

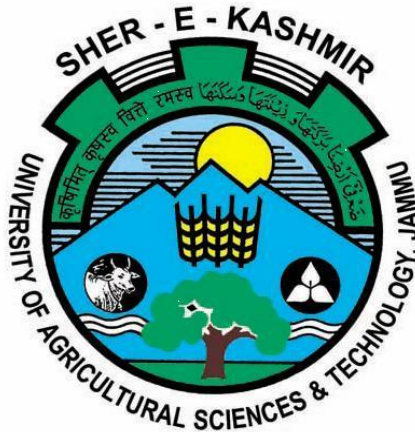
**STUDIES ON SEED PRODUCTION OF BROCCOLI
(*Brassica oleracea* var. *italica*) UNDER ORGANIC
MANAGEMENT**

by

**AMIT KUMAR
J-19-M-696**

Thesis submitted to Faculty of Agriculture
in partial fulfillment of requirements
for the degree of

**MASTER OF SCIENCE IN AGRICULTURE
HORTICULTURE (VEGETABLE SCIENCE)**



Division of Vegetable Science and Floriculture

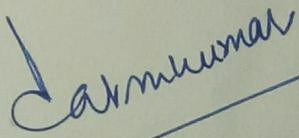
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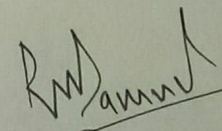
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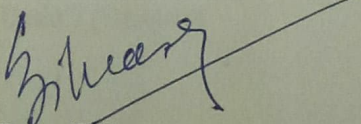
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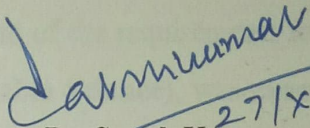
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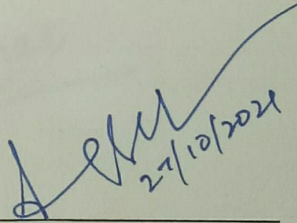

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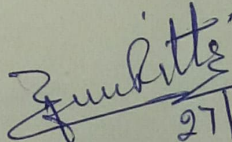
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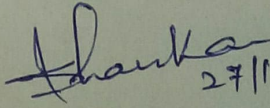
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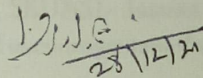

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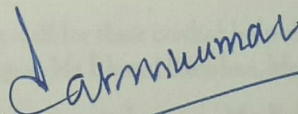

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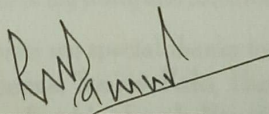
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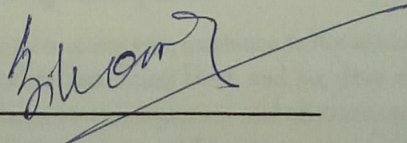


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ACKNOWLEDGEMENT

It gives me great pleasure in writing this acknowledgement, as a token of gratitude to all the people who have always been supportive and helpful throughout the course of these studies.

A precious debt as that of learning is the only liability that is difficult to repay except perhaps through gratitude. At the outset, it gives me immense pleasure to express my sincere regard and deep sense of obligation to my esteemed Major advisor and Chairman of advisory committee, **Dr. Satesh Kumar**, Associate Professor, Department of Vegetable Science & Floriculture for his benevolent sustained guidance, sound suggestions, continuous encouragement and empathy which inspired me to work sincerely.

I have immense pleasure in expressing my whole hearted sense of gratitude to the members of my advisory committee, **Dr. Anil Bhushan**, Assistant Professor, Department of Vegetable Science & Floriculture, **Dr. Balbir Dhotra**, Assistant Professor, Division of Soil Science and Ag. Chemistry and **Dr. Uma Shankar**, Associate Professor Division of Entomology, SKUAST- Jammu for their valuable advice, helpful cooperation, kindness, timely suggestion and encouragement throughout the period of investigation.

