the excessive use of chemical fertilizers led to adverse effect on human health and resulted in land, water and air pollution. Thus, attention is now being shifted towards the alternate sources of nutrients from the organic ones. Use of organic manure, farm yard manure, compost, oil cakes and

crop residues etc. as nutrient sources is being advocated so as to minimize the use of chemical fertilizers (Bhardwaj *et al.*, 2000).

Organic fertilizers are rich in both macro and micro nutrients with vitamins, enzymes and hormones like Auxin, Gibberellin etc. Vermicompost, and cowdung compost can play a crucial role as soil amendments. Cowdung is good organic manure and is a good source of different nutrients. Judicious application of manures and fertilizers can increase crop yield per unit area and minimizes the nutrient imbalance in soil. It is also important to look beyond immediate crop needs in order to build up soil fertility and to conserve good soil health, so as to provide a solid base for increased crop production in future.

Organic manures are considered helpful in improving the physical and nutritional status of the soil and also enhance the activity of soil microflora. They also add considerable amount of major nutrients in the soil besides improving the soil properties. Further, decomposition of organics in the soil leads to different types of biological reactions which are helpful in preventing various diseases causing pathogens (Ramesh *et al.*, 2010).

There are also evidences to show that the intensive agricultural practices have also caused decline in quality of fresh fruits and vegetables. Since, vegetables are mostly consumed as fresh or partially cooked, imbalanced use of fertilizers have resulted in yield stagnation and deterioration of soil health as well as quality of vegetable produce. Proper and regular incorporation of farm organic wastes and bio-inoculants are of utmost importance in maintaining the fertility and productivity of agricultural soils (Yadav, 2009).

Biofertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of vegetable produce. They contain microorganisms which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes. Further, they also increase the productivity of the soil and control many harmful pathogens and microorganisms. Use of biofertilizers for improving the soil properties have been advocated by (Ashokan *et al.*, 2000). The substitution of organic ones is essential for improving the growth, yield and quality of any crop. The scientific information available on the production of exotic vegetable like sprouting broccoli utilizing various sources of nutrients is meager.

Hence, the present investigation have been planned to study the effect of organic manures, bio-fertilizers and their combination on quality production of broccoli with the following objectives:

- ✓ To study the effect of organic manure, bio-fertilizers and their combinations on growth, yield and quality traits of Broccoli.
- ✓ To work out the economics of organic manure, bio-fertilizers and their combinations



CHAPTER-2

REVIEW OF LITERATURE



CHAPTER 2

REVIEW OF LITERATURE

Broccoli is one of the important vegetable recently introduced in our country. It has tremendous production potential and well suited to varied agro-climatic conditions of Uttarakhand. Thus, there is a need to standardize production technology of this crop for growing in different pockets of the state. Nutrient management is one the key factor, which influences the productivity and quality of any crop. Nutrient removal by crops from soil sometimes exceeds replenishment with fertilizers causing a negative balance of nutrients in soil and ultimately resulting in multi-nutrient deficiencies. Therefore, balance between nutrient removal and their incorporation in the form of different nutrient resources are essential. An attempt has been made to review the literature pertaining to the effect of organic, biofertilizers and their combinations on sprouting broccoli but due to the lack of sufficient literature on this crop and aspect, the research work pertaining to other cole crops has also been cited. The literature so far available pertaining to the present study entitled “Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* var *L. italica* plenck.) cv. Green Head” is being presented under the following headings:

- 2.1 Effect of organic manures on growth, yield and quality of broccoli.
- 2.2 Effect of biofertilizers on growth, yield and quality of broccoli.
- 2.3 Effect of nutrient sources in integration (N,P, K, organic manures and biofertilizers) on growth, yield and quality of broccoli.

2.1 Effect of organic manures on growth, yield and quality of sprouting broccoli

Bhardwaj *et al.* (2000) reported that the application of 50 per cent recommended NPK + 50 per cent rapeseed cake (0.72 t/ha) in tomato, 50 per cent recommended NPK + 50 per cent neem cake (0.72 t/ha) in okra, 33.3 per cent recommended NPK + 33.3 per cent farmyard manure (6.66 t/ha) + 33.3 per cent rapeseed cake (0.48 t/ha) in cabbage, 33.3 per cent recommended NPK + 33.3 per cent farmyard manure (6.66 t/ha) + 33.3 per cent neem cake (0.48 t/ha) in cauliflower recorded higher yields, which were statistically at par with recommended doses of chemical fertilizers. Net returns in organic produce of different

vegetables were higher as the produce received higher price in the market. They further reported that the application of sole organic sources of nutrients recorded 11-17 per cent lower yield in different vegetable crops.

Bahadur *et al.* (2004) evaluated the effect of organic manures and biofertilizers on the growth and yield of cabbage. There were 13 treatments combinations consisting of 4 organic manures (farmyard manure, pressmud, digested sludge and vermicompost) and 3 biofertilizers (*Azospirillum*, vesicular arbuscular mycorrhiza and phosphate solubilizing microorganisms) and one control (recommended NPK only). Pressmud + VAM recorded the highest values for all parameters studied i.e. number of outer leaves (13.3), fresh weight of outer leaves (476.67 g), number of inner leaves (31.7), head weight (1616.67 g), head length (16.8 cm), head diameter (15.5 cm) and head yield (602.67 q/ha).

Chaterjee *et al.* (2005) conducted a field experiment to evaluate the effect of organic amendments on broccoli hybrid “Green Country”. Mustard oil cake + biofertilizers resulted in the highest yield (103.70q/ha) and cost: benefit ratio (1:4.46). Poultry manure + biofertilizers produced curds with the highest chlorophyll, ascorbic acid and reducing sugar contents (32.80 mg/100 g, 80.30 mg/100 g and 2.20 per cent, respectively).

Singh *et al.* (2005) conducted an experiment to assess the effect of vermicompost on cauliflower productivity and profitability and found that the return per rupee spent in plots with vermicompost was Rs. 3.30. The farmer’s reaction on the use of vermicompost was highly positive because of its compatibility with the farming system components as well as its cost effectiveness. Moreover, vermicompost was also accepted by the resource-rich farmers who preferred to use vermicompost in place of chemical fertilizers due to environmental considerations and to combat health hazards.

Magd *et al.* (2006) studied the response of vegetative growth and yield of some broccoli varieties to organic manures (cattle and poultry manures) compared with fertilizers. Results indicated that the highest vegetative growth and total yield of broccoli was under plots received 100 per cent cattle manure. However, the highest total yield and quality of broccoli were recorded when poultry manure was added for two consecutive seasons.

Maurya *et al.* (2008) conducted a field experiment to study the effects of nutrient management practices on broccoli cv. Fiesta. The number of fully opened leaves, plant height, leaf length, leaf width was highest in treatments with poultry manure + 50 per cent

RDF during both the years. The highest yield was also obtained with poultry manure + 50 per cent RDF.

Velmurugan *et al.* (2008) carried out investigations on cauliflower (*Brassica oleracea* L. var. *botrytis*) cv. Indam 2435 to determine the effect of different organic manures and biofertilizers on cauliflower with reference to growth and yield attributes. The results revealed that cauliflower showed better response to the application of organic manures and biofertilizers. The combined application of vermicompost along with panchagavya expressed the highest total dry matter content (211.99 g/plant). Application of the recommended dose of fertilizers recorded the maximum curd length (15.66 cm), curd width (17.21 cm) and curd weight (340.12 g/plant) than the control.

Padamwar and Dakore (2009) conducted field trial on cauliflower and applied organic manures (farmyard manure, vermicompost and biofertilizers) to observe their effect on growth, yield and nutritional value. Application of vermicompost was found to be most beneficial in increasing the yield and quality of cauliflower.

Singh *et al.* (2009) conducted a field experiment on alluvial soil to study the effect of potassium and boron on yield, quality and uptake of nutrients in cauliflower. Application of K and B significantly increased the curd and dry matter yield up to 90 kg K₂O and 2 kg boron per ha. Protein content and yield of curd increased significantly with K and B application. Nitrogen, phosphorus, potassium and boron uptake increased significantly up to 90 kg K₂O and 2 kg B per ha.

Chander *et al.* (2010) conducted an experiment to investigate the effect of farmyard manure and boron on cauliflower in north western Himalayas. Twelve treatment combinations consisting of three levels of FYM and four levels of boron were tested. Study revealed that increased level of FYM and boron significantly increase the yield and available N, P and K contents of soil.

Dalal *et al.* (2010) revealed that application of organic manures either alone or in combination with urea enhanced the growth and yield attributes in cabbage over control. Highest growth attributes like plant height, plant spread, number of leaves per plant and leaf area were obtained in the treatment, which received 50 per cent N as urea + 50 per cent N as vermicompost. The effect of vermicompost alone or in combination with chemical fertilizer was at par with application of poultry manure.

Magd *et al.* (2010) conducted field experiments in newly reclaimed soil for two seasons to study the effect of different levels of nitrogen sources on vegetative growth,

yield and quality of two broccoli cultivars. The highest vegetative growth was obtained when all nitrogen requirements was supplemented by 75 per cent organic + 25 per cent mineral treatment. Lower values of plant growth, higher content of ascorbic acid and total phenols were obtained by applying 100 per cent of mineral nitrogen. Treatments where, whole nitrogen was applied as organic manure showed significant increases in the vegetative growth, yield and quality of heads.

Kumar *et al.* (2010) conducted a field experiment to study the effect of vermicompost and VAM inoculation on growth and yield of cauliflower (*Brassica oleraceae* L. var. *botrytis*). Treatments comprised three levels of vermicompost (4, 8 and 12 t/ha) and three levels of VAM (1.0, 1.5 and 2.0 kg/ha) along with a control. Results revealed that higher level of vermicompost (12 t/ha) or VAM (2.0 kg/ha) caused significant increase in growth and yield of cauliflower. Interaction of higher levels of vermicompost (12 t/ha) and VAM (2.0 kg/ha) have significantly increased curd diameter, curd weight and yield per hectare.

Padamwar and Dakore (2010) studied the effect of vermicompost, farmyard manure and biofertilizers on the nutritional quality of cole crops, i.e. cabbage, cauliflower and knol-khol. The treatments comprised of control (no fertilizer), FYM (11.3 t/ha), vermicompost (11.3 t/ha) and mixture of biofertilizers (*Azotobacter*, phosphorous solubilizing bacteria and vesicular arbuscular mycorrhiza) at 3 kg/ha. There was significant increase in percentage dry matter, protein, carbohydrate, vitamin C and calcium contents of curd of all the cole crops due to the application of vermicompost.

Wani *et al.* (2010) conducted an experiment on cauliflower cv. Snowball-16 to evaluate the best combination of organic and inorganic sources of nutrients for maximizing yield and improving quality. Combined application of 50 per cent recommended dose of NPK and poultry manure @ 3 t/ha recorded significantly higher curd yield (325.1 q/ha) followed by application of 50 per cent recommended dose of NPK and mixture of half dose of farmyard manure, poultry manure, sheep manure and pea straw. Curd quality and nutrient uptake also improved with the same treatment. Highest net return (Rs. 178096/ha) and benefit: cost ratio of (3.59:1) was obtained for the above treatment combination

Nath and Singh 2011 investigated the effect of vermicompost singly or in combination with different bio-pesticide on infestation of nematode (*Meloidogyne incognita*) and yield of cauliflower. Mixing of binary combination of vermicompost with neem oil (94%) in the soil caused significant reduction in *M. incognita*. Application of

vermicompost with bio-pesticides increased the productivity of cauliflower more than eight times. The results clearly demonstrated that the use of vermicompost with plant product is more beneficial in organic farming and helpful to compensate the deficiency of nutrients in the soil as well as control of the harmful nematodes.

Sarangthem *et al.* (2011) conducted an experiment to study the effect of organic manures on soil parameters and yield of cabbage (*Brassica oleracea* L. var. *capitata*) in acid soil. The study consisted of two sources of organic manure (vermicompost and FYM) and *Azospirillum* (4 kg per ha). The highest yield of cabbage was obtained with the application of vermicompost at 3 t/ha and *Azospirillum* (4 kg/ha), which was significantly superior than farmyard manure. The post harvest organic carbon and available NPK content of soil significantly improved with the use of vermicompost and *Azospirillum*. The concentration of nutrient (NPK) in shoot and root of cabbage was also observed highest in the treatment receiving vermicompost 3t/ha along with *Azospirillum* as compared to FYM treatments.

Wani *et al.* (2011) investigated the effect of organic and inorganic nutrient sources on cauliflower cv Snowball-16. Among the organic manures, poultry manure in combination with chemical fertilizers proved superior to sheep manure, FYM, paddy straw and mixture of organic manures. The vitamin C, proteins and uptake of nutrients (NPK) by the cauliflower plants significantly increased with individual and combined application of organic manures or inorganic fertilizers over control. The available nitrogen, phosphorus and potassium of soil were also increased with the increase in organic manure applications.

Choudhary *et al.* (2012) conducted a study to evaluate the effect of different organic sources and fertility levels on the growth, yield, quality and economics of sprouting broccoli under semi-arid conditions of Rajasthan. Significant increase in plant height, number of leaves, leaf area, volume and diameter of head, total head yield, crude protein and chlorophyll content in head was recorded under various levels of organic sources and fertility levels. Growth, yield and quality attributes were recorded maximum under treatment combination of vermicompost 5.0 t/ha along with recommended dose of fertilizers (NPK, 100, 80 and 60 kg/ ha), which was at par with poultry manure 5.0 t/ha and recommended dose of fertilizers, respectively. Further, it also registered maximum net return and B: C ratio of 4.09:1.

Kumar *et al.* (2012) studied the effect of temperature on the growth and yield of broccoli heads grown with 19 treatments of integrated nutrient management. Integrated

nutrient management having chemical fertilizers applied along with organic sources of nutrients is an effective method for improving the crop yield. Application of 50 Kg N through vermicompost + 150:100:100 NPK kg/ha resulted in maximum yield of curd.

Kumar *et al.* (2012) conducted a field experiment to study the effects of boron and organic manure on autumn cauliflower (*Brassica oleracea* L. var. *botrytis*) yield, quality, availability and efficiency of boron in soil and its uptake. There were 13 treatments comprising of all the possible combinations of two levels of FYM (20 and 30 t/ha), two boron sources (boron and granular-II), three levels of boron (0.5, 1.0 and 1.5 kg/ha) and an absolute control (farmers' practice). Curd yield, quality, boron uptake, its availability and balance and net income increased due to use of 30 t/ha farmyard manure compared to 20 t/ha.

Mal *et al.* (2015) conducted a field experiment to study the response of vermicompost and inorganic fertilizers on growth, yield and quality of sprouting broccoli to determine the treatments comprised of five levels of vermicompost (0, 2.5, 5, 7.5 and 10 t ha⁻¹) and four levels of inorganic fertilizers (0, 50, 75 and 100% of recommended dose) were evaluated in two factor factorial RBD with three replications. The result revealed that successive increase in vermicompost level significantly increased the growth and yield attributes and application of highest level of vermicompost (10 t ha⁻¹) registered 38% and 43% improvement of central head weight and total head yield respectively over control, whereas application of 100% recommended fertilizers enhanced the head weight and total head yield by 32% and 35% respectively over control. The nutrient schedule comprising of higher level of vermicompost (10 t ha⁻¹) and 100% of recommended inorganic fertilizers emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, early head initiation, advanced head maturity and higher yield as well as superior quality of head as compared other nutrient combination.

2.2 Effect of biofertilizers on growth, yield and quality of sprouting broccoli

Sharma (2002) conducted a field experiment to determine the effect of *Azospirillum* and *Azotobacter* in combination with nitrogen on cabbage (*Brassica oleracea* var. *capitata*) production. Treatments comprised 3 biofertilizer levels (no biofertilizer, *Azospirillum* and *Azotobacter*) and 4 nitrogen levels (0, 30, 45 and 60 kg/ha). *Azospirillum* significantly increased the number and weight of non-wrapper leaves per plant, head length, width, net weight of head per plant and yield per hectare over the 'no biofertilizer'

treatment. Treatment combination of *Azospirillum* + 60 kg N/ha recorded the highest head weight per plant and yield per hectare with a benefit: cost ratio of 2.9:1.

Manivannan and Singh (2004) conducted a field experiment to study the effect of biofertilizers namely *Azospirillum sp* and *Azotobacter sp* applied as 5.0 and 10.0 per cent, respectively on the growth and yield of sprouting broccoli (*Brassica oleracea* L. var. *italica* cv. Fiesta). The maximum plant height (41.72 cm), biomass yield per plant (1.08 kg), number of sprouts per head (15.00), slips per sprout (32.00), curd diameter (17.30 cm), plant spread (62.20 cm), and yield (55.57 t/ha) was recorded in plants applied with 5.0 per cent *Azotobacter sp* and *Azospirillum sp*.

Wange and Kale (2004) studied the growth and yield response of broccoli and lettuce to 12 different treatments of biofertilizers (*Azotobacter* and *Azospirillum*) and N level (100, 125 and 150 kg/ha) under field conditions during the rabi season. In broccoli, the treatment of *Azotobacter* + *Azospirillum* with 150 kg N per ha was significantly superior over the recommended fertilizers.

Singh and Singh (2005) conducted an experiment to evaluate the response of cauliflower cv. Snowball-16 to four biofertilizers (*Azospirillum*, *Azotobacter*, phosphate solubilizing bacteria and vesicular arbuscular mycorrhiza) and two levels of nitrogen and phosphorus. *Azospirillum* + 100 per cent of the recommended NPK recorded the highest values for all growth, yield and quality parameters studied. This treatment also recorded the highest net return (Rs. 53 965/ha) and benefit: cost ratio (2.23:1).

Bahadur *et al.* (2006) carried out an experiment to study the response of organic amendments and biofertilizers on growth, yield and quality attributes of chinese cabbage (*Brassica pekinensis* L.). Combined use of organic amendments coupled with seedlings inoculation in either phosphate solubilizing micro organisms or vesicular arbuscular mycorrhizae registered head yield at par with control (conventional fertilization). Sole application of farmyard manure or digested sludge and/or its combined use with phosphate solubilizing microorganisms significantly increased the dry matter and total carbohydrate content of head. The total carotenoids were significantly higher under combined use of organic amendments or seedling inoculated with either *Azotobacter* or in phosphate solubilizing microorganisms.

Sable and Bhamare (2007) conducted an experiment on cauliflower involving four levels of biofertilizers (no inoculation, *Azospirillum*, *Azotobacter* and *Azotobacter* + *Azospirillum*) with three levels of nitrogen (0, 75% and 100% N). Out of the twelve

treatment combinations, the best was 75 per cent nitrogen (120 kg/ha) + *Azotobacter* + *Azospirillum*, which significantly increased ascorbic acid content (87 mg/100 g), protein content (18.62%), total nitrogen content in plant (2.98%) and compactness of curds (97.39%).

Khare and Singh (2008) conducted a field experiment on cabbage cv. Golden Acre to study the effect of *Azospirillum*, *Azotobacter* and nitrogen application on growth and yield. Twelve treatment combinations comprised of three cultures i.e. no biofertilizer, *Azospirillum*, *Azotobacter* and four levels of nitrogen viz., 0, 50, 75 and 100 per cent. Application of 75 per cent nitrogen of recommended doses (135 Kg/ha) in combination with *Azotobacter* significantly increased the growth parameters (numbers of unfolded leaf, leaf area and leaf area index), yield attributes (number of folded leaf, weight and diameter of head) and yield of cabbage.

Akbar *et al.* (2009) studied the effects of vermicompost and bio-fertilizer (*Azotobacter*) on the performance of cabbage cv Pride of India. The treatments comprised of three levels of each of vermicompost (0, 5 and 10 t/ha) and *Azotobacter* (0, 5 and 10 kg/ha). Results revealed that application of vermicompost @ 10 t/ha resulted in maximum plant spread, largest size of head, and highest yield of heads per hectare, while the number of leaves /plant and number of wrapper leaves/head were maximum with 5 t vermicompost/ha. Among the various levels of bio-fertilizer inoculation, *Azotobacter* @ 10 kg/ha resulted in maximum plant height, diameter of head, maximum number of leaves per plant and number of wrapper leaves/head, whereas, the length of head and head yield per plant were maximum with 5 kg *Azotobacter*/ha.

Khan *et al.* (2009) conducted field experiments during rabi season for two years to investigate the response of *Azospirillum*, *Azotobacter*, phosphate solubilizing bacteria (PSB), and vesicular arbuscular mycorrhiza (VAM) on cauliflower production. The maximum curd yield (213.25 and 219.95 q/ha) was recorded when recommended doses of NPK were applied along with *Azospirillum* followed by 75 per cent recommended doses of NPK applied along with *Azospirillum* during both the years, which was significantly superior over the control (170.95 and 180.34 q/ha). Increase in curd yield due to *Azospirillum*, *Azotobacter*, PSB and VAM was 23, 14, 10 and 16 per cent, respectively over the control (RDF).

Gupta *et al.* (2010) laid out an field experiment to study the effect of biofertilizers (*Azospirillum* and *Azotobacter*) and nitrogen on growth, yield and quality of Knol-khol.

Both the bacterial inoculants responded to all levels of nitrogen with an increase in growth, yield and quality parameters as compared to control. However, better results were obtained by the application of 75 per cent of nitrogen along with both the inoculants. However, the application of *Azospirillum* along with 75 per cent nitrogen proved better than *Azotobacter*.

Khan *et al.* (2010) evaluated the effect of *Azospirillum*, *Azotobacter*, phosphate solubilizing bacteria and vesicular arbuscular mycorrhiza inoculation on the curd yield of cauliflower. The biofertilizers were applied together with 75 per cent dose of N or 100 per cent of the recommended dose of fertilizer (RDF), i.e. NPK at 150:60:60 kg/ha. Maximum curd yield was obtained with the application of *Azospirillum* + 100 per cent RDF (213.25 and 219.95 q/ha) followed by *Azospirillum* + 75 per cent dose of N, during both years.

Sharma and Sharma (2010) conducted a field experiment to investigate the effect of different levels of bio-fertilizers (*Azotobacter* and PSB) in combination with four levels of NPK fertilizers on growth and yield of cauliflower hybrid 'Swati'. The application of biofertilizers alone and in combination resulted in significant improvement in plant height, number of leaves per plant, curd diameter, curd depth, gross weight per plant and marketable curd yield. The increase in marketable curd yield was to the tune of 26.4 per cent, 24.19 per cent and 18.16 per cent with the combined inoculation of bio-fertilizers (*Azotobacter* + PSB), sole application of PSB and *Azotobacter*, respectively, over the uninoculated control. The interaction effects showed that gross weight/plant, marketable curd yield and benefit: cost ratio were increased in a linear manner with the application of bio-inoculants integrated with increasing levels of NPK fertilizers. Furthermore, it was observed that the yield (238.66 q/ha) obtained with the application of 75 per cent NPK + *Azotobacter* + PSB was at par with that of recommended NPK (100 %), thus resulting in net saving of 25 per cent NPK fertilizers with maximum benefit: cost ratio (5.06).

Kumar *et al.* (2011) laid out an experiment to study the effect of biofertilizers with chemical fertilizers on growth and yield of cauliflower (*Brassica oleracea* L. var. *botrytis*) cv. Pusa Snowball K-1. The study consisted of nine treatment combinations of biofertilizers (*Azotobacter*, *Azospirillum* and PSB) and NPK. Results of the study revealed that application of PSB + 120:60:60 NPK kg/ha significantly increased the curd yield and various growth characters like plant height, number of leaves per plant, curd diameter and stem diameter.

Kachari and Korla (2012) carried out a field experiment on cauliflower to know the influence of bio-fertilizers (*Azotobacter*, *Azospirillum* and PSB-1) and inorganic fertilizers

on curd quality and economics of cauliflower. The results indicated that bio-fertilizers in combinations with inorganic fertilizers performed better as compared to control (FYM), recommended dose of NPK and bio-fertilizers alone. The application of PSB + 50 or 75 or 100 per cent of phosphorus + recommended dose of nitrogen and potassium performed significantly better than other treatments including control. The inoculation with PSB-1 + 100 per cent phosphorus + recommended dose of nitrogen and potassium recorded highest yield (33.94 t/ha).

Yadav *et al.* (2012) conducted studies on the effect of nitrogen and biofertilizers on growth of cabbage (*Brassica oleracea* L. var. *capitata*) cv. Pride of India. The experiment consisted of 17 treatments *viz.*, four levels of nitrogen (control, 100 kg, 125 kg and 150 kg) and three doses of biofertilizers (*Azotobacter*, *Azospirillum* and PSB) either singly or in combination and absolute control. The treatment 150 kg N + PSB was recorded maximum plant height (24.64 cm), plant spread (42.87 cm), number of open leaves (20.67), leaf area (247.43 cm²), maximum days taken to head maturity (110.00), diameter of stem (17.51mm) and yield of head per hectare (432.92 q/ha). However, it was statistically at par with 150 kg N + *Azospirillum* and 150 kg N + *Azotobacter* inoculation.

2.3 Effect of nutrient sources in integration (N, P, K, organic manures and biofertilizers) on growth, yield and quality of sprouting broccoli

Sharma (2000) has undertaken a study to find out the influence of integrated nutrient management in broccoli using Green Head variety. The results revealed that integration of organic and inorganic fertilizers application significantly increased the head yield over inorganic fertilizers alone or over the control. The treatment N₁₇₅P₇₅K₆₀ + farmyard manure @ 12.5 t/ha recorded the maximum yield (63.12 q/ha) which was at par with N₁₅₀P₇₅K₆₀ + FYM (12.5 t/ha).

Parmar and Sharma (2001) studied the response of cauliflower cv. PSB-1 to NPK fertilizers and farmyard manure. The yield, net return and the soil available N, P and K, increased with the increase in the level of NPK fertilizers and farmyard manure.

Kamla *et al.* (2002) conducted a field experiment to determine the effect of different NPK fertilizer rates (0, 50 and 100%) applied alone or in combination with different organic manures (no manure, vermicompost and farmyard manure at 25 t/ha) in cauliflower cv. Pusa Snow Ball K-1 on yield and soil fertility. The application of NPK fertilizer (100%) significantly increased the curd weight, diameter, plant height and curd

yield but when organic manure (vermicompost or FYM) was applied in combination with 50 per cent NPK, significant increase in all parameters was observed.

Devi *et al.* (2003) conducted a field experiment on cabbage using 100 and 75 per cent recommended N rate, alone or in combination with biofertilizers (*Azospirillum brasilense* or *Azotobacter chroococcum*), 75 and 50 per cent recommended N rate along with cow dung manure, neem cake or poultry manure. Crop yield was highest (55.82 t/ha) with the application of 75 per cent recommended N + 25 per cent poultry manure + biofertilizers. The highest benefit cost ratio was highest (4.30) was recorded with the application of 75 per cent N and biofertilizers.

Choudhury *et al.* (2004) studied the effect of integrated use of organic manure, biofertilizers and chemical fertilizer on the nutrient status of soil and productivity of cauliflower. The organic carbon and available N status increased significantly with conjunctive use of inorganic fertilizers, biofertilizers and farmyard manure. Soil available nutrients like N, P and K increased significantly with the application of various organic and microbial sources of nutrients in combination with fertilizers over the chemical fertilizers alone. The increase in plant growth and yield of cauliflower was recorded with *Azotobacter*, PSB and farmyard manure along with inorganic fertilizers.

Gupta and Samotra (2004) studied the performance of cabbage (cv. Golden Acre) to different level of N (0, 25, 50, 75 or 100% of the recommended rate of 120 kg/ha), biofertilizers (*Azospirillum* and *Azotobacter*) and farmyard manure. The application of 75 kg N plus *Azospirillum* resulted in increased plant height (25.08 cm), more number of wrapper leaves (31.33), head diameter (14.63 cm), head compactness (45.27), head weight (1.280 kg), yield (435.22 q/ha), net income (79 450 Rs/ha) and benefit cost ratio (4.35).

Bhardwaj *et al.* (2007) studied the effect of N (0, 25, 50, 75 or 100 per cent of the recommended rate of 105 kg/ha and *Azotobacter* inoculation (2 kg/ha or 1.0 kg/10 litres of water applied to seedlings), singly or in combination, on the growth and yield of broccoli (cv. CBH-1). The crop generally showed greater growth and yield with the combined application of N and *Azotobacter*. Further, 75 per cent dose of N + *Azotobacter* was effective for the enhancement of growth and yield parameters. The results indicated that *Azotobacter* inoculation may reduce the N rate by 25 per cent without adversely affecting the performance of broccoli.

Dass *et al.* (2008) conducted trials with seven treatments including chemical fertilizers, vermicompost, cow manure, and microbial inoculants for 3 consecutive years on

a red soils to determine the most effective integrated nutrient management option for enhancing productivity of cabbage (*Brassica oleracea* L. var. *capitata*). Vermicompost appeared to be the best soil additive in terms of yield, net economic return, and water use efficiency (WUE). Use of vermicompost + 50 per cent recommended rate of synthetic fertilizers produced significantly higher yield over 100 per cent recommended dose of fertilizers, with a net return increase of 29.8 per cent.

Sharma *et al.* (2008) conducted a field experiment in high hill dry temperate zone of HP to investigate the response of broccoli (*Brassica oleracea* L. var. *italica*) to integrated nutrient management using organic manure and *Azotobacter* along with chemical fertilizers. There were 12 treatments; i.e., three levels of NPK chemical fertilizer (50, 75, 100%) integrated with two levels each of cow manure (10 and 20t/ha) and inoculation with *Azotobacter* (seedling dipped in culture and no inoculation) in combination. Integration of *Azotobacter* with the recommended practice (100% NPK + 20 t/ha of cow manure) produced the highest marketable yield over the recommended practice of 20 t/ha cow manure + 100 per cent NPK. Moreover, this treatment combination resulted in maximum leaf width, apical and lateral curd weight along with total yield/plant during both the years. Nutrient uptake in plant tissues and nutrient build-up in soil have also followed almost similar trends.

Pandey *et al.* (2008) recorded highest values for growth of broccoli curd in terms of head depth, girth and apical head weight with application of vermicompost @ 2.5 t/ha + ½ dose of recommended NPK + *Azotobacter*.

Kandil and Gad (2009) studied that all mineral solution fertilizers gave a significant synergistic effect for broccoli growth, yield quantity and quality as well as nutrients composition compared the control (mineral N, P, K recommended fertilizers). The mineral formula 19: 19: 19 recorded the highest growth heads, yield and quality along with mineral content in broccoli. Using farmyard manure plus inorganic fertilizers enhanced all growth and yield parameters. He observed that the highest TSS (8.21⁰B), in heads of broccoli was recorded by formula (19: 19: 19) mineral solution fertilizer. Applying farmyard manure plus the mineral solution fertilizer formula 19: 19: 19 caused the superior and optimum figures of broccoli growth, mineral composition as well as heads yield quantity and quality.

Kachari and Korla (2009) laid out an experiment with three levels of inorganic fertilizers (100, 75 and 50 per cent of recommended dose of NPK 125:75:65 kg/ha),

inoculation with four bio-fertilizers (*Azotobacter*, *Azospirillum*, *vesicular arbuscular mycorrhizae* and PSB-1), recommended dose of FYM (25 t/ha) and their combinations in cauliflower. The application of nitrogen and potassium gave consistent results during both the years with respect to growth and yield attributing characters.

Khan *et al.* (2009) studied the response of organic and inorganic manures on yield and economic feasibility in broccoli var. Aishwarya. The integration of organics with inorganic fertilizer application proved beneficial in term of plant height, leaves per plant, days to central head, diameter of head (cm), length of head (cm), size of head (cm) and weight of head per plant than other treatments. The application of vermicompost 2.5 t/ha plus half NPK (75:60:60 kg/ha) recorded the maximum yield (183.16 q/ha), net return (Rs 136552) and B: C ratio (4:1). They concluded that productivity of broccoli could be managed profitably with combined application of chemical fertilizer and vermicompost or farmyard manure.

Meena *et al.* (2011) conducted an experiment on cabbage (*Brassica oleracea* L. var. *capitata*) variety Golden Acre and concluded that the application of 180 kg N, 80 kg P₂O₅ and 40 kg K₂O/ha recorded the highest plant height (28.93 cm), number of open leaves (23.33), number of folded leaves (57.66), cross sectional diameter (17.90 cm), vertical length of head (16.76), T.S.S. (5.38%) and yield (129.66 q/ha). These results were significantly superior to the other treatments including control.

Yildirim *et al.* (2011) investigated the effects of root inoculations with biofertilizers (both N₂-fixing and P-solubilizing) on plant growth, nutrient uptake, and yield of broccoli in comparison with manure (control) and mineral fertilizer application under field conditions. Bacterial inoculations with manure significantly increased yield, plant weight, head diameter, chlorophyll content, nitrogen, potassium, calcium, sulfur, phosphorus, magnesium, iron, manganese, zinc, and copper content of broccoli. Bacterial inoculations with manure significantly increased uptake of macronutrients and micronutrients by broccoli.

Bhardwaj *et al.* (2012) investigated the effect of conjoint use of bio-organics (biofertilizers + crop residues + farmyard manure) and chemical fertilizers on yield and physico-chemical properties. Conjoint bio-organics at varied levels of NPK chemical fertilizers increased yield of cauliflower, which was statistically at par with 75 per cent of the recommended NPK application alone. They concluded that the combination of NPK

fertilizers and bio-organics increased yield, soil available N, K and saved chemical fertilizers.

Chatterjee *et al.* (2012) studied the influence of different nutrient sources on quality attributes of cabbage cv. Golden Acre by combining inorganic and organic sources of plant nutrients. Application of 75 per cent recommended dose of inorganic fertilizers along with vermicompost (5t/ha) in presence of biofertilizers significantly increased the head yield. Substitution of 25 per cent recommended inorganic nitrogen with higher levels of organic manure and biofertilizers also prolonged shelf-life as well as improved nutritional qualities of cabbage heads.

Upadhyay *et al.* (2012) evaluated the effect of different biofertilizers, organic manures and inorganic fertilizers on dry matter partitioning, yield and quality traits in cabbage. Results indicated that treatments comprising recommended fertilizers package coupled with seedling inoculation in biofertilizer had relatively higher dry matter in leaves (head), higher number of non-wrapper leaves and head yield. Application of pressmud or vermicompost plus seedling inoculation in *Azospirillum* or PSB noticed head yield at par with conventional fertilization. The maximum protein content was noticed with sole application of vermicompost (17.4%) or digested sludge (17.3%). The highest total carotenoids content in head was recorded with the use of FYM + PSB. Significantly higher ascorbic acid content in head was registered with the use of either farmyard manure or pressmud along with PSB or VAM.

Kumar *et al.* (2013) conducted an experiment on cauliflower to studied the eleven treatments, T1 -Recommended dose of NPK/ha (120 kg:80 kg:60 kg), T2 -Half dose of NPK/ha + FYM @ 15 tonnes/ha, T3 -Half dose of NPK/ha + *Azospirillum* @ 5 kg/ha, T4 - Half dose of NPK/ha + FYM @ 15 tonnes/ha + *Azospirillum* @ 5 kg/ ha, T5 - Half dose of NPK/ha + VAM @ 5 kg/ha, T6 - Half dose of NPK/ha + FYM @ 15 tonnes/ha + VAM @ 5 kg/ha, T7 - Half dose of NPK/ ha + FYM @ 15 tonnes/ha + *Azospirillum* @ 5 kg/ha + VAM @ 5 kg/ha, T8 - Half dose of NPK/ha + Vermicompost @ 2.5 tonnes/ha, T9 - Half dose of NPK/ha + vermicompost @ 2.5 tonnes/ha + *Azospirillum* @ 5 kg/ha, T10 - Half dose of NPK/ha + vermicompost @ 2.5 tonnes/ha + VAM @ 5 kg/ha, T11 - Half dose of NPK/ha + vermicompost @ 2.5 tonnes/ha + *Azospirillum* @ 5 kg/ha + VAM @ 5 kg/ha were evaluated in Randomized Block Design with the three replication. The treatment T11 registered significantly higher value plant height (62.02cm), number of leaves/plant (25.67), width of leaf (25.53cm), length of stalk (12.08cm), spread of the plant

(64.38cm), diameter of curd (19.20cm), weight of curd (953.31g), yield of curd (267.30q/ha) as compared to rest of the treatments.

Mishra *et al.* (2014) carried out field experiment on knolkhol. The experiment comprised of 11 treatments replicated three times in a Randomized Block Design. Of the eleven treatments seven comprised of 100 per cent NPK with or without organic nutrient supplements, two treatments with 50 per cent NPK +organic nutrient supplements, one treatment with no nutrients (T1 – control), and one treatment with only biofertilizers. The T7 which comprised of 100 per cent NPK (@150-38-63 kg NPK ha⁻¹) application along with vermicompost (@ 2.5 t ha⁻¹), biofertilizer @2 kg ha⁻¹ each of Azotobacter, Azospirillum and PSB) recorded significantly higher values for total dry weight per plant (77.8 g), yield (420.0 q ha⁻¹), chlorophyll content (56.96%) TSS (3.10Brix), ascorbic acid content(55.2 mg/ 100g) and protein content (44.2 g/100g) followed by T6. The treatment T6 had same nutrients as T7 except, FYM instead of vermicompost. But the T6 proved to be most economical treatment with a benefit: cost ratio of 2.7.

Chatterjee *et al.* (2014) conducted a field experiment the influence of different nutrient source on growth, head yield and nitrogen use efficiency in cabbage. Comprised of 15 different nutrients source combining inorganic fertilizers, organic manures (farmyard manure and vermicompost) and Azophos biofertilizers were laid out in RBD with 3 replications. Growth and head attributes of cabbage were significantly influenced by different nutrient combination and vermicompost emerged as better organic nutrient source over farmyard manure. Inoculation with biofertilizers exerted more positive result over uninoculated treatments. The nutrient schedule comprising of higher amount of vermicompost (5 t/ha) along with 75% of recommended inorganic fertilizers in presence of biofertilizers inoculation emerged as potential nutrient source and resulted in many fold improvement in the form of vigorous growth, advanced head maturity, maximum curding percent and highest head yield as compared other nutrient combination.

Shree *et al.* (2014) studied different combinations of five different sources of nutrients including organic, inorganic and bio fertilizers and effect of different treatments were observed and noted that maximum plant height (66.75), plant spread (58.64), curd diameter (16.09), depth of curd (11.76), curd volume (702.00), weight of curd (568.00), yield per hectare (252.48) and ascorbic acid (63.19) was noted by application of ½ N:P:K(recommended dose)+ FYM@5t/ha + poultry manure@2t/ha+ *Azospirillum* (T14). Hence it can be said that the application of ½ recommended dose of NPK along with FYM

@5t/ha + poultry manure @2t/ha as well as seedling inoculation with *Azospirillum* was found to be the most effective treatment combination for getting enhanced yield and quality.



CHAPTER -3

MATERIALS AND METHODS



CHAPTER 3

MATERIALS AND METHODS

The present studies entitled “Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* var *L. italica* Plenck.)” were carried out at the at Organic and Dairy Block, College of Horticulture, Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand from August 2015. The details of experimental site, material used and methodologies employed have been described as under:

3.1 General features of experimental site

3.1.1 Location

Pauri Garhwal is one of the thirteen districts of Uttarakhand, and is located between 29° 20'-29° 75' N latitude and 78° 10'-78° 80' E longitude. Bharsar is situated at about 60 km from the district head quarter (Pauri) in the East- south direction on the road side area of Pauri- Thailisan- Ramnagar National High way 121/41. The meaning of Bharsar in local dialect is flourished with natural wealth. Since the ancient time, it is famous for its vast reserve of biodiversity and geographically the temperature climate conditions of the region are quite congenial for the horticulture.

3.1.2 Climate

In general, the climate of the Bharsar represents the mild summer, higher precipitation and colder or severe cold prolonged winter. The climate factors i.e. precipitation, temperature, relative humidity and wind, in association with elevation, proximity to great Himalaya, slope aspects, drainage, vegetation are responsible for the micro- climate of this area. Major output of precipitation is in the form of rain fall, besides occasional occurrence of due, hailstorm, fog, frost, snow fall etc. the south-east monsoon commences towards the end of June while the North- east monsoon causes occasional winter showers during November- February. During winter, snow fall is common in this region. During the summer months, the valley has hot climate prevailing for few hours in a day, the maximum temperature during May- June is may reach in between 25-29°C however, and nights are cool. December and January are the coldest months, the minimum temperature reaches to 1-4°C. Relative humidity is normally highest during rainy season (July-August), often recorded near to saturation point (92-97%) in thickly forest in this zone, it gradually decreases towards December (Bisht and Sharma 2014).

3.1.3 Soil

Before laying out the experiment, random soil samples were collected from the furrow slice (0-15 cm depth) of different spots and composite sample was prepared for determination of various soil characteristics.

The methods employed and results obtained for important physico-chemical characteristics of the soils of experimental area have been presented in general, amount of organic carbon, nitrogen, phosphorus and potassium content present in the soil were 1.162 (g/kg), 324.09 (kg/ha), 55.352 (kg/ha) and 381.92 (kg/ha), respectively.

The pH of the soil was 5.2.

Table 3.1. Physico-chemical properties of soil before transplanting

Particulars	Value obtained	Method Employed
A. Mechanical analysis (%)		
1. Sand	41.42	International Pipette Method (Piper, 1966)
2. Silt	31.25	
3. Clay	27.33	
B. Chemical analysis		
Year	2015	
1. Soil pH (1: 2.5)	5.2	Digital pH Meter (Jackson, 1973)
2. Organic carbon (%)	1.162	Rapid Titration Method (Walkley and Black, 1934)
3. Available N (kg/ha)	324.09	Alkaline Potassium Permanganate Method (Subbiah and Asija, 1956)
4. Available P (kg/ha)	55.352	Olsen Method (Olsen <i>et al.</i> , 1954)
5. Available K (kg/ha)	381.92	Normal Neutral Ammonium Acetate Method (Merwin and Peech, 1951)

3.2 Experimental details

3.2.1 Cultivar

Cultivar 'Green Head' of broccoli was chosen for the present study. The cultivar has been recommended for cultivation in different agro-climatic zones of Uttarakhand.

Head of the cultivar is dark green, medium in size and rich in vitamin A. The average yield of cultivar ranges from 100-175 q/ha.

3.2.2 Treatments

The present study comprised of 10 treatments, which consisted of sole application of organic sources (vermicompost, neem cake, biovita granules and farmyard manure), biofertilizers (*Azotobacter* and Phosphate Solubilizing Bacteria) and their combinations as detailed in Table 3.2.