I extend my thanks to **Dr. R.K Samnotra**, Professor and Head, Department of Vegetable science & Floriculture for providing me the necessary facilities during the course of investigation. I am much elated to extend my thanks to all the teaching staff viz, **Dr. Sandeep Chopra**, Professor, Department of Vegetable Science and Floriculture, **Dr. Sanjeev Kumar**, Assistant Professor, Department of Vegetable Science and Floriculture, **Dr. Manoj Kumar**, Assistant Professor, Department of Vegetable Science and Floriculture, for their candid help and cooperation throughout my studies.

I am highly thankful to non-teaching staff for their cordial help directly or indirectly during my studies, **Mr. Rajesh**, **Mrs. Neetu**, **Mr. Yograj**, **Mr. Bharat Bhushan**, **Mr. Pankaj** and **Mr. Jasbir**.

I express my ingenuous thanks to my respected seniors **Mr. Rakesh Aggarwal**, **Mr. Sachin S. Chikkeri**, **Mr. Atal**, **Mr. Divyanshu Sharma** and **Mr. Aaqib Ayub** for their constant support and provocation during the entire course of my study and research.

Mere words are insufficient to express my special thanks to **Arjun Singh**, **Davinder Paul**, **Vivek Sharma**, **Sumita Meenia**, **Anil Sharma**, **Sourav Kalsi**, **Himanshu Kamboj**, **Saurabh Sharma**, **Naveen Kamboj**, **Lovkesh Kamboj**, **Surekha**, **Sonali**, **Vimal**, **Sajid**, **Ashvinder**, **Aqib**, **Reshav**, for supporting, encouraging and helping me whenever, I needed during the course of study and compilation of the thesis along with my advisor.

On the spur of the moment, I owe my very existence to the towering peaks of my life, my beloved father **Sh. Daya Ram**, mother **Smt. Kunti Devi**, and my dearest brother **Mr. Ashish Atri** whose blessings, selfless love, constant encouragement and obstinate sacrifices have been the most vital source of inspiration and motivation in my life.

Above all I thank the ALMIGHTY for giving me patience & strength to overcome the difficulties, which cross my faith in accomplishment of the endeavor.

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Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu

Title of thesis	:	Studies on Seed Production of Broccoli (<i>Brassica oleracea</i> var. <i>italica</i>) under Organic Management.
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ABSTRACT

To find out the effect of different biofertilizers, organic manures and bio pesticides on growth, yield and seed quality of broccoli, a field-experiment entitled “**Studies on seed Production of broccoli (*Brassica oleracea* var *italica*) under organic management**” was conducted at Vegetable block, OFRC. Chatha, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, during rabi season of 2020-21 The experiment was conducted in RCBD (factorial) consisting of 03 factors *viz.*, biofertilizers at three levels, organic manure and bio-pesticides each at two levels respectively. There were 12 treatments combinations which were tried on to the crop with three replications. Application of biofertilizers was done as seedling dip whereas FYM was applied as basal dose to the crop Vermicompost was applied at the time of earthing up operations and bio pesticides were sprayed at different stages of crop growth. Initially the experimental field was slightly alkaline in reaction (pH, 7.79), but low in organic carbon (0.6 %), available nitrogen (194.7 kg/ha) and available potassium (175.4 kg/ha) but medium in phosphorus (18.1kg/ha).

Results depicted that among biofertilizer BF-I (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded significantly higher growth parameters (plant height, plant spread, days to 50% curd initiation and days to 50% curd maturity). It gave maximum curd yield and seed yield as compared to other treatments. Soil macro nutrients like available N, P and K was also found influenced significantly by this treatment.

In case of organic manures, FYM recorded significantly higher growth parameters (plant height, plant spread, days to 50% curd initiation and days to 50% curd maturity) and curd and seed yield as compared to other treatments of organic manures. It also influenced soil macro nutrients like available N, P and K

Among bio pesticides (Neem oil + *Baeuveria bassiana*) recorded lowest incidence of diseases (curd rot and black rot) and in case of insect pest (NSKE + *Baccillus thuringensis* (BT)) recorded lowest (cabbage semi-looper and cabbage butterfly) population as in broccoli under organic management. Non-significant response was however recorded for soil macro nutrients.