Experimental details:-

The details of the experiment to be conducted in 2015 as under

Experiment Design	-	Randomized Complete Block Design (RCBD)
Treatment	-	10
Replication	-	03
Spacing	-	45 cm x 45 cm
Plot size	-	1.8m x1.35m (2.43m ²)
Number of plant per plot	-	12

Table 3.2. Detail of treatments

Treatment code		Treatment Detail
1. T ₁	-	Farmyard manure (FYM) @20t/ha
2. T ₂	-	Vermicompost @5t/ha
3. T ₃	-	Neem cake @ 2t/ha
4. T ₄	-	Biovita granules @50 kg/ha
5. T ₅	-	Biofertilizers (<i>Azotobacter</i> +PSB) each @5kg/ ha
6. T ₆	-	Farmyard manure + Biofertilizers
7. T ₇	-	Vermicompost + Biofertilizers
8. T ₈	-	Neem cake + Biofertilizers
9. T ₉	-	Biovita granules + Biofertilizers
10. T ₁₀	-	Control

Allotment of treatments in experiment field under RBD

Replication-1	Replication-2	Replication-3
T-5	T-2	T-9
T-2	T-3	T-10
T-3	T-7	T-6
T-4	T-5	T-7
T-10	T-1	T-8
T-7	T-9	T-1
T-6	T-10	T-3
T-8	T-6	T-4
T-9	T-8	T-2
T-1	T-4	T-5

3.2.3 Procurement of seed

The seed of the cultivar “Green Head” was procured from Department of Vegetable Science College of Horticulture VCSG Uttarakhand University Of Horticulture And Forestry, Bharsar, Pauri Garhwal, Uttarakhand, India, 246123

3.2.4 Nursery raising

The seed of the cultivar was sown in the well prepared nursery bed in lines and covered with a layer of soil and farmyard manure mixture. Further, these beds were covered with a thin layer of dried grass as mulch and watered with the help of rose cane. Regular watering was done in these beds to maintain moisture at field capacity for the proper growth and development of seedlings. After germination of the seedlings, dry grass was removed to expose the seedlings to sunlight for better growth. Nursery was kept free from weeds. Timely plant protection measures were also followed to prevent nursery from damping off and other diseases.

3.2.5 Field Preparation

The experimental field was thoroughly ploughed by tractor 15 days prior to date of transplanting. Stones, pebbles and residues of previous crop were removed. Experimental field was levelled properly and sufficient provision for drainage was made. There after, the



Plate. 1 : View of experimental site

layout of the experiment was done, plots were prepared and treatments were allocated according to the layout plan.

3.3 Method of different treatment application

3.3.1 Application of organic manures

The entire calculated dose of vermicompost, neem cake, biovita granules and farmyard manure as per treatment combination were applied in the individual specified plots before transplanting of the seedlings by broadcasting method and was thoroughly mixed up well with the soil.

3.3.2 Application of biofertilizers

The biofertilizers (*Azotobacter* and PSB) were applied through seedlings dip method. A solution of *Azotobacter* and PSB was prepared by dissolving 200 grams of each biofertilizers in 5 litres of water and seedlings were dipped in this solution for 30 minutes before transplanting. After dipping, seedlings were immediately transplanted in the field.

3.3.3 Harvesting

The green compact heads and axillary sprouts were harvested at full maturity stage with the help of sharp knife. The harvesting was carried out in stages as per the maturity of central head and secondary heads. The first harvesting of heads was started from third week of November 2015.

3.4 Observations recorded

The following observations were recorded:

3.4.1 Days taken to 50 per cent heading

This observation was recorded by visiting the experimental field daily and numbers of days were counted right from the date of transplanting of seedlings to the date, when head were matured in 50 per cent of the plants per plot.

3.4.2 Plant height at maturity (cm)

Plant height was measured from the ground level to the top of the longest leaf at the time of harvesting with the help of measuring scale. The height of randomly selected five plants was measured and the average value was expressed in centimetres.

3.4.3 Number of leaves per plant

All the fully grown leaves were counted except for the leaves attached to the heads. The number of leaves were counted randomly in selected five plants and averaged to get number of leaves per plant.

3.4.4 Head size (cm²)

Polar and equatorial diameter of each head was measured in centimetres on five randomly selected plants and accordingly multiplied to obtain the head size and mean value was worked out, which was expressed in cm².

3.4.5 Average head weight (g)

Randomly five heads from different plants were selected from each plot, their weight was recorded and average value was expressed in grams.

3.4.6 Number of spears /plant

The number of secondary marketable heads were counted on five randomly selected plants from each plot and mean value was worked out.

3.4.7 Average spears weight (g)

The weight of secondary heads was recorded on randomly selected five plants from each plot and mean value was worked out and was expressed in grams.

3.4.8 Average plant yield (g)

Total weight of terminal head and spear weight was divided by number of plants to obtain average plant yield.

3.4.9 Yield quintal per hectare (q/ha)

The yield data pertaining to central head and secondary heads was recorded on all the plants (q/ha) and accordingly yield per hectare was calculated and expressed in q/ha.

3.4.10 Shelf life (days)

Shelf life of fruits was estimated by keeping the fruits at ambient room temperature conditions till they shrunk and become unfit for consumption.

3.4.11 Total Soluble Solids (°B)

The total soluble solids content in fruits was determined by Erma Hand Refractometer (0 to 32°Brix). The refractometer was calibrated with distilled water before use and then a few drops of fruit juice were placed on the prism and the reading was recorded. A temperature correction was applied when it was above or below 20°C (AOAC, 1970). The results were expressed in °Brix.

3.4.12 Ascorbic acid (mg/100g)

Vitamin C is biochemically known as ascorbic acid, which was estimated by titrimetric method as suggested by Ranganna (1995). Aliquots were prepared by grinding of well mixed head sample along with metaphosphoric acid solution and titrated against 2,6-dichlorophenol indophenol dye to pink end point. The vitamin C content was calculated by using formula as given below:

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot taken for estimation} \times \text{weight of the sample taken (g)}} \times 100$$

$$\text{Dye factor} = \frac{0.5}{\text{Titre value (Standardization of dye with standard ascorbic acid)}}$$

3.5 Cost of cultivation

Cost of cultivation was calculated on the basis of prevailing local charges for different inputs like labourer, implements, seeds, fertilizers and other chemicals, used in cultivation of crops under different treatments.

3.5.1 Gross returns

The sale rate of broccoli heads and / spears, leaves and plant stalk yield of Broccoli were converted into gross return (Rs./ha) on the basis of prevailing local market prices of produce (broccoli heads and /spears/ leaves).

3.5.2 Net returns

The net return of each treatment was calculated by deducting the cost of cultivation from the gross return of individual treatment.

3.5.3 Benefit: Cost ratio

Benefit– cost ratio was calculated as follows:

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

3.6 Statistical analysis

The statistical analysis was carried out for each observed character under the study using MS-Excel, OPSTATE. The mean values of data were subjected to analysis of

variance and ANOVA was set as per Gomez and Gomez (1984) for Randomized Complete Block Design. For estimation of different statistical parameters, following procedure and formulae were adopted:

Analysis of variance

Source of variance	Degree of freedom	Sum of squares	Mean sum of squares		Variance ratio (V.R.)
Replication (r)	r-1	Sr	Sr/(r-1)	= Mr	Mr/Me
Treatments (t)	k-1	Sk	Sg/(t-1)	= Mt	Mt/Me
Error (e)	(r-1) (k-1)	Se	Se/(r-1) (g-1) = Me		

Where,

- r = Number of replications
- k = Number of treatments
- Sr = Sum of squares due to replications
- Sk = Sum of squares due to treatments
- Se = Sum of squares due to error
- Mr = Mean sum of squares due to replications
- Mk = Mean sum of squares due to treatments
- Me = Mean sum of squares due to error

The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one entry over the others.

The standard error and critical differences were calculated as follows:

$$SE (m) \pm = \sqrt{Me/r}$$

$$SE (d) \pm = \sqrt{2 Me/r}$$

$$CD_{0.05} = S.E. (d) \times t_{(0.05) (r-1) (k-1) df}$$

Where,

- SE (m) \pm = Standard error of mean
- SE (d) \pm = Standard error of difference
- CD_{0.05} = Critical difference at 5 per cent level of significance



CHAPTER-4

EXPERIMENTAL RESULTS



CHAPTER 4

EXPERIMENTAL RESULTS

Broccoli has been regarded as one of the nature's most valuable health promoting food capable of preventing the numerous health disorders. Now a days, broccoli attracted more attention due to its multifarious uses. It is consumed as raw, fried and cooked with other vegetables. The heads of broccoli are richest source of vitamins, proteins and antioxidants. Generally, excess amount of inorganic fertilizers are being applied for higher yield and it may cause problems for human health. Therefore, complementary use of locally available enriched manures and biofertilizers may increase yield with less use of costly fertilizers. Observations recorded on various aspects in the present studies entitled "Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck.)" are presented in this chapter. The data recorded on different characters were statistically analyzed and analysis of variance for different parameters studied has been presented in appendix II. The results so obtained in the present investigation have been described character wise here under:

4.1 Growth characters

4.1.1 Plant height at maturity (cm)

The data pertaining to plant height at maturity have been presented in Table 3 and graphically expressed in Fig 4.1. The results revealed significant differences among different treatments for plant height. Maximum plant height at maturity was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 35.45cm. It was however, found to be statistically at par with treatment T₇ (Vermicompost + Biofertilizers), 35.41cm. On the other hand, minimum plant height at maturity was recorded in treatment T₁₀ (control) 27.38cm, which was followed by T₈ (Neem cake + Biofertilizers) 30.28 cm, T₉ (Biovita granules + Biofertilizers) 30.83cm.

Table 4.1 Effect of various organic manures, biofertilizers and their combinations on plant height at maturity

Treatments	Plant height at maturity (cm) ± SE(m)
T ₁ FYM @20t/ha	31.60 ± 0.57
T ₂ Vermicompost @5t/ha	32.32 ± 0.57
T ₃ Neem cake @2t/ha	31.86 ± 0.57
T ₄ Biovita granules@50kg/ha	31.75 ± 0.57
T ₅ Biofertilizers @5kg/ ha	31.62 ± 0.57
T ₆ FYM + Biofertilizers	35.45 ± 0.57
T ₇ Vermicompost+ Biofertilizers	35.41 ± 0.57
T ₈ Neem cake + Biofertilizers	30.28 ± 0.57
T ₉ Biovita granules + Biofertilizers	30.83 ± 0.57
T ₁₀ Control	27.38 ± 0.59
SE(d)	0.84
CD (5%)	1.79

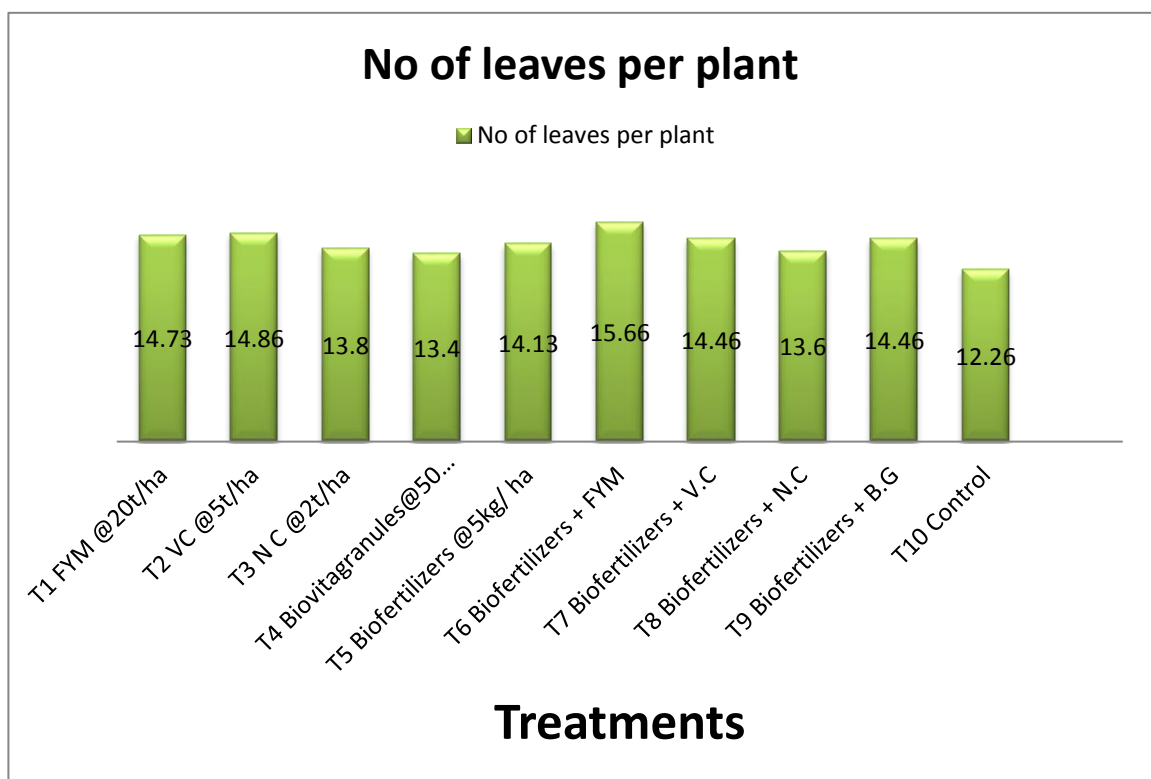
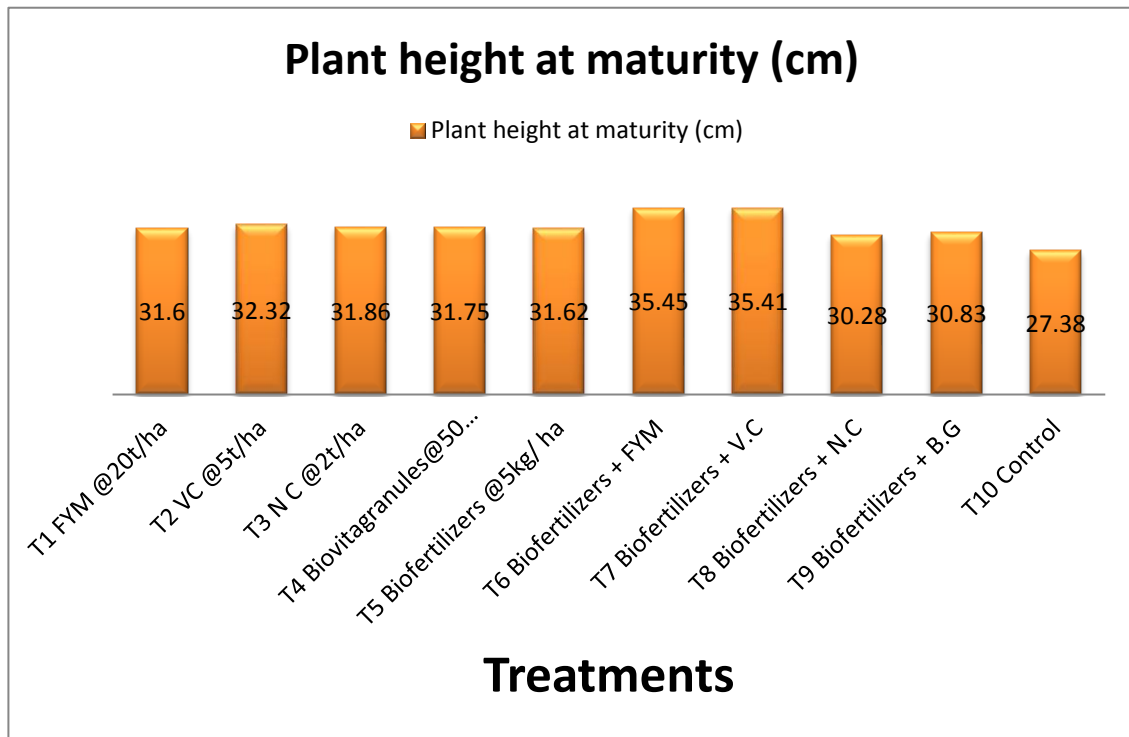
4.1.2 Number of leaves per plant

It is evident from the data presented in Table 4.2 and graphically expressed in Fig 4.1. That number of leaves per plant varied non-significant in different treatments. Maximum number of leaves per plant was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 15.66. In contrast, minimum value was registered in treatment T₁₀ (control) 12.26.

Table 4.2 Effect of various organic manures, biofertilizers and their combinations on number of leaves per plant

Treatments	No. of leaves per plant \pm SE(m)
T ₁ FYM @20t/ha	14.73 \pm 1.33
T ₂ Vermicompost @5t/ha	14.86 \pm 0.46
T ₃ Neem cake @2t/ha	13.80 \pm 0.52
T ₄ Biovita granules @50kg/ha	13.40 \pm 1.15
T ₅ Biofertilizers @5kg/ ha	14.13 \pm 0.96
T ₆ FYM + Biofertilizers	15.66 \pm 0.70
T ₇ Vermicompost + Biofertilizers	14.46 \pm 0.83
T ₈ Neem cake + Biofertilizers	13.60 \pm 1.21
T ₉ Biovita granules+ Biofertilizers	14.46 \pm 0.43
T ₁₀ Control	12.26 \pm 1.18
SE(d)	1.32
CD (5%)	2.77

Fig. 4.1 Graphical representation of effect of various organic manures, biofertilizers and their combinations on plant height at maturity / number of leaves per plant



4.1.3 Days taken to 50 per cent heading

A persual of the data presented in Table 4.3 and graphically presented in Fig 4.2, which revealed significant differences among different treatments on days taken to 50 per cent heading. Among different treatments, minimum number of days taken to 50 per cent heading were recorded in treatment T₆ (FYM + Biofertilizers) 63.40, which was found statistically at par with treatment T₁ (FYM @20t/ha) 63.60, T₇ (Vermicompost + Biofertilizers) 65.13, T₃ (Neem cake 2 t/ha) 65.73, T₂ (Vermicompost @5 t/ha) 66.73. On the other hand, maximum number of days taken to 50 per cent heading was recorded in treatment T₈ (Neem cake + Biofertilizers) 74.93. It was however, found to be statistically at par with T₅ (Biofertilizers) 70.73, and T₉ (Biovita granules + Biofertilizers) 70.73.

Table 4.3 Effect of various organic manures, biofertilizers and their combinations on days to 50 per cent heading

Treatments	Days of 50% heading ± SE(m)
T ₁ FYM @20t/ha	63.60 ± 0.83*
T ₂ Vermicompost @5t/ha	66.73 ± 0.78
T ₃ Neem cake @2t/ha	65.73 ± 2.25
T ₄ Biovita granules@50kg/ha	68.93 ± 1.57
T ₅ Biofertilizers @5kg/ ha	70.73 ± 0.83
T ₆ FYM + Biofertilizers	63.40 ± 0.11*
T ₇ Vermicompost + Biofertilizers	65.13 ± 0.83
T ₈ Neem cake + Biofertilizers	74.93 ± 0.37
T ₉ Biovita granules + Biofertilizers	70.73 ± 3.1
T ₁₀ Control	69.50 ± 4.09
SE(d)	2.39
CD (5%)	5.02

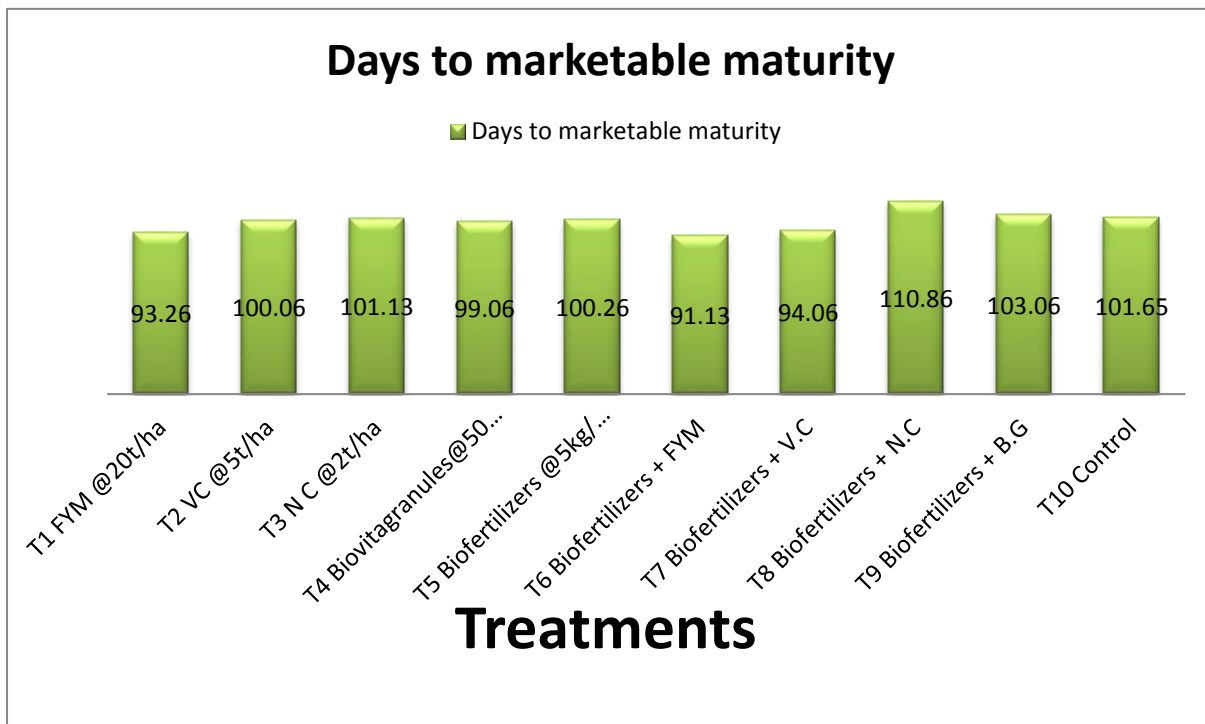
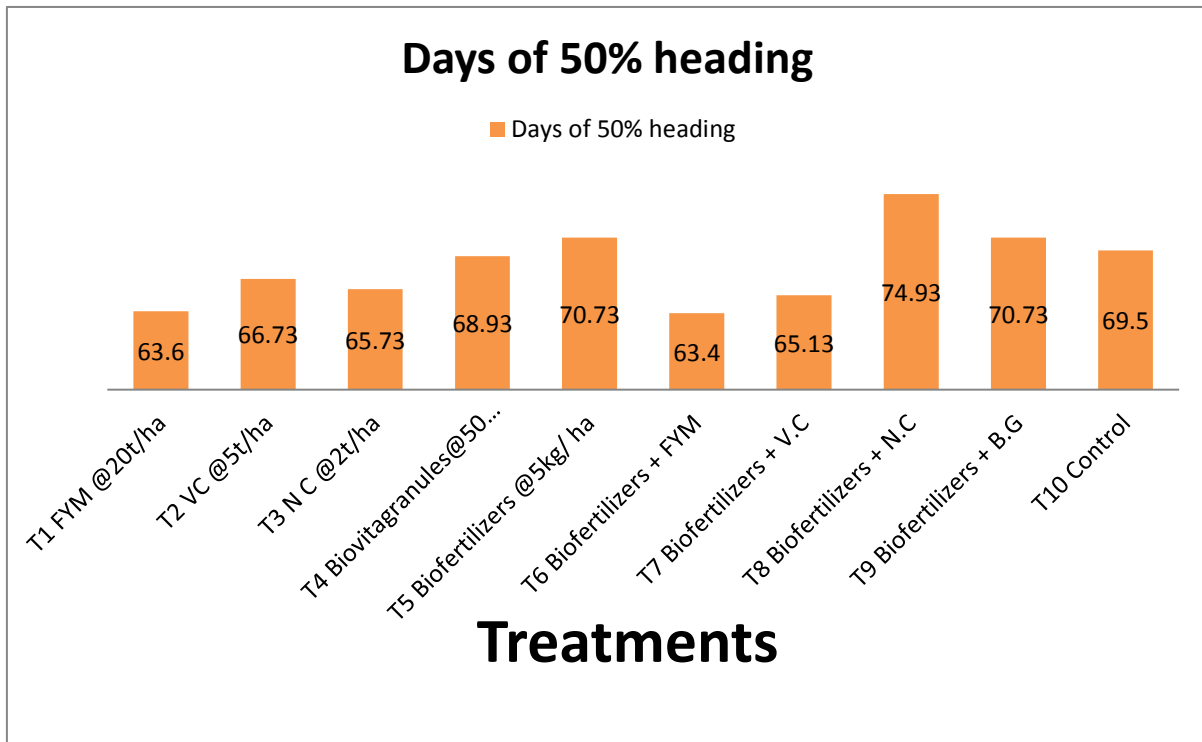
4.1.4 Days to marketable maturity