Among different interactions, BF-I (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) in combination with OM 2 (FYM) and BP-1 (Neem oil + *Baeuveria bassiana*) was found superior in obtaining maximum growth, yield, and insect pest and disease management significantly as compared to other combinations. Non- significant response was however recorded for soil macro nutrients

Hence, based on one year study, it can be concluded that application of FYM @ 25 t/ha as a basal dose, seedling dip treatment of biofertilizers (*Azotobacter* @ 0.5 kg/ha + Phosphate Solubilising Bacteria @ 1.0 l/ha + Potassium Mobilising Bacteria @ 750 ml/ha) along with the scheduled application of Neem oil + *Baeuveria bassiana* 1, 3, 7, 15 days interval after disease symptoms was found superior in obtaining higher ,

curd yield (109.57 q/ha) and seed yield (604.96 kg/ha). This treatment played a vital role in combating disease and insect/ pest management in broccoli under organic management.

Key words: Bio fertilizers, biopesticides, nutrient dynamics, organic manures, broccoli, *Brassica oleracea* var. *italica*.

Signature of Major Advisor

Signature of the Student

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ABBREVIATIONS

%	Percentage
/	Per
°C	Degree Celsius
@	At the rate of
Bt	<i>Bacillus thuringensis</i>
Cm	Centimeter
CD	Critical difference
CV	Coefficient of variance
<i>Et al.</i> ,	Et alia(co-workers)
EC	Electrical conductivity
Etc.	Etcetera
FAO	Food and agriculture organization
Fig.	Figure
FYM	Farm Yard Manure
G	Gram
ha	Hectare
i.e.	id. est. (that is)
K	Potassium
KMB	Potassium mobilizing bacteria
kg	Kilogram
ha	Hectare
l	Litre
m	Meter
M ²	Square meter
mm	Millimeter
MT	Metric tonne
Max.	Maximum
Min.	Minimum
SMW	Standard Meteorological Week
N	Nitrogen
NSKE	Neem Seed Kernel Extract
No.	Number
OC	Organic carbon
NPK	Nitrogen, Phosphorus and Potassium
pH	Potential of hydrogen
P	Phosphorus
PSB	Phosphate solubilizing bacteria
q	Quintal
RH	Relative humidity
Se(m) ±	Standard error of mean
Var.	Variety
Viz.,	Videlicet (namely)

Chapter-1

Introduction

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica*), locally called as Hari/Seli Gobhi, belongs to family *Brassicaceae* with basic chromosome number as $2n=2x=18$. It contains carbohydrate 7g (2%), fat-0.4g, Sodium-33 mg (1%), Potassium-316 mg (9%), Dietary fibre-2.6g (10%), Sugar-1.7g, Protein 2.8g, Vitamin A 12%, Vitamin C-148%, Calcium-4%, Iron-3%, Vitamin B6-10%, Magnesium-5%, Phosphorus-79mg per 100 g (Annonymus-2015). It is also well known for high antioxidants such as ascorbic acid, β -carotene, tocopherols and phenolics. In addition, it has sulphur containing phytochemicals like glucosinolate having strong anti-carcinogenic activity as reported by American Cancer Society (Pandey and Rai, 2006). Its market value is very high particularly in hotels, restaurants and eateries. The broccoli curd is having green coloration and is formed from flower head that rapidly develops into a mass of productive buds (Biggs, 1993). In India, it is mostly cultivated in hilly areas of Himachal Pradesh, Uttar Pradesh, Nilgiri Hills and Northern plains of India (Shankar *et.al* 2019). In Jammu region of J&K UT, this crop is gaining popularity among the consumers and farmers are growing it as an exotic vegetable crop. It is generally high nutrition demanding crop and requires about 25 tonnes of FYM along with 120kg N, 60kg P₂O₅, and 60Kg K₂O per hectare of inorganic fertilizers, as recommended for its proper growth, yield and quality (Anonymous, 2020). Nutrient stress during the critical growth and development stages of broccoli affects all the morphological and yield related traits of the crop like plant height, curd initiation, compactness, size, colour and maturity. Seed attributes viz., number of seed stalks/plant, pod size, seed weight and yield is also compromised under nutrient stress conditions. It also makes the plant prone to various economic insect-pests like Cabbage butterfly (*Pieris brassicae*), semi-loppers (*Trichopulsia spp*) and diseases like curd rot (*Alternaria brassicae*) and black rot (*Xanthomonas campestris*) etc affecting seed quality drastically. Growing broccoli in situations like newly reclaimed soils, virgin fields with low organic carbon, rainfed areas with poor soil nutrient availability etc demand large amount of mineral fertilizers that has a negative effect on both environment

and human health. Moreover its continuous use leads to soil degradation, therefore, for quality growth and seed yield, abundant and timely availability of nutrients is desired in this crop.

Cultivation of broccoli under organic management poses serious challenge to the growers. Organic farming, that largely avoids the use of synthetic fertilizers, pesticides, insecticides, growth regulators and other chemicals etc. depends largely on the application of bio-fertilizers and bulk organic manures for nutrition and bio-pesticides for managing insect pest and diseases, besides green manuring, crop rotation, mulching, crop residues and other practices etc. Therefore, efforts have been done to blend nutrients together at their optimum dosages to fulfill the nutrient demand of this crop.

Biofertilizers are natural, beneficial ecological friendly solution which may reduce adverse environmental effect of mineral fertilization and improve the soil fertility status for sustainable crop yield (Mostafa and Abo Baker, 2010). They are living micro-organisms which are applied as seed, seedling and soil treatment, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host various insect plants and effectively reduce the requirement of synthetic fertilizers in respect to nitrogenous and phosphatic fertilizers (Singh *et al.*, 2017).

Organic manures like farm yard manure and vermicompost are considered as bulk manures that add considerable amount of major nutrients to the soil besides improving its physico-chemical properties. Decomposition of organic matter in the soil leads to different types of biological reactions which are helpful in preventing various disease causing pathogens are considered helpful in improving the physical and nutritional status of the soil and also enhance the activity of soil micro flora (Panwar *et al.*, 2010).

On the other hand, bio-pesticides are the derivatives which include a wide range of microbial pesticides, biochemicals obtained from microorganisms and other natural sources, and genetic integration of DNA into agricultural commodities to provide pest resistance. Among important bio-pesticides, Neem derived from the neem tree (*Azadirachta indica*), this contains several chemicals, including 'Azadirachtin', which

affects the reproductive and digestive process of a number of important pests. *Beauveria bassiana* acts as a contact insecticide and infect susceptible insects by utilizing infective conidia as the active agent to penetrate its integument. *Bacillus thuringiensis* (Bt) when ingested by pest larvae, releases toxins which damage the mid gut of the pest, eventually killing it. Several bio-pesticides such as Neem Seed Kernel Extract (NSKE), Trichoderma, Neem Oil, *Pseudomonas florescens*, *Bacillus thuringiensis* (Bt), *Beauveria bassiana* (Gupta *et al.*, 2013).

To have an effective module for quality seed production in broccoli under organic management system, an experiment entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**” was conducted to study the effect of various combinations of organic amendments including bio fertilizers, organic manures and bio-pesticides on growth, seed yield and quality traits in broccoli with the following objectives:

- I. To study the effect of organic amendments on seed yield and quality parameters of broccoli
- II. To study the effect of organic amendments on major insect pest and disease of broccoli
- III. To study the effect of organic amendments on soil nutrient dynamics.