The data pertaining to number of days to marketable maturity have been presented in Table 4.4 and graphically representation in Fig 4.2, the results revealed significant differences. Among different treatments, minimum number of days to marketable maturity was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 91.13, which was statistically at par with T₁ (FYM) 93.26, T₇ (Vermicompost + Biofertilizers) 94.06 and T₄ (Biovita granules 50 kg/ha) 99.06. It was however, found to be statistically at par with T₉ (Bioita granules + Biofertilizers) 103.06. On the other hand, Maximum number of days to marketable maturity was recorded in treatment T₈ (Neem cake + Biofertilizers) 110.86.

Table 4.4 Effect of various organic manures, biofertilizers and their combinations on days to marketable maturity

Treatments	Days to marketable maturity \pm SE(m)
T ₁ FYM @20t/ha	93.26 \pm 0.88*
T ₂ Vermicompost @5t/ha	100.06 \pm 1.38
T ₃ Neem cake @2t/ha	101.13 \pm 1.16
T ₄ Biovita granules@50kg/ha	99.06 \pm 4.83
T ₅ Biofertilizers @5kg/ ha	100.26 \pm 0.96
T ₆ FYM + Biofertilizers	91.13 \pm 0.78*
T ₇ Vermicompost + Biofertilizers	94.06 \pm 0.93
T ₈ Neem cake + Biofertilizers	110.86 \pm 0.73
T ₉ Biovita granules + Biofertilizers	103.06 \pm 3.15
T ₁₀ Control	101.65 \pm 6.62
SE(d)	3.91
CD (5%)	8.22

Fig. 4.2 Graphical representation of effect of various organic manures, biofertilizers and their combinations on days to marketable maturity/ days to 50 per cent heading



4.2 Yield attributing characters

4.2.1 Polar diameter of head size (cm)

A persual of data showed in Table 4.5 and graphically presented in Fig 4.3, revealed that significant differences were observed for polar diameter of head size. Maximum head size was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 11.68cm, which was statistically at par with T₇ (Biofertilizers + Vermicompost) 11.37 cm, T₁ (FYM @20t/ha) 11.16 cm, T₅ (Biofertilizers) 10.04cm, T₄ (Biovita granules @50kg/ha) 9.90cm, T₃ (Neem cake @2t/ha) 9.74cm and T₂ (Vermicompost 5 t/ha) 9.69cm. Minimum head size was registered in T₁₀ (control) 8.13cm, which was found statistically at par with T₈ (Neem cake + Biofertilizers) 8.47cm, T₉ (Biovita granules + Biofertilizers) 9.46 cm, T₂ (Vermicompost @5t/ha) 9.69cm, T₃ (Neem cake @2t/ha) 9.74cm, T₄ (Biovita granules @50kg/ha) 9.90cm and T₅ (Biofertilizers) 10.08cm

Table 4.5 Effect of various organic manures, biofertilizers and their combinations on polar diameter of head size (cm)

Treatments	Polar diameter of head (cm) ± SE(m)
T ₁ FYM @20t/ha	11.16 ± 0.34*
T ₂ Vermicompost @5t/ha	9.69 ± 0.35
T ₃ Neem cake @2t/ha	9.74 ± 0.44
T ₄ Biovita granules@50kg/ha	9.90 ± 1.24
T ₅ Biofertilizers @5kg/ ha	10.08 ± 0.23
T ₆ FYM + Biofertilizers	11.68 ± 0.83*
T ₇ Vermicompost + Biofertilizers	11.37 ± 0.95*
T ₈ Neem cake+ Biofertilizers	8.47 ± 0.46
T ₉ Biovita granules + Biofertilizers	9.46 ± 1.10
T ₁₀ Control	8.13 ± 0.68
SE(d)	0.98
CD (5%)	2.06

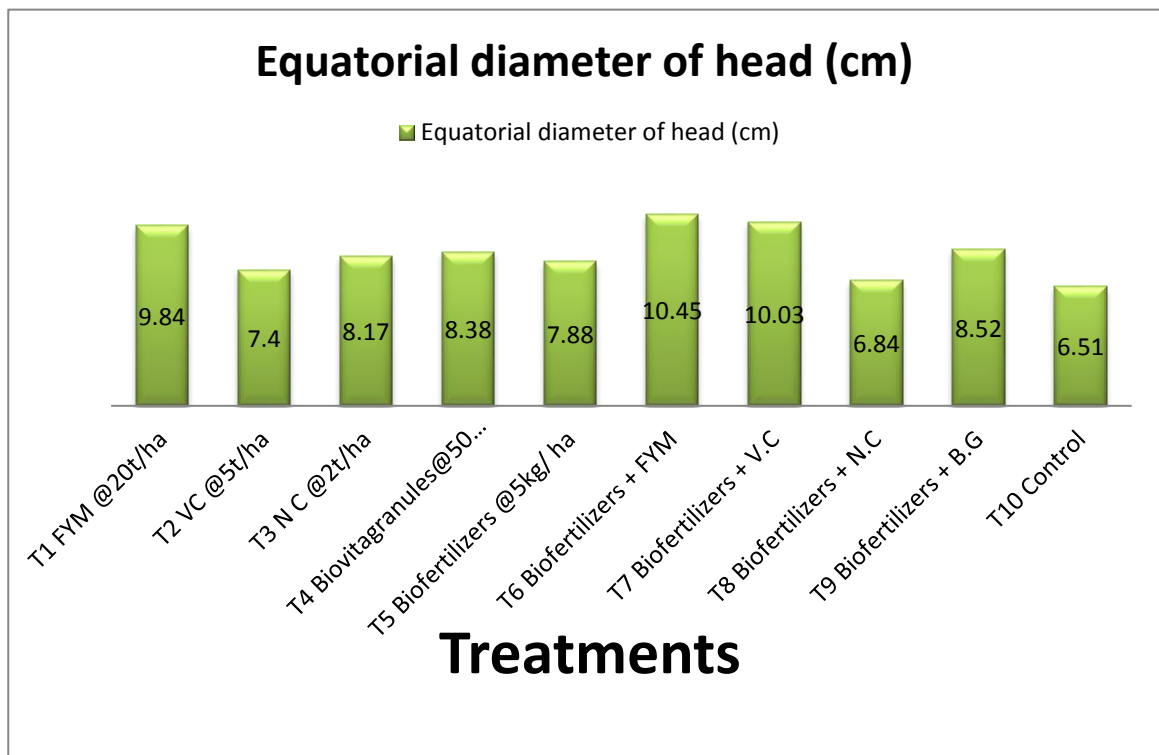
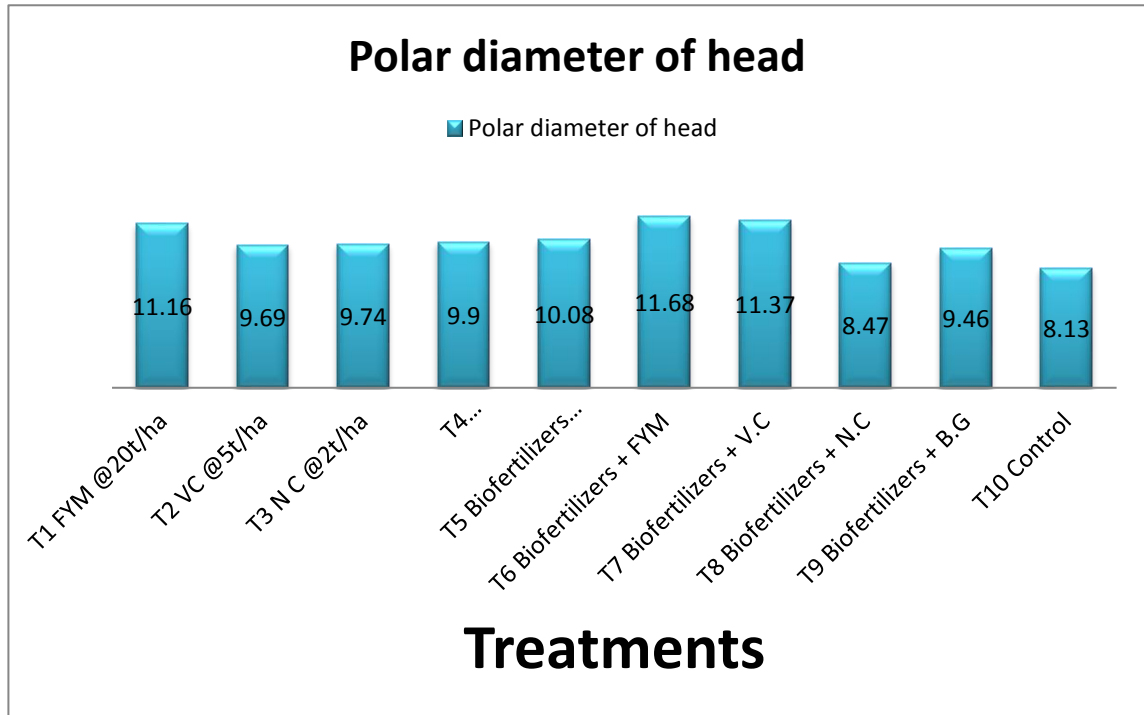
4.2.2 Equatorial diameter of head size (cm)

A perusal of data given in Table 4.6 and graphically presented in Fig 4.3, which revealed that significant differences were observed for Equatorial diameter of head size. Maximum head size was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 10.45cm, which was statistically at par with T₇ (Vermicompost + Biofertilizers) 10.03 cm, T₁ (FYM @20t/ha) 9.84 cm T₉ (Biovita granules + Biofertilizers) 8.47cm , T₄ (Biovita granules @50kg/ha) 8.38cm and T₃ (Neem cake @2t/ha) 8.17. Minimum head size was registered in T₁₀ (control) 6.51cm, which was found statistically at par with T₈ (Neem cake + Biofertilizers) 6.84cm, T₂ (Vermicompost 5 t/ha) 7.40 cm, T₅ (Biofertilizers) 7.88cm, T₃ (Neem cake @2t/ha) 8.17cm, T₄ (Biovita granules @50kg/ha) 8.38cm and T₉ (Biovita granules + Biofertilizers) 8.52cm

Table 4.6 Effect of various organic manures, biofertilizers and their combinations on equatorial diameter of head size (cm)

Treatments	Equatorial diameter of head (cm) ± SE(m)
T ₁ FYM @20t/ha	9.84 ± 1.71*
T ₂ Vermicompost @5t/ha	7.40 ± 0.54
T ₃ Neem cake @2t/ha	8.17 ± 0.92
T ₄ Biovita granules@50kg/ha	8.38 ± 1.28
T ₅ Biofertilizers @5kg/ ha	7.88 ± 0.24
T ₆ FYM + Biofertilizers	10.45 ± 0.99*
T ₇ Vermicompost + Biofertilizers	10.03 ± 0.29*
T ₈ Neem cake + Biofertilizers	6.84 ± 0.32
T ₉ Biovita granules + Biofertilizers	8.52 ± 1.47
T ₁₀ Control	6.51 ± 0.55
SE(d)	1.11
CD (5%)	2.34

Fig. 4.3 Graphical representation of effect of various organic manures, biofertilizers and their combinations on polar diameter of head size (cm) / equatorial diameter of head size (cm)





T₃ Neem cake



T₄ Biovita granules



T₃ Neem cake



T₄ Biovita granules



T₅ Biofertilizers



T₆ Biofertilizers + FYM



T₇ Biofertilizers + V.C



T₈ Biofertilizers + Neem cake



T₉ Biofertilizers + B.G



T₁₀ Control

Plate. 3 : Pictures of broccoli head

4.2.3 Terminal head weight (g)

The data presented in Table 4.7 and graphically expressed in Fig 4.4, revealed significant differences among treatments with respect to average head weight. Maximum head weight was recorded in treatment T₇ (Vermicompost + Biofertilizers) 51.96 g. It was followed by T₆ (Farmyard manure + Biofertilizers) 49.42, T₅ (Biofertilizers) 43.30. Minimum head weight of was recorded in treatment T₁₀ (control) 20.09g, and it was followed by T₈ (Neem cake + Biofertilizers) 29.76, T₂ (Vermicompost @5t/ha) 31.68.

Table 4.7 Effect of various organic manures, biofertilizers and their combinations on terminal head weight (g)

Treatments	Terminal head weight (g) ± SE(m)
T ₁ FYM @20t/ha	38.57 ± 0.00*
T ₂ Vermicompost @5t/ha	31.68 ± 0.57*
T ₃ Neem cake @2t/ha	42.51 ± 0.57*
T ₄ Biovita granules @50kg/ha	34.98 ± 1.15*
T ₅ Biofertilizers @5kg/ ha	43.30 ± 0.57*
T ₆ FYM + Biofertilizers	49.42 ± 0.57*
T ₇ Vermicompost + Biofertilizers	51.96 ± 0.57*
T ₈ Neem cake + Biofertilizers	29.76 ± 0.57*
T ₉ Biovita granules + Biofertilizers	40.01 ± 0.57*
T ₁₀ Control	20.09 ± 0.57
SE(d)	0.93
CD (5%)	1.95

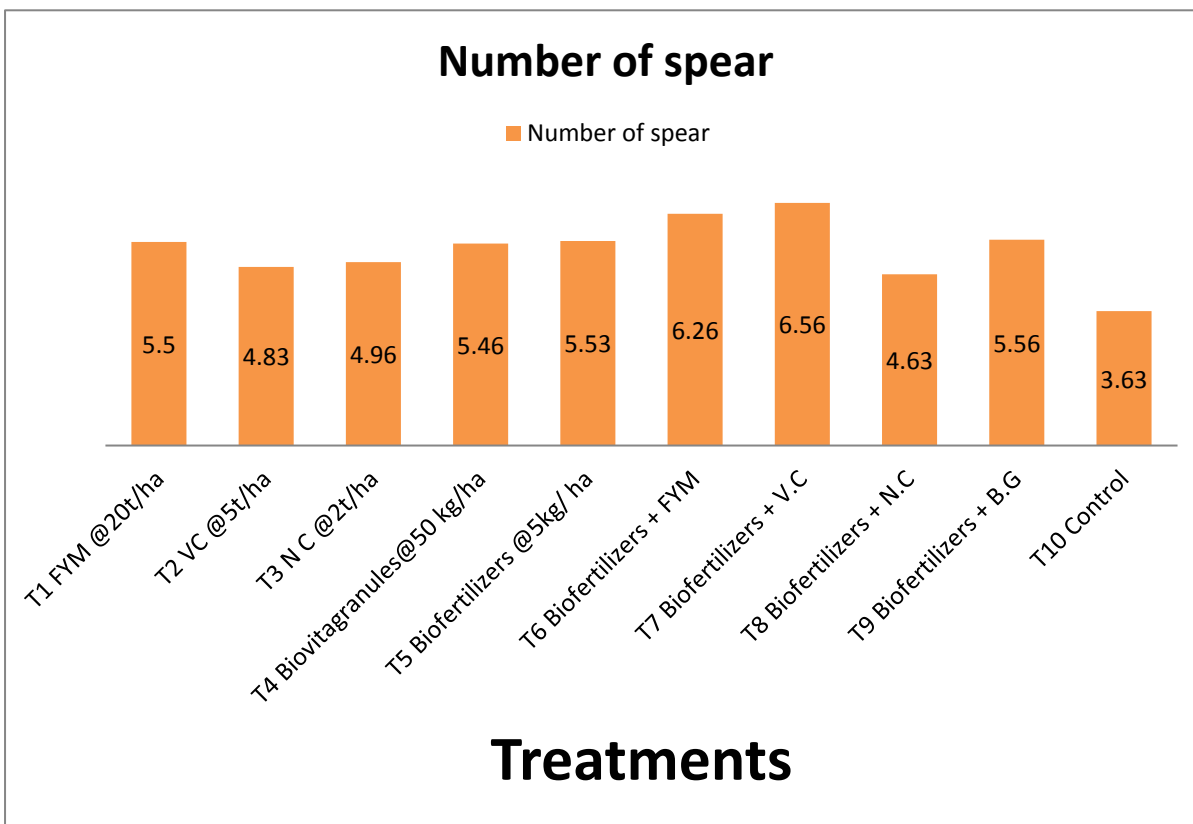
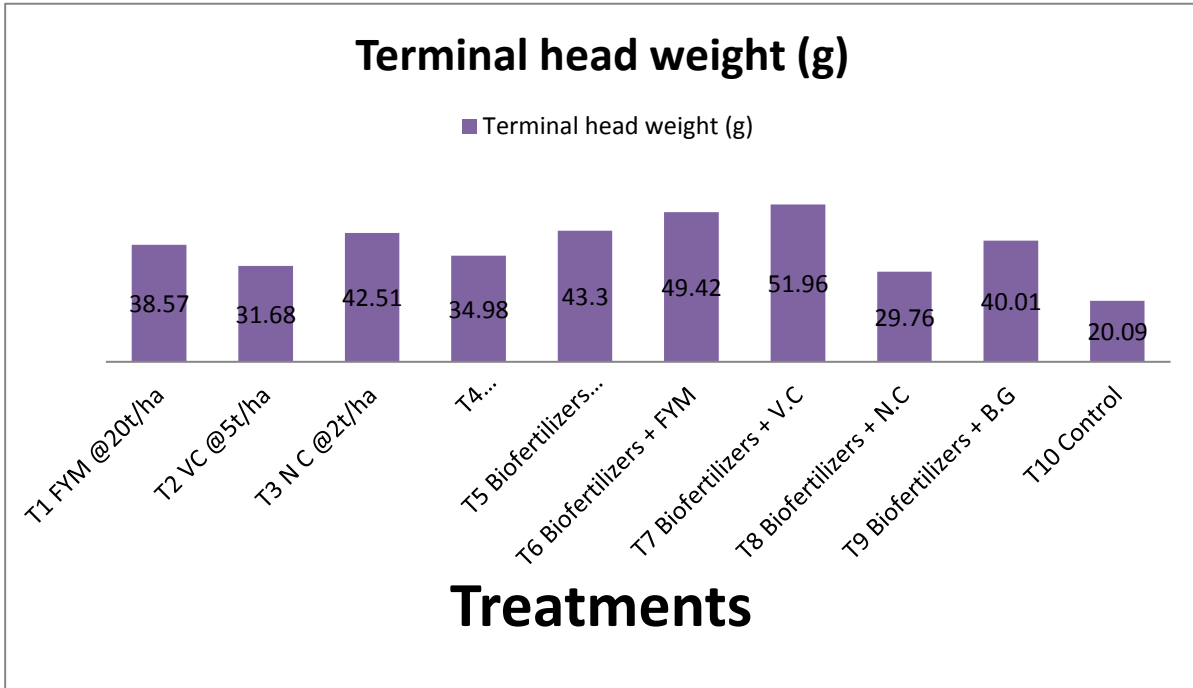
4.2.4 Number of spear per plant

It is evident from the data presented in Table 4.8 and graphically expressed in Fig 4.4 that non- significant differences were registered for number of spear per plant in different treatments. Maximum number of spear per plant were recorded in treatment T₇ (Vermicompost + Biofertilizers) 6.56. Minimum spear was recorded in treatment T₁₀ (control) 3.63.

Table 4.8 Effect of various organic manures, biofertilizers and their combinations on number of spear per plant

Treatments	Number of spear \pm SE(m)
T ₁ FYM @20t/ha	5.50 \pm 0.57
T ₂ Vermicompost @5t/ha	4.83 \pm 0.57
T ₃ Neem cake @2t/ha	4.96 \pm 0.57
T ₄ Biovita granules @50kg/ha	5.46 \pm 0.57
T ₅ Biofertilizers @5kg/ ha	5.53 \pm 0.57
T ₆ FYM + Biofertilizers	6.26 \pm 0.57
T ₇ Vermicompost + Biofertilizers	6.56 \pm 0.57
T ₈ Neem cake + Biofertilizers	4.63 \pm 0.57
T ₉ Biovita granules + Biofertilizers	5.56 \pm 0.57
T ₁₀ Control	3.63 \pm 0.57
SE(d)	0.74
CD (5%)	1.73

Fig. 4.4 Graphical representation of effect of various organic manures, biofertilizers and their combinations on terminal head weight (g) / number of spear per plant



4.2.5 Average spear weight (g)

Observations recorded on average secondary head weight have been presented in Table 4.9 and graphically expressed in Fig 4.5, revealed significant differences among different treatments. Maximum average spear weight was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 32.12g. It was statistically at par with T₇ (Vermicompost + Biofertilizers) 29.15 g, and T₃ (Neem cake @2t/ha) 28.61g. In contrast, minimum value was recorded in treatment T₁₀ (control) 20.08g, and found statistically at par with T₈ (Neem cake + Biofertilizers) 23.29g.

Table 4.9 Effect of various organic manures, biofertilizers and their combinations on average spear weight (g)

Treatments	Average spear weight (g) ± SE(m)
T ₁ FYM @20t/ha	28.61 ± 1.48*
T ₂ Vermicompost @5t/ha	24.57 ± 0.70*
T ₃ Neem cake @2t/ha	25.97 ± 1.06
T ₄ Biovita granules @50kg/ha	23.74 ± 2.02*
T ₅ Biofertilizers @5kg/ ha	25.03 ± 1.35*
T ₆ FYM + Biofertilizers	32.12 ± 1.50*
T ₇ Vermicompost + Biofertilizers	29.15 ± 0.54*
T ₈ Neem cake + Biofertilizers	23.29 ± 0.43
T ₉ Biovita granules + Biofertilizers	27.75 ± 1.14*
T ₁₀ Control	20.08 ± 1.03
SE(d)	1.23
CD (5%)	3.65

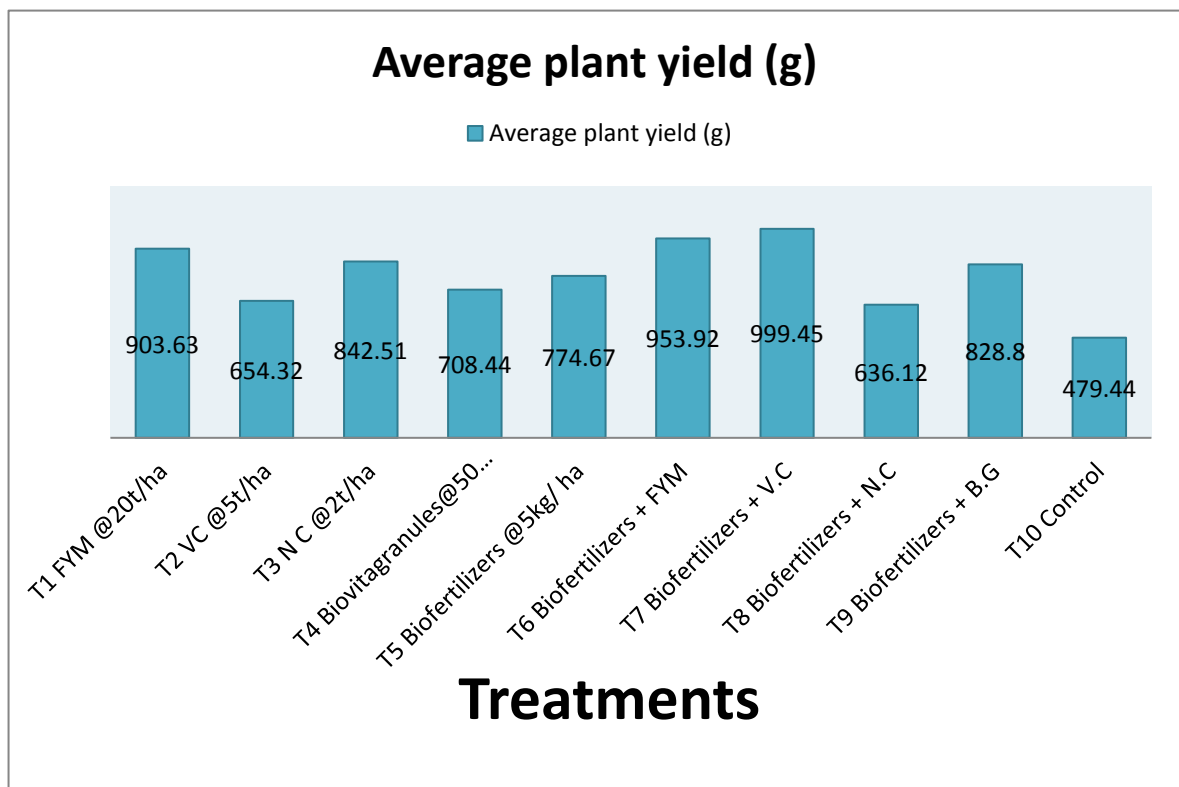
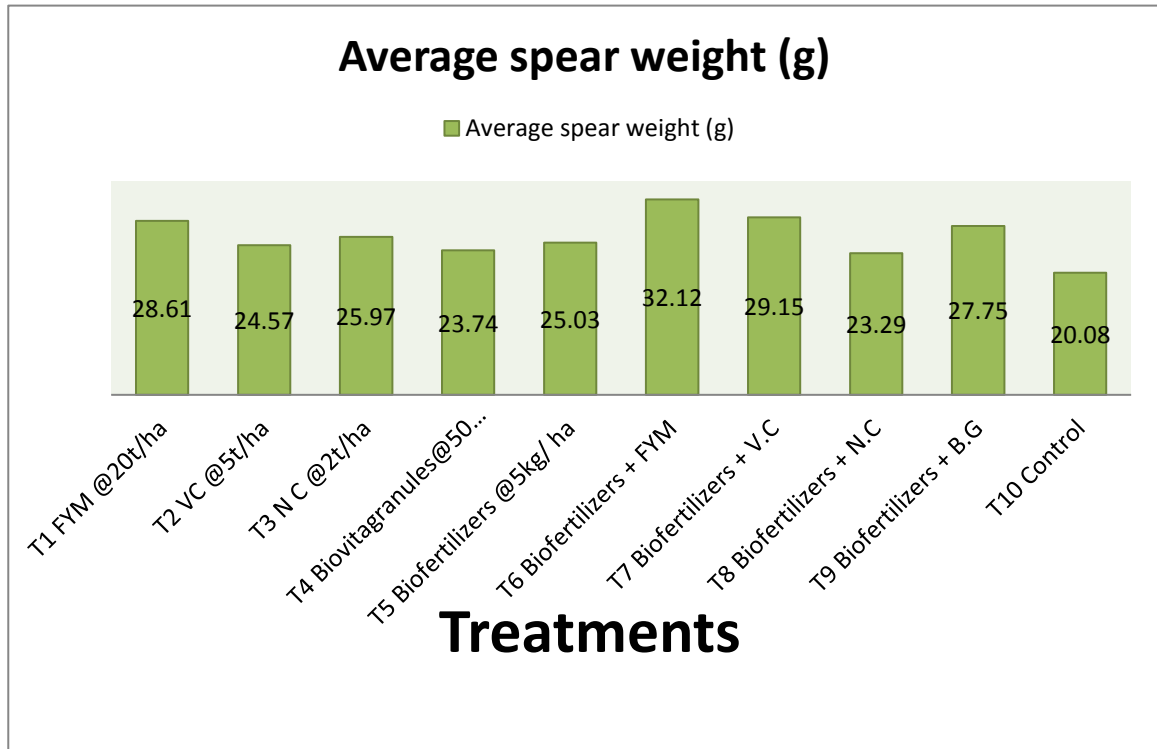
4.2.6 Average plant yield (g)

Data recorded on Average plant yield (g) have been presented in Table 4.10 and graphically expressed in Fig 4.5. The results revealed significant variations have been observed among different treatments. Maximum average yield was registered in treatment T₇ (Vermicompost + Biofertilizers) 999.45g. It was followed by T₆ (Farmyard manure + Biofertilizers) 953.92g, T₁ (FYM @ 20t/ha) 903.63g, and Minimum average yield was registered in treatment T₁₀ (control) 479.04g. It was followed by T₈ (Neem cake + Biofertilizers) 636.92g, T₂ (Vermicompost @ 5t/ha) 654.32g.

Table 4.10 Effect of various organic manures, biofertilizers and their combinations on average plant yield (g)

Treatments	Average plant yield (g) ± SE(m)
T ₁ FYM @20t/ha	903.63 ± 0.19*
T ₂ Vermicompost @5t/ha	654.32 ± 0.57*
T ₃ Neem cake @2t/ha	842.51 ± 0.57*
T ₄ Biovitagranules@50kg/ha	708.44 ± 0.57*
T ₅ Biofertilizers @5kg/ ha	774.67 ± 0.57*
T ₆ FYM + Biofertilizers	953.92 ± 0.57*
T ₇ Vermicompost + Biofertilizers	999.45 ± 0.57*
T ₈ Neem cake + Biofertilizers	636.12 ± 0.57*
T ₉ Biovita granules + Biofertilizers	828.80 ± 0.57*
T ₁₀ Control	479.44 ± 0.57
SE(d)	0.33
CD (5%)	0.58

Fig. 4.5 Graphical representation of effect of various organic manures, biofertilizers and their combinations on average spear weight (g) / average plant yield (g)



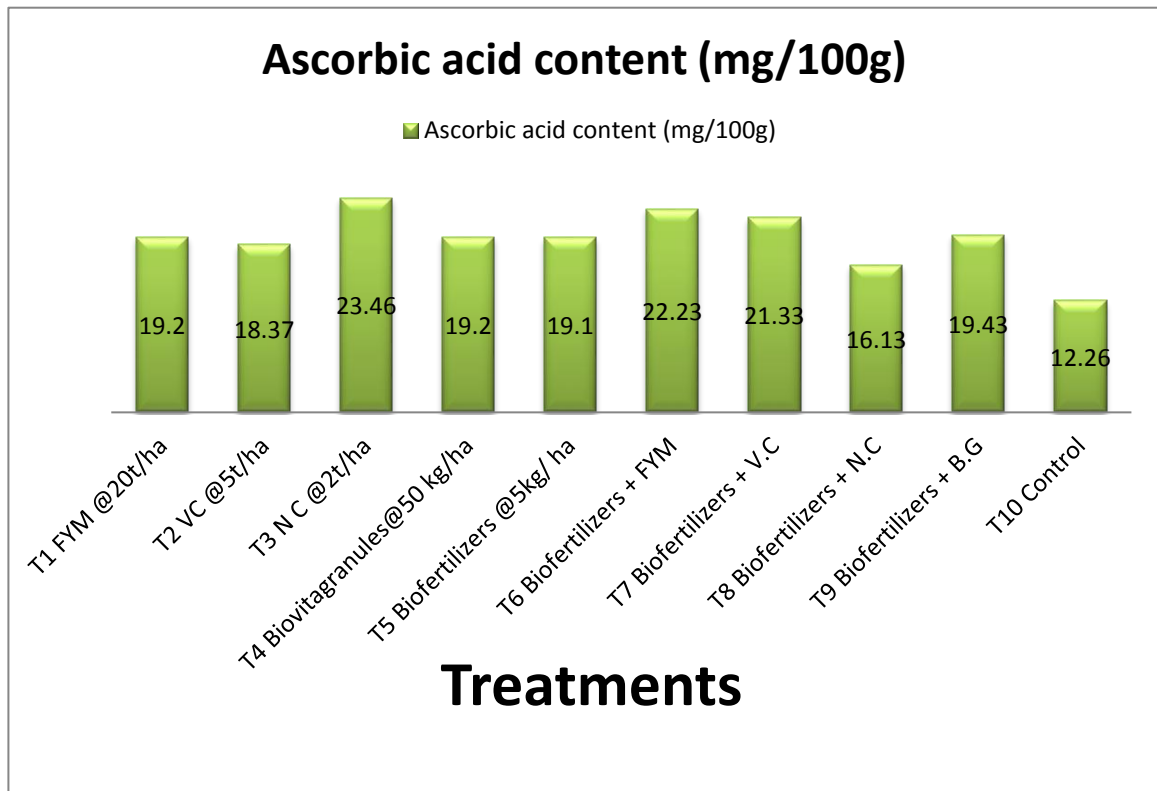
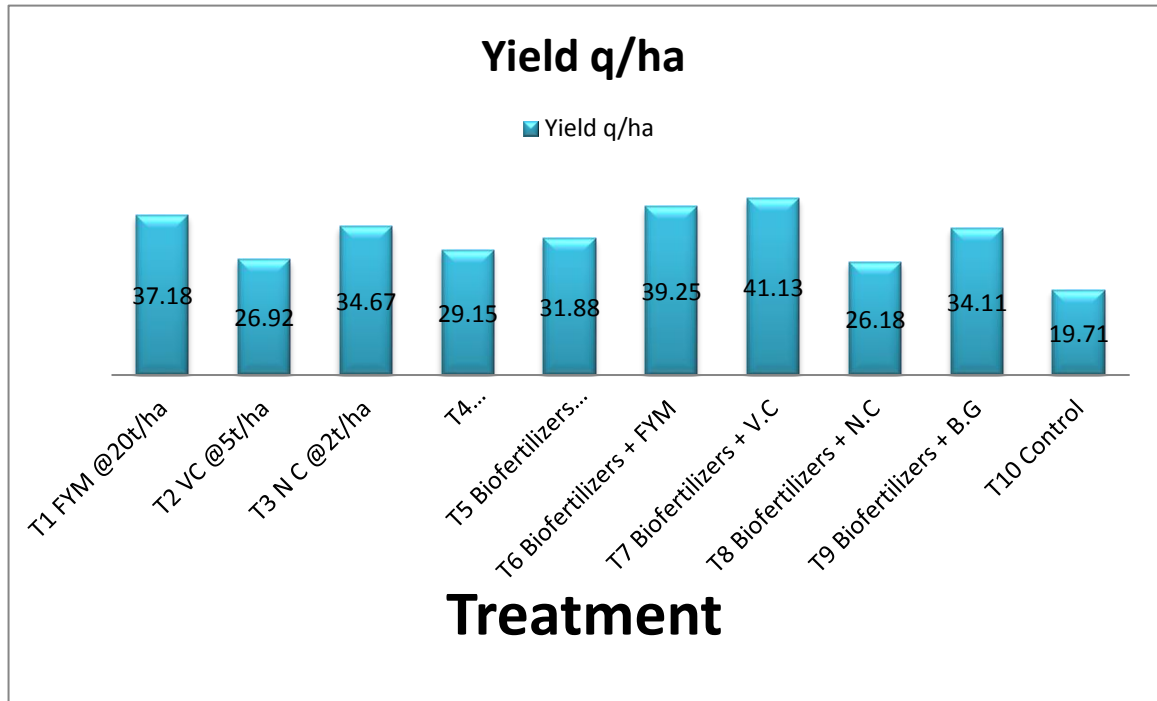
4.2.7 Yield quintal per hectare (q/ha)

The data pertaining to yield quintal per hectare have been presented in Table 4.11 and graphically representation in Fig 4.6, which showed significant differences among the treatments. Higher yield quintal per hectare was found in treatment T₇ (Vermicompost + Biofertilizers) 41.13q/ha .which was statistically at par with T₆ (FYM + Biofertilizers) 39.25 q/ha, T₁ (FYM @20t/ha) 37.18 q/ha and T₃ (Neem cake @2t/ha) 34.67q/ha. Lower yield of was recorded in treatment T₁₀ (control) 4.79 q/ha, which was statistically at par with T₈ (Biofertilizers + Neem cake) 26.18.

Table 4.11 Effect of various organic manures, biofertilizers and their combinations on yield quintal per hectare

Treatments	Yield q/ha ± SE(m)
T ₁ FYM @20t/ha	37.18 ± 1.97*
T ₂ Vermicompost @5t/ha	26.92 ± 1.37*
T ₃ Neem cake @2t/ha	34.67 ± 67*
T ₄ Biovitagranules@50kg/ha	29.15 ± 3.42*
T ₅ Biofertilizers @5kg/ ha	31.88 ± 4.11*
T ₆ FYM + Biofertilizers	39.25 ± 2.45*
T ₇ Vermicompost + Biofertilizers	41.13 ± 2.32*
T ₈ Neem cake + Biofertilizers	26.18 ± 0.77
T ₉ Biovita granules + Biofertilizers	34.11 ± 2.92*
T ₁₀ Control	19.71 ± 1.02
SE(d)	3.17
CD (5%)	6.72

Fig. 4.6 Graphical representation of effect of various organic manures, biofertilizers and their combinations on yield quintal per hectare (kg) / ascorbic acid content (mg/100g)



4.3 Quality characters

4.3.1 Ascorbic acid content (mg/100g)

The data pertaining to ascorbic content in broccoli have been presented in Table 4.12 and graphically representation in Fig 4.6 which revealed non - significant differences among various treatments. Maximum content of ascorbic acid was recorded in treatment T₃ (Neem cake) 23.46 mg/100g. In contrast, minimum value for this trait was observed in treatment T₁₀ (control) 12.26 mg/100g.

Table 4.12 Effect of various organic manures, biofertilizers and their combinations on ascorbic acid content (mg/100g)

Treatments	Ascorbic acid content (mg/100g) ± SE(m)
T ₁ FYM @20t/ha	19.20 ± 3.69
T ₂ Vermicompost @5t/ha	18.37 ± 2.59
T ₃ Neem cake @2t/ha	23.46 ± 2.82
T ₄ Biovitagranules@50kg/ha	19.20 ± 3.69
T ₅ Biofertilizers @5kg/ ha	19.10 ± 1.88
T ₆ FYM + Biofertilizers	22.23 ± 1.70
T ₇ Vermicompost + Biofertilizers	21.33 ± 3.84
T ₈ Neem cake + Biofertilizers	16.13 ± 1.73
T ₉ Biovita granules + Biofertilizers	19.43 ± 3.49
T ₁₀ Control	12.26 ± 0.58
SE(d)	3.97
CD (5%)	8.34

4.3.2 Total soluble solids (°B)

It is apparent from the data presented in Table 4.13 and graphically representation in Fig 4.8, that significant differences were observed among the treatments for the T.S.S in broccoli. Maximum T.S.S was recorded in treatment T₅ Biofertilizers @ 5kg/ ha, which was statistically at par with T₄ (Biovita granules) 11.56 ° B, T₆ (FYM + Biofertilizers) 11.26° B, T₉ (B.G + Biofertilizers) 10.96° B, T₇ (Vermicompost + Biofertilizers) 10.76 ° B, T₁ (FYM @20t/ha) 10.53° B and T₃ (Neem cake @2t/ha), 10.43° B. Minimum T.S.S was recorded in treatment T₁₀ (control) 8.43 ° B and found statistically at par with T₂ (Vermicompost @5t/ha) 8.56 ° B.