Chapter-2

Review of Literature

REVIEW OF LITERATURE

The relevant literature pertaining to the present investigation entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**” has been reviewed under the following heads:

- 2.1 Effect of organic manures and biofertilizers on growth, yield and quality of broccoli
- 2.2 Effect of biopesticides on insect pest and disease management in broccoli
- 2.3 Effect of organic amendments on soil nutrient dynamics

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

Sharma (2002) conducted a field trial to study the impact of *Azospirillum* and *Azotobacter* mixed with nitrogen on cabbage (*Brassica oleracea* var. *capitata*) production. *Azospirillum* significantly increased number and weight of non-covering leaves per plant, head length, width, net load of head per plant and yield per hectare over 'no biofertilizer' treatment. Treatment blends of *Azospirillum* + 60 kg N/ha recorded the most noteworthy head weight per plant and yield per hectare with a benefit: cost ratio of 2.9:1.

Bahadur *et al.* (2004) assessed the impact of organic manure and biofertilizers on the growth and yield of cabbage. There were 13 treatment blends comprising of 4 organic manures (farmyard fertilizer, pressmud, processed muck and vermicompost) and 3 biofertilizers (*Azospirillum*, Phosphate Solubilizing Microorganisms Vesicular Arbuscular Mycorrhiza and) and one control (NPK). Among the treatments Pressmud + VAM recorded the most elevated qualities like number of external leaves (13.3), weight of external leaves (476.67 g), number of inward leaves (31.7), head weight (1616.67 g), head length (16.8 cm), head distance across (15.5 cm) and head yield (602.67 q/ha).

Manivannan and Singh (2004) conducted a field trial to examine the impact of biofertilizers like *Azospirillum* and *Azotobacter* applied as 5.0 and 10.0 percent, respectively on the growth and yield of broccoli (*Brassica oleracea* L. var. *italica*) cv. Fiesta. Results revealed that the plants applied with 5.0 percent *Azotobacter* and *Azospirillum* recorded 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 width (17.30 cm), plant spread (62.20 cm), and yield (55.57 t/ha).

Chatterjee *et al.* (2005) conducted an experiment to study the role of organic manures and bio-fertilizers on sprouting broccoli and observed that among the organic sources, the application of mustard oilcake + BFII (*Azotobacter* + VAM + potash mobilizer) had produced significantly highest yield (103.70 q/ha) over rest of the treatments, whereas lowest yield was recorded in the treatment having (Cow dung + *Azospirillum* + phosphate solubilizer + potash mobilizer) (37.78 q/ha)

Magd *et al.* (2006) examined the response of broccoli varieties to organic manure (cattle and poultry) compared with fertilizers. Results demonstrated that maximum vegetative development and yield of broccoli was recorded under the treatment having 100% cattle manure. However, the most elevated absolute yield and quality of broccoli were recorded when poultry manure was added for two successive seasons.

Velmurugan *et al.* (2008) experimented on cauliflower cv. Indam 2435 to study the impact of various biofertilizers and organic manures on it concerning growth and yield attributes. The outcomes revealed that this hybrid showed better response to the use of organic manures and biofertilizers. The application of vermicompost along with panchagavya recorded the highest total dry curd width (17.21 cm), curd weight (340.12 g/plant), curd length (15.66 cm) and matter content (211.99 g/plant), , than the control.

Akbar *et al.* (2009) examined the impact of vermicompost and bio-fertilizer (*Azotobacter*) on the growth and yield of cabbage cv Pride of India. The treatments contained three levels of each of vermicompost (0, 5 and 10 t/ha) and *Azotobacter* (0, 5 and 10 kg/ha). Results showed that application of vermicompost @ 10 t/ha brought about maximum plant spread, biggest size of head, and highest yield of heads per hectare, while

the quantity of leaves/plant and number of covering leaves/head were maximum with 5 t vermicompost/ha. Among the different levels of bio-fertilizer inoculation, *Azotobacter* @ 10 kg/ha resulted in maximum plant height, plant spread, maximum number of leaves per plant and number of covering leaves/head, though, the length of head and head yield per plant were maximum with *Azotobacter* @ 5 kg /ha.