Table 4.13 Effect of various organic manures, biofertilizers and their combinations on total soluble solids (°B)

Treatments	Total soluble solids (°B) ± SE(m)
T ₁ FYM @20t/ha	10.53 ± 0.26*
T ₂ Vermicompost @5t/ha	8.56 ± 0.29
T ₃ Neem cake @2t/ha	10.43 ± 0.17*
T ₄ Biovita granules @50kg/ha	11.56 ± 0.29*
T ₅ Biofertilizers @5kg/ ha	11.56 ± 0.74*
T ₆ FYM + Biofertilizers	11.26 ± 0.12*
T ₇ Vermicompost + Biofertilizers	10.76 ± 0.17*
T ₈ Neem cake + Biofertilizers	10.90 ± 0.30*
T ₉ Biovita granules + Biofertilizers	10.96 ± 0.59*
T ₁₀ Control	8.43 ± 0.17
SE(d)	0.46
CD (5%)	0.96

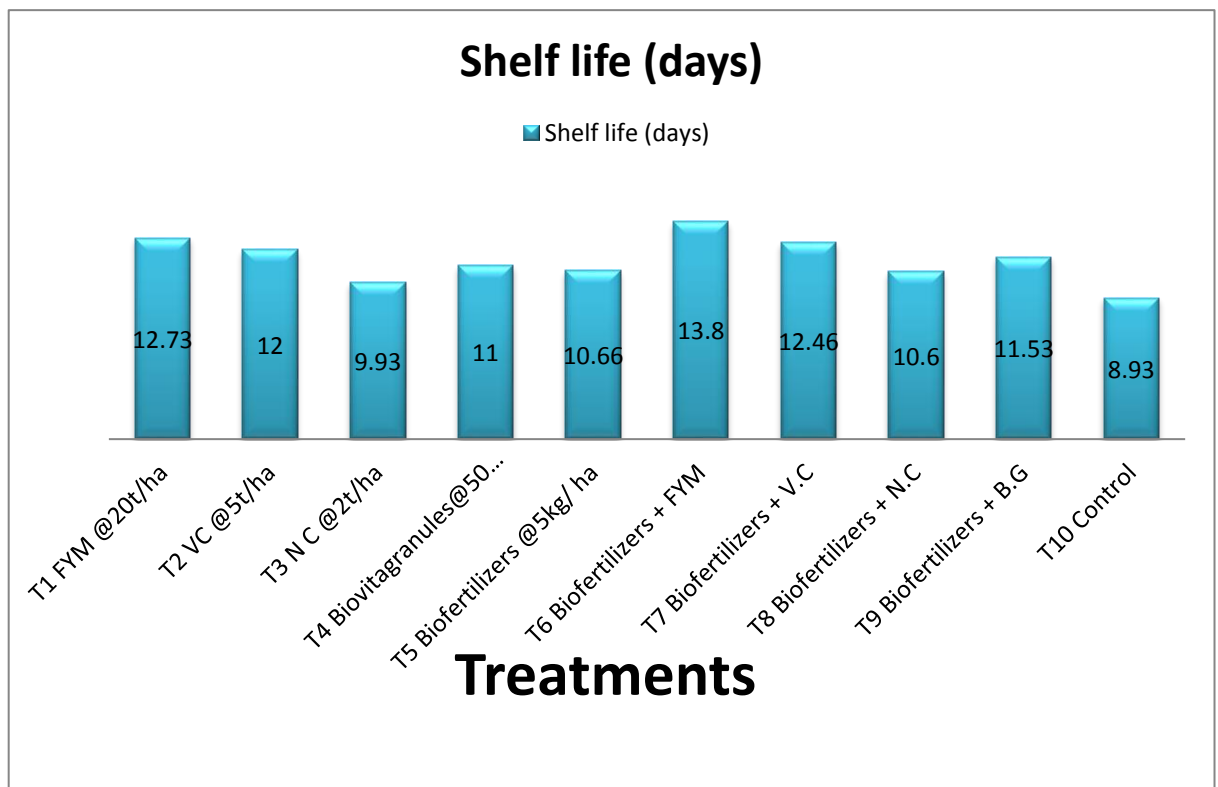
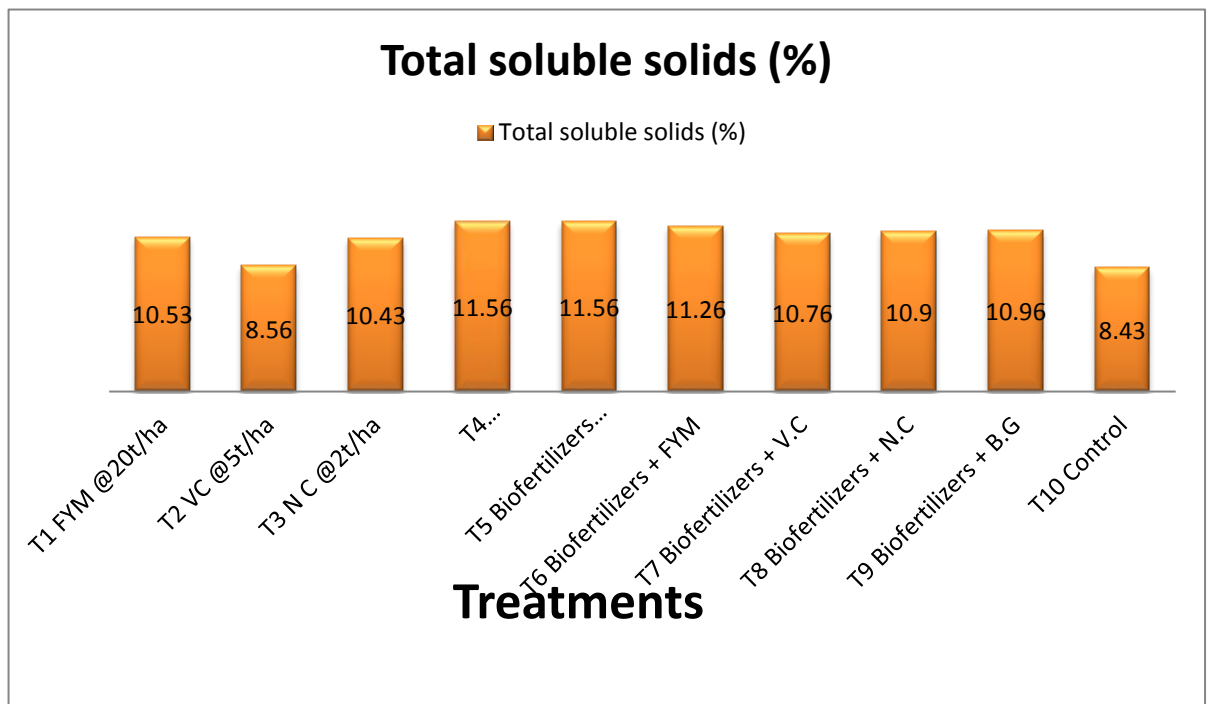
4.3.3 Shelf life (days)

It is evident from the data presented in Table 4.14 and graphically representation in Fig 4.8, exhibited significant differences among different treatments. Maximum shelf life of broccoli was recorded in treatment T₆ (Farmyard manure + Biofertilizers) 13.801. It was followed by T₁ (FYM @20t/ha) 12.73, T₇ (Vermicompost + Biofertilizers) 12.46 and T₂ (Vermicompost @5t/ha) 12.004. Minimum shelf life of broccoli was recorded in treatment T₁₀ (control) 2.0 t/ha, and found statistically at par with T₃ (Neem cake @2t/ha) 9.93.

Table 4.14 Effect of various organic manures, biofertilizers and their combinations on shelf life (days)

Treatments	Shelf life (days) ± SE(m)
T ₁ FYM @20t/ha	12.73 ± 0.13*
T ₂ Vermicompost @5t/ha	12.00 ± 0.40*
T ₃ Neem cake @2t/ha	9.93 ± 0.24*
T ₄ Biovita granules@50kg/ha	11.00 ± 0.20*
T ₅ Biofertilizers @5kg/ ha	10.66 ± 0.06*
T ₆ FYM + Biofertilizers	13.80 ± 0.11*
T ₇ Vermicompost + Biofertilizers	12.46 ± 0.40*
T ₈ Neem cake + Biofertilizers	10.60 ± 0.11*
T ₉ Biovita granules + Biofertilizers	11.53 ± 0.17*
T ₁₀ Control	8.93 ± 0.17
SE(d)	0.31
CD (5%)	0.65

Fig. 4.8 Graphical representation of effect of various organic manures, biofertilizers and their combinations on total soluble solids (⁰Brix) / shelf life (days)





T₄ Biovita granules



T₇ Biofertilizers + Vermicompost



T₆ Biofertilizers + FYM



T₁₀ Control



T₈ Biofertilizers + Neem cake

Plate. 4 : Shelf life of broccoli



T₉ Biofertilizers + Biovita granules



T₅ Biofertilizers



T₁ FYM



T₃ Neem cake



T₂ Vermicompost

Plate. 5 : Shelf life of broccoli


4.4.1 Economics of the treatments

4.4.1.1 Cost: Benefit ratio

The data pertaining to cost of cultivation for different treatments have been presented in Table 4.15 and in appendix III to appendix XIII. A persual of the data revealed that highest gross income per hectare was obtained in treatment T₇ (Vermicompost+ Biofertilizers) Rs. 329496.21, followed by in treatment T₆ (FYM + Biofertilizers) Rs. 314561.23 and treatment T₁ (FYM @20t/ha) Rs. 297959.27 whereas, lowest gross income per hectare was calculated in treatment T₁₀ (control) 158029.39. On the other hand, the highest total cost of cultivation per hectare was incurred in treatment T₇ (Vermicompost + Biofertilizers). Rs. 72812.25, followed by in treatment T₂ (Vermicompost @5t/ha) Rs.71892.25 and in treatment T₈ (Biofertilizers + Neem cake) Rs. 65043.85. The lowest cost of cultivation of was obtained in treatment T₁₀ (control) Rs. 49104.82. Net returns per hectare were however, highest in treatment T₆ (FYM+Biofertilizers) Rs. 252982.41, followed by in treatment T₇ (Vermicompost+Biofertilizers) Rs. 235592.39 and in treatment T₁ (FYM @20t/ha) Rs. 237304.45, whereas, lowest net return was calculated in treatment T₁₀ (Control) Rs. 108924.57. Maximum C:B ratio was observed in treatment T₉ (Biovita granules+ Biofertilizers) 1: 4.16, followed by treatment T₆ (Biofertilizers + FYM) 1:4.10 and in treatment T₅ (Biofertilizers @5kg/ ha) 1:4.10, whereas, minimum C:B ratio of was observed in treatment T₁₀ (control) 1:1.01


Table 4.15 Effect of organic, biofertilizers and their combinations on economics of treatments

Treatments	Yield (kg)/ha	Total Cost of Cultivation (Rs./ha)	Gross Income (Rs. / ha)	Net Return (Rs./ha)	C:B Ratio
T ₁ FYM @20t/ha	3718.66	60654.82	297959.27	237304.45	1: 3.91
T ₂ Vermicompost @5t/ha	2692.67	71892.25	215806.77	143914.52	1:2.0
T ₃ Neem cake @2t/ha	3467.13	64119.82	277785.97	213666.15	1: 3.33
T ₄ Biovita granules @50kg/ha	2915.42	51992.32	233613.51	181621.19	1: 3.49
T ₅ Biofertilizers @5kg/ ha	3187.95	50028.28	255436.54	205407.72	1: 4.10
T ₆ FYM + Biofertilizers	3925.59	61578.82	314561.23	252982.41	1: 4.10
T ₇ Vermicom + Biofertilizers	4112.98	72812.25	329496.21	256683.96	1: 3.52
T ₈ Neem cake +Biofertilizers	2617.78	65043.82	209795.04	144751.23	1:2.22
T ₉ Biovitagranules+Biofertilizers	3410.70	52916.32	273300.05	220383.73	1:4.16
T ₁₀ Control	1971.35	49104.82	98888.89	49784.07	1:1.01



CHAPTER-5

DISCUSSION



CHAPTER 5

DISCUSSION

In this present health conscious era, sprouting broccoli (*Brassica oleracea* L. var. *italica* Plenck) is gaining popularity in human diet. It is regarded as important functional food due to its high nutritional value i.e. vitamin A, protein and anticarcinogenic compounds like sulphoraphane and glucoraphanin. In the last few decades, production of vegetable crops has been enhanced manifold by the excessive use of chemical fertilizers and pesticides. Further, the indiscriminate use of chemical fertilizers will reduce yield of crops over time due to their adverse effect on soil health and fertility, which causes multi-nutrient deficiencies. Moreover, in developing country like India, chemical fertilizers are also costly. Therefore, there is urgent need to develop low cost input management practices like application of organic manure with biofertilizers for sustainable crop production. Organic manures and biofertilizers have the capabilities to provide many essential nutrients to the plants and improve the soil environment. Therefore, the application of organics and biofertilizers will minimize use of costly fertilizers inputs and results into more fertilizer use efficiency. Further, use of nutrient supply system that include organic and biofertilizers increases the yield apart from soil health.

Keeping in view the above facts, the present investigation entitled “Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck)” were carried out and the results obtained have been discussed in the light of available literature.

5.1 Growth characters

5.1.1 Days taken to 50 per cent heading

Days taken to 50 per cent heading is an important attribute in order to determine earliness of crop. In the present studies, minimum number of days taken to 50 per cent heading were recorded in treatment T₆ (FYM + Biofertilizers) 63.40. This may be due to the lesser availability of available nitrogen throughout the growing season and early conversion of vegetative stage to reproductive stage. Present findings are in line with those reported by Kumar *et al.* (2013) in broccooli. Chatterjee *et al.* (2014) in cabbage. Treatment T₈ (Neem cake + Biofertilizers) took maximum days. Further, the data also revealed that the combination of different organic, biofertilizers and reduced levels of recommended

dose of fertilizers took more days to 50 per cent heading than sole application of different manure and biofertilizers. Similar observations have been recorded by Chatterjee *et al.* (2005) in broccoli. Yadav *et al.* (2012) have also reported that application of nitrogen and biofertilizers increases the availability of available soil nitrogen content at the latter stages, which ultimately favored more uptake of nutrients and increased the vegetative growth, thereby, took more days to head formation.

5.1.2 Days to marketable maturity

The data pertaining to number of days to marketable maturity have been revealed significant variations among the treatments on vegetative growth and head characters of Broccoli. Among different treatments, minimum number of days to marketable maturity was recorded in treatment T₆ (Farmyard manure + Biofertilizers). This might be due to the increased availability of nitrogen due to the action of *Azotobacter* which is an important constituent of chlorophyll and protein thus causing more growth. FYM helps in improving soil health and it ensures proper aeration in soil and improves water holding capacity of soil. The present findings are in line with the results of Chatterjee *et al.* (2005) in broccoli, Mal *et al.* (2015) in broccoli, Kumar *et al.* (2013) in broccoli. In cabbage, Chaubey *et al.* (2006) observed that higher fertility level favoured the maturity time whereas the process of growth and development was slower at lower fertility level. On the other hand, Maximum number of days to marketable maturity was recorded in treatment T₈ (Neem cake + Biofertilizers) similar observations have been recorded by Chatterjee *et al.* (2014) in cabbage. Moreover, broccoli being a medium duration crop, quick release of nutrients favored both vegetative and reproductive growth phases.

5.1.3 Plant height at maturity

The different treatment combinations showed significant variation with respect to plant height. In the present investigation, maximum plant height at maturity was recorded in treatment T₆ (Farmyard manure + Biofertilizers). This may be attributed to better water holding capacity, supply of micro-nutrient and availability of major nutrients due to favourable soil conditions offered by the farmyard manure. Chaudhary *et al.* (2012). The present findings are in line with the results of Chatterjee *et al.* (2005) in broccoli, Pandey *et al.* (2008) in broccoli. Bhardwaj *et al.* (2007) also stated that application of biofertilizers help in secretion of growth promoting substances, which lead to better root development,

transportation of water, uptake and decomposition of nutrients. The present results are also in agreement with the findings of Sharma (2002) in cabbage and Magd *et al.* (2006) in broccoli. On the other hand, minimum plant height at maturity was recorded in treatment T₁₀ (control).

5.2 Yield attributing characters

5.2.1. Head Size

Proper head size of broccoli is one of the important parameter in order to fetch premium price in the market. In the present investigation, maximum head size was recorded in treatment T₆ (Farmyard manure + Biofertilizers). This might be due to additional supply of N through FYM, which increased the synthesis of chlorophyll and amino acid, which in turn enhanced the head size Sharma *et al.* (2002). Almost identical results have been reported by Bahadur *et al.* (2003), Kandil and Gad (2009) in broccoli. Another possible reason for larger head size may be ascribed to combined application of bio-inoculants, which resulted in significant improvement compared to individual application of biofertilizers. The higher bacterial activity due to application of bio-fertilizers also contributed towards the improvement of fertility in the soil. Sharma and Sharma (2010), Pandey *et al.* (2008) also reported the positive effect of biofertilizers in broccoli, were of the opinion that both the bio-inoculants in combination with organic manures significantly increased the head size. Similar findings of Parmar and Sharma (2001) in cauliflower, Brahma *et al.* (2002) in broccoli, Sharma *et al.* (2005) and Katiyar *et al.* (2011) in broccoli also supported the above findings.

5.2.2 Average head weight

Maximum head weight was obtained in the treatment T₇ (Vermicompost + Biofertilizers). It is probably due to the fact that biofertilizers in combination with organic fertilizers help in better root proliferation, which facilitate more uptake of nutrients and water, higher leaf number and more area responsible for effective photosynthesis and enhanced food accumulation. Vermicompost is considered as an excellent product since it is homogenous, has desirable aesthetics, reduced level of contaminates, plant growth hormones, higher level of soil enzymes, greater microbial population and tends to hold more nutrients over a longer period without adversely impacting the environment. The present findings are in line with those of Sharma (2002) and Bhardwaj *et al.* (2007) in

broccoli. According to Yadav *et al.* (2012) more average head weight was recorded due to effective utilization of nutrients for increased metabolism and synthesis of carbohydrates, thereby, resulted in increased vegetative growth and subsequent partitioning and translocation of photosynthates from leaf (source) to the head, which ultimately influenced the average head weight. Mal *et al.* (2015) in broccoli observed that vermicompost offers great potential as organic amendment and it can be used beneficially in combination with fertilizers for broccoli cultivation. The present results are in accordance with the finding of Kumar and Chaudhary (2002) in cauliflower, Chatterjee (2010) in cabbage, Wani *et al.* (2010) in cauliflower and Chaudhary *et al.* (2012) in sprouting broccoli.

5.2.3 Average spear weight (g)

Average spear weight also influences the total yield. The higher number of spear per plant and average spear weight contributed towards the total yield. In the present investigation, maximum average spear weight was recorded in treatment T₆ (Farmyard manure + Biofertilizers). Increase in secondary head weight might be due to higher and continuous nutrient availability from different sources like organic manures and biofertilizers at different stages of growth. It might have resulted in better translocation of carbohydrates to storage organs and influenced the number of lateral heads and their weight. Similar findings have also been reported by Bhardwaj *et al.* (2007) and Kumar *et al.* (2012) in sprouting broccoli and cauliflower, respectively.

5.2.4 Average plant yield (g)

Perusal of data revealed considerable variability in yield level. The results revealed significant variations have been observed among different treatments. Maximum average yield was registered in treatment T₇ (Vermicompost + Biofertilizers) 999.45g. This might be due to the combined application of the biofertilizers with organic manures produced maximum average plant yield (g) followed by application of organic manure like farmyard manure. The increase in the total yield resulting by organic manuring may be attributed to that organic manuring enhanced soil aggregation, soil aeration and increasing water holding capacity and offers good environmental conditions for the root system of broccoli plants. In addition, organic manures are slow release nutrients all over the growth season. FYM is rich in its nitrogen and nutrients content. These favourable conditions creates

better nutrients absorption and favours the growth and development of root system which in true reflects better vegetative growth, photosynthetic activity and dry matter accumulation. The reports recorded by other investigators such as Magd *et al.* (2006) on broccoli plants. The quality attributes of broccoli head were also influenced significantly in presence of vermi-compost and organic fertilizers. The present findings are in agreement with the results of Bahadur *et al.* (2003) in cabbage, Sharma *et al.* (2005) in sprouting broccoli, Singh & Singh (2005) in cauliflower, Pandey *et al.* (2008), Sharma *et al.* (2008) and Magd *et al.* (2010) in sprouting broccoli.

5.2.5 Yield q/ha

The data pertaining to yield quintal per hectare showed significant differences among the treatments. Higher yield quintal per hectare was found in treatment T₇ (Vermicompost + Biofertilizers) 41.13 q/ha. The combination of biofertilizers with organic manures produced maximum yield quintal per hectare followed by application organic manure like farmyard manure. This may be because of appropriate levels of nitrogen, which act as an integral component of many compounds including chlorophyll and enzymes that are critical for carbohydrate use within plants. This might be due to the combined application of the biofertilizers with vermicompost played a significant role in enhancing the growth. Improvement in this growth attribute with the application of vermicompost might be due to more availability of water, micro-nutrients and major nutrients because of favourable soil condition Chaudhary *et al.* (2012). The quality attributes of broccoli head were also influenced significantly in presence of vermi-compost and organic fertilizers. The present findings are in agreement with the results of Singh and Singh (2000), Sharma (2000) and Sharma *et al.* (2002) in sprouting broccoli, Bahadur *et al.* (2003) in cabbage, Sharma *et al.* (2005) in sprouting broccoli, Singh & Singh (2005) in cauliflower, Kalabandi *et al.* (2007) in cabbage, Pandey *et al.* (2008), Sharma *et al.* (2008) and Magd *et al.* (2010) in sprouting broccoli.

5.3 Quality characters

5.3.1 Total soluble solids (⁰B)

Total soluble solids content is one of the most important quality parameters in the processing industry. It represents the sum total of all fruit components other than water and volatile compounds. Mishra *et al.* (2014) in knolkhol, reported that the TSS content was

increased with the increase in the nutrient level in the treatments along with organic nutrient supplements. In the present investigation, maximum T.S.S was recorded in treatment T₄ (Biovita granules). In contrast, minimum value minimum T.S.S was recorded in treatment T₁₀ (control). Similar findings have also been reported by Kandil and Gad (2009) in broccoli, Chatterjee *et al.* (2012) in cabbage.

5.3.2 Shelf life

Shelf life has been globally identified as an important component of keeping quality and whole fruit firmness in broccoli. In the present investigation, maximum self life of broccoli was recorded in treatment T₆ (Farmyard manure + Biofertilizers). Application of organic manures influences broccoli longevity due to the increased nutrient uptake by plants and greater development of water conducting tissue. The similar findings on shelf life are in agreement with Chatterjee *et al.* (2013) in tomato, Chatterjee *et al.* (2012) in cabbage also observed that the higher shelf life in the treatments containing 75% in combination with higher amount of organic manure and biofertilizer could be due to slower rate of respiration and transpiration which might have prevented the moisture loss from the head surface resulted in delay in loosening of head therefore retained the head freshness for the longer period.

5.4 Economics of the treatments

5.4.1 Cost: Benefit Ratio

The data pertaining to cost: benefit ratio revealed that maximum cost: benefit ratio was obtained in that treatment, which fetched highest gross return. Treatment combination T₇ (Vermicompost+ Biofertilizers) registered maximum cost:benefit ratio closely followed by the treatment combination, which received organic and biofertilizers in combination treatment T₉ (Biovita granules + Biofertilizers) due to higher yield and lesser cost of Biovita Granules. The results obtained with respect to cost: benefit ratio are in line with the findings of Chaterjee *et al.* (2005) in broccoli, Bhardwaj *et al.* (2000) in cauliflower and cabbage, Sharma (2000), Sharma *et al.* (2008) and Khan *et al.* (2010) in cauliflower, whereas, minimum benefit: cost ratio was obtained in the treatment T₁₀ i.e. (control) due to lesser yield, ultimately lesser gross income and lesser net return, taking into consideration all aspect, it can be concluded that application of organic, and biofertilizers in combination gave higher cost: benefit ratio as compare to sole application of different nutrient sources and biofertilizers. Therefore, balance nutrition in integration is essential to enhance the

cost: benefit ratio in broccoli Dass *et al.* (2008) and Maurya *et al.* (2008). Mishra *et al.* (2014) in knolkhol, reported that the benefit: cost ratio was found to be higher in FYM treatment due to higher cost of the vermicompost. If the farmer can have his own vermicompost production the benefit of its use can be better realised.



CHAPTER-6

SUMMARY AND CONCLUSION



CHAPTER 6

SUMMARY AND CONCLUSION

The present investigation entitled “Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck)” was carried out at the Organic and Dairy Block, College of Horticulture, Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand from August 2015, to find out the most suitable and economical combination of organic, and biofertilizers for growth, yield and quality parameters. All the standard package of practices were followed for raising healthy crop. The experimental detail consisted of 10 treatments. The observations were recorded on plant height at maturity (cm), number of leaves per plant, days taken to 50 per cent heading, days to marketable maturity, head size (cm²), polar diameter of head, equatorial head weight, terminal head weight (g), number of spear /plant, average spear weight (g), average plant yield (g) and yield per hectare (kg), ascorbic acid (mg/100 g), total soluble solids (⁰Brix), shelf life (days) and cost : benefit ratio. The salient findings of the investigation are summarized as follows:

6.1 Growth characters

- Maximum plant height 35.45cm at maturity was obtained in treatment T₆ i.e, Farmyard manure + Biofertilizers, whereas, least plant height at maturity were recorded in treatment T₁₀ (control) 27.38cm.
- The data revealed that days taken to 50 per cent heading was earliest in T₆ (Farmyard manure + Biofertilizers) 63.40, and maximum in treatment T₈ (Neem cake + Biofertilizers) 74.93.
- Minimum number of days to marketable maturity 91.13 was recorded in treatment T₆ i.e, Farmyard manure + Biofertilizers. On the other hand, Maximum number of days to 110.86 marketable maturity was recorded in treatment T₇ (Neem cake + Biofertilizers)

6.2 Yield attributing characters

- Larger head size i.e. polar diameter and equatorial diameter, was recorded maximum in treatment T₆ (Farmyard manure + Biofertilizers) 11.68cm and 10.45cm respectively.

- Terminal head weight and average spear weight was recorded maximum in treatment T₇ (Vermicompost + Biofertilizers) 51.96g and T₆ (Farmyard manure + Biofertilizers) 32.12g respectively. On the other hand, minimum terminal head weight and average spear weight was recorded in treatment T₁₀ (control).

6.3 Head yield character

- Average plant yield (999.45g) and yield per hectare (41.13q/ha) was recorded to be maximum in the plots receiving Vermicompost + Biofertilizers, i.e T₇, whereas minimum yield in treatment T₁₀ (control).

6.4 Quality character

- All the quality characters studied i.e. total soluble solids (⁰Brix), shelf life (days) were maximum in T₅ (Biofertilizers @5kg/ha) 11.56 (⁰Brix) and T₆ (Farmyard manure + Biofertilizers) 13.80 respectively, whereas minimum quality characters was recorded in treatment T₁₀ (control).

6.5 Economics of treatments

- Maximum cost: benefit ratio of was observed in treatment T₉ (Biofertilizer + Biovita granules) 1:4.16 with a total net returns of Rs. 220383.73 and minimum C:B ratio was found in T₁₀ (control) 1:1.01.

Conclusion

Thus from the present study, it can be concluded that treatment T₇ (Biofertilizer + Vermicompost) followed by T₆ (Bio fertilizer + Farmyard manure) can give maximum yield in broccoli cv. Green Head. Owing to the economy of production, T₆ (Bio fertilizer + Farmyard manure) can be recommended for commercial cultivation in long run for sustainable crop production as it maintains the soil health and ultimately improves the productivity of the crop. Further, application of Biofertilizers and Biovita granules in combination gave higher cost benefit ratio (1:4.16) as compared to the sole application of nutrients from different sources and biofertilizers. Thus, balance integration of nutrients is essential for enhancing the production and economic returns in the broccoli.



CHAPTER-7

LITERATURE CITED



CHAPTER 7

LITERATURE CITED

Akbar P I, Kumar V and Malik M F. 2009. Effect of bio-organic fertilizers on the performance of cabbage under western UP conditions. *Annals of Horticulture* 2(2): 204-206.

Anonymous. 2015. www.omaf.gov.on.ca.

AOAC. 1970. Official and tentative methods of analysis. Association of official Analytical Chemists. William Star Wetglad. Washington.

Ashokan R, Mohandas S and Anand L. 2000. Biofertilizers and biopesticides for horticultural crops. *Indian Horticulture* 2: 44-52.

Bahadur A, Singh J and Singh K P. 2004. Response of cabbage to organic manures and biofertilizers. *Indian Journal of Horticulture* 61(3): 178-179.

Bahadur A, Singh J, Singh K P, Upadhyay A K and Rai Mathura. 2006. Effect Of Organic Amendments And Biofertilizers On Growth, Yield And Quality Attributes Of Chinese Cabbage (*Brassica Pekinensis*). *Indian Journal of Agricultural Sciences* 76(10): 596-598.

Bahadur A, Singh J, Upadhyay A K and Singh K P. 2003. Effect Of Organic Manures And Biofertilizers On Growth, Yield And Quality Attributes Of Broccoli (*Brassica Oleracea* L Var./*Italica Plenck*). *Vegetable Science* 30(2): 192-194.

Bhardwaj A K, Kumar P and Singh R K. 2007. Response of Nitrogen and Pre-Planting Treatment Of Seedlings With The *Azotobacter* On Growth And Productivity Of Broccoli (*Brassica Oleracea* Var. *Italica*). *The Asian Journal of Horticulture* 2(1): 15-17.

Bhardwaj M L, Harender Raj and Koul B L. 2000. Yield response and economics of organic sources of nutrients as substitute to inorganic sources in tomato (*Lycopersicon esculentum*), okra (*Abelmoschus esculentus*), cabbage (*Brassica oleracea* var. *capitata*) and cauliflower (*B. oleracea* var. *botrytis*). *Indian Journal of Agricultural Sciences* 70(10): 653-656.

- Bhardwaj S K, Sharma S D and Kumar P. 2012. Effect of conjoint use of bio-organics and chemical fertilizers on yield, soil properties under french bean – cauliflower based cropping system. *Archives of Agronomy and Soil Science* 58(7): 759-763.
- Bisht A S and Sharma K D. 2014. Plant utilization by the communities of Bharsar and adjoining area of Pauri Garhwal District, Uttarakhand, India. *Biodiversitas* 15(1):94-100.
- Brahma S, Phookan D B, Gautam B P and Dora D K. 2002. Effect of Nitrogen, Phosphorus And Potassium on Production Of Sprouting Broccoli (*Brassica Oleracea* Var *Italica*) Cv. Kts-1. *Vegetable Science* 29(2): 154-156.
- Chander G, Verma T S and Sharma S. 2010. Nutrient content of cauliflower (*Brassica oleracea* L. var. *botrytis*) as influenced by boron and farmyard manure in north west Himalayan alfisols. *Journal of the Indian Society of Soil Science* 58(2): 248-251.
- Chatterjee B, Ghanti P, Thapa U and Tripathy P. 2005. Effect of Organic Nutrition In Sprouting Broccoli (*Brassica Oleracea* L. Var. *Italica* Plenck). *Vegetable Science* 32(1): 51-54.
- Chatterjee R, Bandhopadhyay S and Jana J C. 2014. Organic Amendments Influencing Growth, Head Yield And Nitrogen Use Efficiency In Cabbage (*Brassica Oleracea* Var. *Capitata* L.) *American International Journal of Research In Formal, Applied & Natural Sciences* 5(1): 90-95.
- Chatterjee R, Jana J C and Paul P K. 2012. Enhancement of head yield and quality of cabbage (*Brassica oleracea*) by combining different sources of nutrients. *Indian Journal of Agricultural Sciences* 82(4): 323-327.
- Chatterjee R, Jana J C and Paul P K. 2013. Vermicompost Substitution Influences Shelf Life And Fruit Quality of Tomato (*Lycopersicon Esculentum* Mill.) *Columbia International Publishing American Journal of Agricultural Science and Technology* 1: 69-76.
- Chatterjee R. 2010. Physiological attributes of cabbage as influenced by different sources of nutrient under Eastern Himalayan Region. *Research Journal of Agriculture Science* 1(4): 318-321.

- Chaubey T, Srivastava B K, Singh M, Chaubey P K And Rai M .2006. Influence Of Fertility Levels And Seasons on Maturity And Morphological Traits of Cabbage. *Vegetable Science* 33(1) : 29-33.
- Choudhary S, Soni A K and Jat N K. 2012. Effect of organic and inorganic sources of nutrients on growth, yield and quality of sprouting broccoli cv. CBH-1. *Indian Journal of Horticulture* 69(4): 550-554.
- Choudhury M R, Saikia A and Talukdar N C. 2004. Response of cauliflower to integrated nutrient management practices. *Bioved* 15: 83-87.
- Dalal V V, Bharadiya P S and Aghav V D. 2010. Effect of organic and inorganic sources of nitrogen on growth and yield of cabbage (*Brassica oleracea* L. var. *capitata*). *Asian Journal of Horticulture* 5(2): 291-293.
- Dass A, Lenka N K, Patnaik U S and Sudhishri S. 2008. Integarted nutrient management for production, economics and soil improvement in winter vegetables. *International Journal of Vegetable Science* 14(2): 104-120.
- Devi H J, Maity T K and Paria N C. 2003. Effect of different sources of nitrogen on yield and economics of cabbage. *Environment and Ecology* 21(4): 878-880.
- Gomez K A and Gomez A A. 1984. Statistical procedures for agricultural research. John Wiley and Sons Inc., New York. pp. 357-427.
- Gupta A K and Samnotra R K. 2004. Effect of biofertilizers and nitrogen on growth, quality and yield of cabbage (*Brassica oleracea* L.var. *capitata*) cv Golden Acre. *Environment and Ecology* 22(3): 551-553.
- Gupta A, Sharma N and Samnotra R K. 2010. Effect of biofertilizers and nitrogen on growth, yield and quality traits in knol khol (*Brassica oleracea* L. var *gongylodes*). *Asian Journal of Horticulture* 5(2): 294-297.
- Jackson M L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Pvt. Ltd. New Delhi.
- Kachari M and Korla B N. 2009. Effect of biofertilizers on growth and yield of cauliflower cv. PSB K-1. *Indian Journal of Horticulture* 66(4): 496-501.

- Kachari M and Korla B N. 2012. Studies on influence of biofertilizers on quality economics of cauliflower cv. PSB K-1 production. *Indian Journal of Horticulture*. 69(2): 215-220.
- Kalabandi B M, Dabhande R S and More S S. 2007. Effect of organic and inorganic fertilizer on growth, yield and quality of cabbage (*Brassica oleracea* var. capitata). *Asian Journal of Horticulture* 2(2): 144-147.
- Kamla K, Paliyal S S and Nandal T R. 2002. Integrated nutrient management in cauliflower (Pusa Snow Ball K-1). *Research on Crops* 3(3): 579-583.
- Kandil H and Gad N. 2009. Effects Of Inorganic And Organic Fertilizers On Growth And Production Of Broccoli (*Brassica Oleracea* L.). *Factori Și Procese Pedogenetice Din Zona Temperată 8 S. Nouă* 61-69.
- Katiyar D, Tripathi S M, Dwivedi A K and Pandey V. 2011. Studies on the interaction and economics of nitrogen and phosphorus on crop growth, relating traits of broccoli (*Brassica oleracea* L. var. italica). *Annals of Horticulture* 4(2): 176-180.
- Khan N, Dubey A P, Ram P and Mishra A. 2009. Integrated nutrient management in broccoli (*Brassica oleracea* L. italica Plenck). *Plant Archives* 9(1): 423-425.
- Khan N, Singh S K, Srivastava J P and Siddiqui M Z. 2010. Effect of biofertilizers on production potential and economic feasibility of cauliflower (*Brassica oleracea* L. var. botrytis). *Progressive Agriculture* 10(2): 371-373.
- Khan N, Srivastava J P and Singh S K. 2009. Effect of bio fertilizers on production potential of cauliflower (*Brassica oleracea* L. var. botrytis). *Annals of Horticulture* 2(1): 122-123.
- Khare R K and Singh K. 2008. Effect of biofertilizers and nitrogen on growth and yield of cabbage. *Orissa Journal of Horticulture* 36(1): 37-39.
- Kumar A, Parmar D K and Suri V K. 2012. Effect of born fertilizers and organic manure on autumn cauliflower in western Himalayas. *Annals of Horticulture* 5(1): 17-24.
- Kumar M, Das B, Prasad K K And Kumar P. 2013. Effect Of Integrated Nutrient Management On Growth And Yield Of Broccoli (*Brassica Oleracea* Var. Italica) Under Jharkhand Conditions. *Vegetable Science* 40(1): 117-120.

- Kumar M, Kumari P, Ojha R K, Kumar A And Prasad K K. 2012. Effect Of Temperature On Growth And Yield Of Broccoli Under Integrated Nutrient Management. *Progressive Horticulture*. 44(2): 307-312.
- Kumar S and Choudary D R. 2002. Effect of FYM, molybdenum and boron application on yield attributes and yield of cauliflower. *Crop Research*. 24: 494-496.
- Kumar S, Verma M K and Yadav Y C. 2011. Studies on effect of biofertilizers with chemical fertilizers on growth and yield of cauliflower (*Brassica oleracea* L var botrytis) cv Pusa Snowball K-1. *Annals of Horticulture*. 4(2): 202-205.
- Kumar V, Kumar V, Tyagi A K, Singh B and Kumar N. 2010. Effect of vermicompost and VAM inoculation on growth and yield of cauliflower (*Brassica oleracea* L.var. botrytis). *Progressive Agriculture* 10: 197-199.
- Magd E, Sawan M M and Zaki M F. 2010. Productivity and quality of two broccoli cultivars as affected by different levels of nitrogen fertilizers. *Australian Journal of Basic and Applied Sciences* 4(12): 6125-6133.
- Magd M A, Bassiony A M and Fawzy Z F. 2006. Effect of organic manure with or without chemical fertilizers on growth, yield and quality of some varieties of broccoli plants. *Journal of Applied Sciences Research* 2(10): 791-798.
- Mal D, Chatterjee R and Nimbalkar K H. 2015. Effect of Vermi-Compost And Inorganic Fertilizers on Growth, Yield And Quality of Sprouting Broccoli (*Brassica Oleracea* L. Var. *Italica Plenck*). *International Journal of Bio-Resource and Stress Management* 5(4):507-512.
- Mandal J, Ghosh C, Chattopadhyay G N. 2013. Proportional Substitution of Chemical Fertilizers With Vermi-Compost on Growth And Production Potential of Onion (*Allium Cepa* L.) *International Journal of Bio- Resource And Stress Management* 4(2) : 356-357.
- Manivannan M I and Singh J P. 2004. Effect of biofertilizers on the growth and yield of sprouting broccoli (*Brassica oleracea* var. *Italica Plenck*) under Allahabad agro-climatic conditions. *Bioved* 15(1/2): 33-36.

- Maurya A K, Singh M P, Srivastava B K, Singh Y V, Singh D K, Singh S and Singh P K. 2008. Effect of organic manures and inorganic fertilizers on growth characters, yield and economics of sprouting broccoli cv. Fiesta. *Indian Journal of Horticulture* 65(1): 116-118.
- Meena M L, Ram R B, Singh M K and Yogita. 2011. Effect of nitrogen, phosphorus and potassium on growth, yield and quality of cabbage (*Brassica oleracea* L. var. *capitata*). *Environment and Ecology* 29(3): 1109-1111.
- Merwin H D and Peech M. 1951. Exchangeability of soils potassium in the silt and clay fractions as influenced by the nature of the complimentary exchangeable cations. *Soil Science Society of American Proceedings* 15: 125-128.
- Michaud D S, Pieti nen P, Taylor P R, M Virtanen, Virtamo J and Albanes D. 2002. Intakes of fruits and vegetables, carotenoids and vitamin A, E, C in relation to the risk of bladder cancer in the ATBC cohort study. *International Journal of Cancer* 87: 960-965.
- Mishra P P, Das A K and Mishra N. 2014. Effect of Integrated Nutrient Management On Yield, Quality And Economics Of Knolkhol (*Brassica Oleracea* L. Cv. *Gongylodes*). *The Asian Journal of Horticulture* 9(2):382-385.
- Nath G and Singh K. 2011. Role of vermicompost as biofertilizer for the productivity of cauliflower (*Brassica oleracea*) and biopesticides against nematode (*Meloidogyne incognita*). *World Applied Sciences Journal* 12(10): 1676-1684.
- Olsen S R, Cole C V, Watanable F S and Dean L A. 1954. Estimation of available phosphorous in soil by extraction with sodium bicarbonate. *USDA Circular* 939: 1-19.
- Padamwar S B and Dakore H G. 2009. Influence of organic fertilizers on morphological and nutritional parameters of cauliflower. *Bioinfolet* 6(2): 158-160.
- Padamwar S B and Dakore H G. 2010. Role of vermicompost in enhancing nutritional value of some cole crops. *International Journal of Plant Sciences* 5(1): 397-398.
- Pandey A K, Mishra R K and Rai M. 2008. Influence of soil amendments and Azotobacter on growth and yield of broccoli (*Brassica oleracea* L var *italica*). *Vegetable Science*. 35(2): 165-168.

- Parmar D K and Sharma V. 2001. Integrated nutrient management in cauliflower under mid hills of Western Himalayas. *Annals of Agricultural Research* **22**: 432-433
- Piper C S. 1966. Soil and Plant analysis. Bombay Hansa Publishers. pp. 59-75
- Ramesh P, Panwar N R, Singh A B, Ramana S, Yadav S K and Rao A S. 2010. Status of Organic Farming in India. *Current Science* **98(9)**: 1190-1194.
- Ranganna S. 1995. *Handbook of analysis and quality control for fruit and vegetable products*. 2nd edition. Tata McGraw Hills Education Private Limited. New Dehli. 1112p.
- Sable P B and Bhamare V K. 2007. Effect of biofertilizers (*Azotobacter* and *Azospirillum*) alone and in combination with reduced levels of nitrogen on quality of cauliflower cv. Snowball - 16. *Asian Journal of Horticulture* **2(1)**: 215-217.
- Sarangthem I, Misra A D D and Chakraborty Y. 2011. Cabbage productivity, nutrient uptake and soil fertility as affected by organic and bio-sources. *Agricultural Science Digest* **31(4)**: 260-264.
- Sharma A, Parmar D K, Kumar P, Singh Y and Sharma R P. 2008. *Azotobacter* soil amendment integrated with cow manure reduces need for NPK fertilizers in sprouting broccoli. *International Journal of Vegetable Science*. **14(3)**: 273-285.
- Sharma A, Sood S, Sharma J J, Kumar Rakesh. 2005. Effect of planting date, plant density and fertilizer levels on sprout yield and yield-attributing characters of brussels-sprout (*Brassica oleracea* L. var. *gemmifera*) under high hill dry temperate conditions of north-western Himalayas. *Indian Journal of Agricultural Sciences* **75(5)**: 292-293.
- Sharma K C and Sharma L K. 2010. Effect of biofertilizers and NPK levels on growth and yield of mid-maturity group of cauliflower under mid hill sub-humid conditions of Himachal Pradesh. *Journal of Hill Agriculture* **1(1)**: 19-22.
- Sharma K C. 2000. Influence of integrated nutrient management on yield and economics on broccoli (*Brassica oleracea* L var. *italica* Plenck) under cold temperate conditions. *Vegetable Science* **27(1)**: 62-63.

- Sharma S K, Sharma R And Korla B N. 2002. Response Of N And P On Growth And Yield Of Sprouting Broccoli (*Brassica Oleracea* Var. *Italica*). *Indian Journal Of Horticulture* 59(3): 313-315.
- Sharma S K. 2002. Effect of *Azotobacter*, *Azospirillum* and nitrogen on growth and yield of cabbage (*Brassica oleracea* var. *capitata*). *Indian Journal of Agriculture Sciences* 72(9): 555-557.
- Shree S, Singh V K And Kumar R. 2014. Effect Of Integrated Nutrient Management On Yield And Quality Of Cauliflower (*Brassica Oleracea* Var. *Botrytis* L.) *The Bioscans* 9(3): 1053-1058.
- Singh A K and Singh A. 2000. Influence of nitrogen and potassium on growth and head yield of broccoli (*Brassica oleracea* L var *italica*) under low hills subtropical condition of H P. *Vegetable Science* 27: 99-100.
- Singh J P, Singh O V and Solanki V P S. 2009. Effect of potassium and boron on yield and uptake of nutrients by cauliflower. *Annals of Horticulture* 2(1): 80-82.
- Singh R K, Bara N and Singh R P. 2005. Verification trial on use of vermicompost in cauliflower in farmers' fields. *Journal of Research* 17(2): 237-240
- Subbiah B V and Asija G L. 1956. Rapid method for estimation of available nitrogen in soils. *Current Science* 25: 259-260.
- Thamburaj S and Singh N. 2001. Textbook of Vegetables, Tubercrops and Spices. ICAR. New Dehli. 469p.
- Upadhyay A K, Bahadur A and Singh J. 2012. Effect of organic manures and biofertilizers on yield, dry matter partitioning and quality traits of cabbage (*Brassica oleracea* var. *capitata*). *Indian Journal of Agricultural Sciences* 82(1): 31-34.
- Velmurugan M , Balakrishnamoorthy G, Rajamani K, Shanmugasunderam P and Gnanam R. 2008. Effect of organic manures, biofertilizers and bio-stimulants on growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*) cv. Indam 2435. *Crop Research* 35(1/2): 42-45.
- Walkley A and Black T A. 1934. An experiment of the vegetative modification of the chromic acid filtration method. *Soil Science* 37: 38-39.

- Wange S S and Kale R H. 2004. Effects of microbial inoculants with graded levels of inorganic nitrogen on broccoli and lettuce. *Journal of Soils and Crops* 14(1): 18-21.
- Wani A B J, Raj Narayan, Ahmed N, Singh A K, Chattoo M A and Sumati N. 2011. Influence of organic and inorganic sources of nutrients on growth, yield and quality of cauliflower (*Brassica oleracea* L. Var. *botrytis*). *Environment and Ecology* 29(4A): 1941-1947.
- Wani A J, Mubarak T and Rather G H. 2010. Effect of organic and inorganic nutrient sources on growth and curd yield of cauliflower (*Brassica oleracea* L. var *botrytis*) cv. Snowball-16. *Environment and Ecology* 28(3): 1660-1662.
- Yadav A K. 2009. Organic Status in India. Regional Centre of Organic Farming, Department of Agriculture and Cooperation, MOA, GOI, Bangalore. 1p.
- Yadav L P, Kavita A and Maurya I B. 2012. Effect Of Nitrogen And Biofertilizers On Growth Of Cabbage (*Brassica Oleracea* Var *Capitata* L.) Var. Pride Of India. *Progressive Horticulture* 44(2): 318-320.
- Yildirim E, Karlidag H, Turan M, Dursun A and Goktepe F. 2011. Growth, nutrient uptake, and yield promotion of broccoli by plant growth promoting rhizobacteria with manure. *Horticulture Science* 46(6): 932–936.



ABSTRACT

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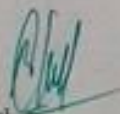
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The present investigation entitled "Response of various organic manures and bio-fertilizers on growth, yield and quality of broccoli (*Brassica oleracea* L. var. *italica* Plenck.)" was carried out at Organic and Dairy Block, College of Horticulture, Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand during August 2015. Ten treatments combinations of organic manures and biofertilizers were replicated thrice in a plot having dimensions of 1.8 m x 1.35 m. The experiment was laid out in a randomized complete block design and a spacing of 45 cm x 45 cm was followed. One month old seedlings were transplanted in last week of August.

Observation on various growth, yield, quality parameter were recorded, for plant height at maturity (cm), days taken to 50 per cent heading, days to marketable maturity, polar diameter of head (cm), equatorial diameter of head (cm), terminal head weight (g), average spear weight (g), average plant yield (g), yield per hectare (q), total soluble solids ($^{\circ}$ Brix), shelf life (days) and cost:benefit ratio. The results revealed that treatment (T₆) i.e. Farmyard manure + Biofertilizers, observed best for plant height at maturity (cm) 35.45cm, days taken to 50 per cent heading (63.40), days to marketable maturity (91.13), polar diameter of head (11.68cm), equatorial diameter of head (10.45cm), average spears weight (32.12g), and shelf life (13.80) and Vermicompost + Biofertilizers, i.e. (T₇) was best for characters such as average terminal head weight (51.96 g), average plant yield (999.45g) and yield per hectare (41.13q/ha) and Further, application of and Biovita granules and Biofertilizers in combination gave higher cost benefit ratio (1: 4.16) as compared to the sole application of nutrients from different sources and biofertilizers.

It was concluded that application of biofertilizers and organic manures in combination gave better results hence, there is a great scope of improvement in growth, yield, and quality of broccoli.

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Ekta
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सारांश

नाम - एकता नेगी
प्रवेश का वर्ष - 2013-14
मुख्य - सब्जी विज्ञान
तद्यु - मृदा विज्ञान

परिचय पत्र संख्या - 13121
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औद्योगिकी सब्जी विज्ञान

शोध का शीर्षक : विभिन्न जैविक खादों एवं जैविक उर्वरकों का ब्रोकली (ब्रेसिका ऑल्लिरेसिया वेरायटी इटैलिका) के विकास उपज एवं गुणवत्ता पर प्रभाव

सलाहकार - प्रो० बी० पी० नौटियाल

सह-सलाहकार - डॉ० शैलजा पुनेठा

वर्तमान शोध विषय 'विभिन्न जैविक खादों एवं जैविक उर्वरकों का ब्रोकली (ब्रेसिका ऑल्लिरेसिया वेरायटी इटैलिका) के विकास उपज और गुणवत्ता पर प्रभाव अगस्त-दिसम्बर 2015 के दौरान जैविक एवं दुग्ध-प्रखण्ड वी० च० सि० ग० उत्तराखण्ड औद्योगिकी एवं वानिकी विश्वविद्यालय, भरसार में किया गया। वर्तमान शोध में जैविक खादों और उनके समिश्रण के दस उपचार क्रमशः गोबर की खाद, केंचुए की खाद, नीम पत्तियों की खाद, बायोविटा ग्रेनुयल, गोबर की खाद + जैविक उर्वरक, केंचुए की खाद + जैविक उर्वरक नीम पत्तियों की खाद + जैविक उर्वरक, बायोविटा ग्रेनुयल + जैविक उर्वरक का प्रयोग किया गया। यह शोध कार्य रैन्डोमाइज्ड ब्लाक डिजाइन में तीन पुनरावृत्तियों में लगाया गया प्रत्येक पुनरावृत्ति में ब्रोकली की प्रजाति ग्रीन हेड के बारह पौधों को $45 \text{ से०मी०} \times 45 \text{ से०मी०}$ की दूरी पर लगाया गया।

इस शोध के अध्ययन में यह पाया गया कि उपचार T₆ (गोबर की खाद + जैविक उर्वरक) में परिपक्वता के समय पौधों की लम्बाई (35.45), 50 प्रतिशत शीर्ष (63.40), परिपक्वता में लगे दिन (91.93), धुवीय व्यास (11.68 से०मी०), भूमध्यवर्ती व्यास (0.45), औसत स्पीयर्स वजन (32.12) जीवन अवधि (13.80) सर्वोत्तम पायी गयी। तथा औसत सीमान्त शीर्ष का वजन (51.96 ग्र), औसत पौध उपज (999.45 ग्र), उपज प्रति हेक्टेयर उपचार (केंचुए की खाद तथा जैविक उर्वरक) T₆ के समिश्रण में सर्वोत्तम पाये गये। एक ही पोषक तत्वों के विभिन्न स्रोतों की तुलना में जैव उर्वरकों एवं बायोविटा ग्रेनुयल का प्रयोग में उच्चतम 1:4:16 लागत लाभ अनुपात प्राप्त किया गया।



अतः इस अध्ययन से यह निष्कर्ष निकलता है कि जैविक उर्वरकों और जैविक खादों को समिश्रित कर ब्रोकली की उपज एवं पैदावार में अधिक लाभ अर्जित किया जा सकता है।

सलाहकार

प्रो० बी० पी० नौटियाल

लेखिका

एकता नेगी



APPENDICES

APPENDIX – II

ANALYSIS OF VARIANCE FOR DIFFERENT CHARACTERS UNDER STUDY

Source of variation	D.f	Mean sum of squares													
		Plant height at maturity (cm)	Number of leaves per plant	Days to 50 per cent heading	Days to marketable maturity	Polar diameter of head size (cm)	Equatorial diameter of head size (cm)	Terminal head weight (g)	Number of spear per plant	Average spear weight (g)	Average plant yield (g)	Yield per hectare (q)	Ascorbic acid content (mg/100 g)	Total soluble solids (°Brix)	Self life (days)
Replication	2	0.399	2.933	34.934	45.489	3.706	11.556	0.3075	2.1	4.018	7.2	56.16	23.5685	1.1635	0.2775
Treatment	18	5.613*	2.630	40.527**	96.218**	4.113*	5.430*	267.725**	2.090	35.915**	74,204.339**	131.068**	30.007	3.775**	6.205**
Error	29	1.075	2.618	8.574	23.012	1.450	1.875	1.299	0.878	4.548	0.201	15.147	23.652	0.317	0.147

APPENDIX – IV

Cost of cultivation of broccoli as affected by Vermicompost treatment

A.	PARTICULARS (per hectare)	COST(Rs.)
1.	Seed cost	385
2.	Preparation of nursery beds and sowing of seeds 5 man/ days @ Rs.200/man/ day	1000
3.	Thinning and other intercultural practices in nursery beds 2 man/ day @ Rs. 200/ man/ day	400
4.	Application of Pseudomonas and Trichoderma 2 man/day @ Rs.200/ man/ day	400
5.	Irrigation of nursery beds 1 man/ day @ Rs.200/man/ day 4 times	800
6.	Preparation of field 1 ploughings @ Rs.300/hr 6 hrs for one hectare + 2 man	2400
7.	Lifting of seedlings & their transplanting 12 man/day @ Rs. 200/ man /day	2400
8.	Planking, layout, Channel & beds preparation 8 man/day @ Rs. 200/ man/ day	1600
9.	Total Irrigations in crop 8 irrigations 3 hrs/irrigation 14 man /day @ Rs.200/ man /day	6400
10.	Weeding, raking, hoeing & gap filling 30 man/day @ Rs. 200/ man/ day 2 times	12000
11.	Botanical spray (self prepared+ cow-urine) 50 L @ Rs.5/L+2 man	650
12.	Neem spray 02 L @ Rs.110/250 ml +2 man	1080
13.	Harvesting, packing, cleaning, grading etc. 30 man /day @ Rs.200/ man/ day	6000
14.	Rental value of land Rs.5000/ha/3 months	5000
	Total	40515
B.	Individual Costs for Separate Treatments	
A.	Organic fertilizers application	
	Details of treatment to be used	
T2	Vermicompost 50 q/ha @ Rs. 400/q	20000
C.	Other costs	1000
1.	Depreciation costs (building, instruments etc.)	1000
2.	Risk factor (5% of working capital)	3125.75
3.	Management Cost (10% of working capital)	6251.5
	Total	31377.25
	Total cost	71892.25
	Sale rate of broccoli heads-Rs. 80/kg	215413.6

Yield of Broccoli is = 2692.67

Sale rate of broccoli (organic) /kg @ Rs. 80

Total sale rate of broccoli heads = Rs. 215413.6

Sale rate of spears, leaves and plant stalk = Rs. 393.17

Total gross return = Rs. 215413.6 + 393.17 = 215806.77

Net return = gross return – total cost of cultivation

$$=215806.77- 71892.25=143914.52$$

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

$$=143914.52/71892.25=2.00$$

APPENDIX – V

Cost of cultivation of broccoli as affected by Neem cake manure treatment

A.	PARTICULARS (per hectare)	COST(Rs.)
1.	Seed cost	385
2.	Preparation of nursery beds and sowing of seeds 5 man/ days @ Rs.200/man/ day	1000
3.	Thinning and other intercultural practices in nursery beds 2 man/ day @ Rs. 200/ man/ day	400
4.	Application of Pseudomonas and Trichoderma 2 man /day @ Rs.200/ man/ day	400
5	Irrigation of nursery beds 1 man/ day @ Rs.200/man/ day 4 times	800
6	Preparation of field 2 ploughings @ Rs.300/hr 6 hrs for one hectare + 2 man	2400
7	Lifting of seedlings & their transplanting 12 man/day @ Rs. 200/ man /day	2400
8	Planking, layout, Channel & beds preparation 8 man/day @ Rs. 200/ man/ day	1600
9	Total Irrigations in crop 8 irrigations 3 hrs/irrigation 14 man /day @ Rs.200/ man /day	6400
10.	Weeding, raking, hoeing & gap filling 30 man/day @ Rs. 200/ man/ day 2 times	12000
11	Botanical spray (self prepared+ cow-urine) 50 L @ Rs.5/L+2 man	650
12	Neem spray 02 L @ Rs.110/250 ml +2 man	1080
13	Harvesting, packing, cleaning, grading etc. 30 man /day @ Rs.200/ man/ day	6000
14	Rental value of land Rs.5000/ha/3 months	5000
	Total	40515
B.	Individual Costs for Separate Treatments	
A.	Organic fertilizers application	
	Details of treatment to be used	
T3.	Neem cake 20 q/ha. @Rs. 650/q	13000
C.	Other costs	1000
1.	Depreciation costs (building, instruments etc.)	1000
2.	Risk factor (5% of working capital)	2775.75
3.	Management Cost (10% of working capital)	5829.07
	Total	23604.82
	Total cost	64119.82
	Sale rate of broccoli heads-Rs. 80/kg	277370.4

Yield of Broccoli is = 3467.13

Sale rate of broccoli (organic)/kg Rs. 80

Total sale rate of broccoli heads = Rs. 277370.4

Sale rate of spears, leaves and plant stalk = Rs. 415.57

Total gross return = Rs. 277370.4+ 415.57 = 277785.97

Net return = gross return – total cost of cultivation

$$= 277785.97-64119.82=213666.15$$

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

$$=213666.15/64119.82=3.33$$

APPENDIX – XI

Cost of cultivation of broccoli as affected by Biofertilizers+ B.G treatment

A.	PARTICULARS (per hectare)	COST(Rs.)
1.	Seed cost	385
2.	Preparation of nursery beds and sowing of seeds 5 man/ days @ Rs.200/man/ day	1000
3.	Thinning and other intercultural practices in nursery beds 2 man/ day @ Rs. 200/ man/ day	400
4.	Application of Pseudomonas and Trichoderma 2 man /day @ Rs.200/ man/ day	400
5	Irrigation of nursery beds 1 man/ day @ Rs.200/man/ day 4 times	800
6	Preparation of field 1 ploughings @ Rs.300/hr 6 hrs for one hectare + 2 man	2400
7	Lifting of seedlings & their transplanting 12 man/day @ Rs. 200/ man /day	2400
8	Planking, layout, Channel & beds preparation 8 man/day @ Rs. 200/ man/ day	1600
9	Total Irrigations in crop 8 irrigations 3 hrs/irrigation 14 man /day @ Rs.200/ man /day	6400
10.	Weeding, raking, hoeing & gap filling 30 man/day @ Rs. 200/ man/ day 2 times	12000
11	Botanical spray (self prepared+ cow-urine) 50 L @ Rs.5/L+2 man	650
12	Neem spray 02 L @ Rs.110/250 ml +2 man	1080
13	Harvesting, packing, cleaning, grading etc. 30 man /day @ Rs.200/ man/ day	6000
14	Rental value of land Rs.5000/ha/3 months	5000
	Total	40515
B.	Individual Costs for Separate Treatments	
A.	Organic fertilizers application	
	Details of treatment to be used	
T9.	Biofertilizers (<i>Azotobacter</i> 5 kg/ha. @ Rs.80/Kg + PSB 5 kg/ha. @ Rs.80/Kg)+ B.G	3300
C.	Other costs	1000
1.	Depreciation costs (building, instruments etc.)	1000
2.	Risk factor (5% of working capital)	2290.75
3.	Management Cost (10% of working capital)	4810.57
	Total	12401.32
	Total cost	52916.32
	Sale rate of broccoli heads-Rs. 80/kg	272856

Yield of Broccoli is = 3410.70

Sale rate of broccoli (organic) /kg @ Rs. 80

Total sale rate of broccoli heads = Rs.272856

Sale rate of spears, leaves and plant stalk = Rs. 444.05

Total gross return = Rs. 272856 + 444.05 = 273300.05

Net return = gross return – total cost of cultivation

= 273300.05 - 52916.32 = 220383.73

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

=220383.73/52916.32 = 4.16

APPENDIX – XII

Cost of cultivation of sprouting broccoli as affected by Control treatment

A.	PARTICULARS (per hectare)	COST(Rs.)
1.	Seed cost	385
2.	Preparation of nursery beds and sowing of seeds 5 man/ days @ Rs.200/man/ day	1000
3.	Thinning and other intercultural practices in nursery beds 2 man/ day @ Rs. 200/ man/ day	400
4.	Application of Pseudomonas and Trichoderma 2 man /day @ Rs.200/ man/ day	400
5	Irrigation of nursery beds 1 man/ day @ Rs.200/man/ day 4 times	800
6	Preparation of field 1 ploughings @ Rs.300/hr 6 hrs for one hectare + 2 man	2400
7	Lifting of seedlings & their transplanting 12 man/day @ Rs. 200/ man /day	2400
8	Planking, layout, Channel & beds preparation 8 man/day @ Rs. 200/ man/ day	1600
9	Total Irrigations in crop 8 irrigations 3 hrs/irrigation 14 man /day @ Rs.200/ man /day	6400
10.	Weeding, raking, hoeing & gap filling 30 man/day @ Rs. 200/ man/ day 2 times	12000
11	Botanical spray (self prepared+ cow-urine) 50 L @ Rs.5/L+2 man	650
12	Neem spray 02 L @ Rs.110/250 ml +2 man	1080
13	Harvesting, packing, cleaning, grading etc. 30 man /day @ Rs.200/ man/ day	6000
14	Rental value of land Rs.5000/ha/3 months	5000
	Total	40515
B.	Individual Costs for Separate Treatments	
A.	Organic fertilizers application	
	Details of treatment to be used	
T10.	Control	-
C.	Otsher costs	1000
1.	Depreciation costs (building, instruments etc.)	1000
2.	Risk factor (5% of working capital)	2125.75
3.	Management Cost (10% of working capital)	4464.07
	Total	8589.82
	Total cost	49104.82
	Sale rate of broccoli heads-Rs. 80/kg	157708

Yield of Broccoli is = 1971.35

Sale rate of broccoli (organic) /kg @ Rs.80

Total sale rate of broccoli heads = Rs.157708

Sale rate of spears, leaves and plant stalk = Rs.321.39

Total gross return = Rs.157708+ 321.39 = 158029.39

Net return = gross return – total cost of cultivation

$$= 158029.39- 49104.82 =108924.57$$

Net return

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

$$108924.57/49104.82=2.21$$

APPENDIX – XIII

Cost of cultivation of broccoli as affected by different treatments

A.	PARTICULARS (per hectare)	COST (Rs.)
1.	Seed cost	385
2.	Preparation of nursery beds and sowing of seeds 5 man/ days @ Rs.200/man/ day	1000
3.	Thinning and other intercultural practices in nursery beds 2 man/ day @ Rs. 200/ man/ day	400
4.	Application of Pseudomonas and Trichoderma 2 man /day @ Rs.200/ man/ day	400
5	Irrigation of nursery beds 1 man/ day @ Rs.200/man/ day 4 times	800
6	Preparation of field 1ploughings @ Rs.300/hr 6 hrs for one hectare + 2 man	2400
7	Lifting of seedlings & their transplanting 12 man/day @ Rs. 200/ man /day	2400
8	Planking, layout, Channel & beds preparation 8 man/day @ Rs. 200/ man/ day	1600
9	Total Irrigations in crop 8 irrigations 3 hrs/irrigation 14 man /day @ Rs.200/ man /day	6400
10.	Weeding, raking, hoeing & gap filling 30 man/day @ Rs. 200/ man/ day 2 times	12000
11	Botanical spray (self prepared+ cow-urine) 50 L @ Rs.5/L+2 man	650
12	Neem spray 02 L @ Rs.110/250 ml +2 man	1080
13	Harvesting, packing, cleaning, grading etc. 30 man /day @ Rs.200/ man/ day	6000
14	Rental value of land Rs.5000/ha/3 months	5000
	Total	40515
B.	Individual Costs for Separate Treatments	
A.	Organic fertilizers application	
1.	Vermicompost 50 q/ha @Rs. 400/q	20000
2.	FYM 200 q/ha @Rs.50/q	10000
3.	Neem cake 20 q/ha @Rs. 650/q	13000
4.	Biovita granules 50 kg/ha @ Rs.50/kg	2500
B.	Biofertilizers application	
1.	Azotobacter 5 kg/ha. @Rs.80/Kg	400
2.	PSB 5 kg/ha. @ Rs./Kg	400
C.	Other costs	1000
1.	Depreciation costs (building, instruments etc.)	1000
2.	Risk factor (5% of working capital)	4440.75
3.	Management Cost (10% of working capital)	9325.57
	Total	62066.32
	Total cost	102581.32
	Sale rate of broccoli heads-Rs. 80/kg	800000
		0

Yield of Broccoli is 10000

Sale rate of broccoli (organic) /kg @Rs. 80

Total sale rate of broccoli heads = Rs. 800000

Sale rate of spears, leaves and plant stalk = Rs. 20000

Total gross return = Rs. 800000 + 20000 = 820000

Net return = gross return – total cost of cultivation

$$=820000 – 102581.32= 717418.68$$

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

$$717418.68/102581.32= 6.99$$

CURRICULUM VITAE

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Scholarship/ Stipend/ Fellowship, any
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during the study period : No