Khan *et al.* (2009) conducted a field experiment for two years to study the effect of *Azospirillum*, *Azotobacter*, Phosphate Solubilizing Bacteria (PSB), and Vesicular Arbuscular Mycorrhiza (VAM) on growth, yield of cauliflower. They reported that when recommended doses of NPK were applied along with *Azospirillum* followed by 75 per cent recommended doses of NPK applied along with *Azospirillum*, maximum curd yield (213.25 and 219.95 q/ha) was recorded during both the years, which was significantly superior over the control (170.95 and 180.34 q/ha). There were 23, 14, 10 and 16 per cent increase in curd yield due to *Azospirillum*, *Azotobacter*, PSB and VAM, respectively over the control (RDF).

Gupta *et al.* (2010) in their field experiment on knol-khol cv. King of Market reported significant increase in growth, yield and quality characters over control by the inoculation of *Azospirillum*. However, better results were obtained by the application of 75% of chemical nitrogen along with both the inoculants, thereby a saving of 25% chemical nitrogen application during both the years of study. And the application of *Azospirillum* along with 75% chemical nitrogen proved to be better than *Azotobacter*.

Padamwar and Dakore (2010) in their experiment on cole crops using farmyard manure vermicompost, and biofertilizers found that there was significant increase in quality parameters like dry matter, protein, sugar, vitamin C and content of curd of all the cole crops.

Kachari *et al.* (2012) carried out a field experiment on cauliflower (*Brassica oleracea* L. var. *botrytis* cv. Pusa Snowball K-1) with objectives to know the influence of bio-fertilizers (*Azotobacter*, *Azospirillum*, AMF, PSB) and inorganic fertilizers (RDF of NPK kg/ha) on yield, quality and economics of cauliflower. The results revealed that bio-fertilizers in combinations with inorganic fertilizers performed better as compared to

control (FYM). The inoculation of PSB + 100 per cent phosphorus+ recommended dose of nitrogen and potassium recorded highest yield (33.94 t/ha) with cost benefit ratio of 1:2.58 and application of PSB + 50 or 75 or 100 per cent of phosphorus+ recommended dose of nitrogen and potassium performed significantly better for quality characters.

Lal *et al.* (2015) studied the effect of bio-fertilizers on growth, yield and quality of sprouting broccoli. The experiment consist of 16 treatment combinations consisting four levels of bio-fertilizers (Control, *Azospirillum*, PSB, *Azospirillum* + PSB) and four levels of Zinc sulphate ($ZnSO_4$) (0, 10, 20 and 30 kg/ha) with 3 replications. Results revealed that application of different bio-fertilizers and zinc levels enhanced the growth, yield and quality of sprouting broccoli. Application of *Azospirillum* +PSB was observed the best treatment in terms of broccoli Head net and gross yield (223.40 q/ha and 237.15 q/ha).

Bhushan and Sharma (2017) conducted a field experiment on integrated nutrient management (INM) in broccoli var. Early Green for two years to study the influence of *Azospirillum* and organic manures on growth and yield in broccoli under intermediate zone of Jammu & Kashmir, India. The results revealed that the treatment combination of 50% N + FYM (20t/ha) + seedling dip with *Azospirillum* recorded significantly highest yield (158.8 q/ha) and other yield contributing characters namely, curd weight (between 130.9g and 129.4g) and curd diameter (between 10.3cm and 10.7cm).

Meena *et al.* (2017) studied the effect of organic manures and biofertilizers on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica* Plenck) using different combinations of organic manure and bio-fertilizers and observed that among various combinations of organic manures and bio-fertilizers, the treatments combination (RDF 25% + Vermicompost 50% + *Azospirillum* 25%) responded well as substitute to sole fertilizer for vegetative growth of plant.

Kumar *et al.* (2017) conducted a field experiment to study the effect of biofertilizers on growth yield and quality of broccoli The experiment consists of different doses of biofertilizers namely , RDF *Azotobacter*, *Azospirillum*, VAM (SB (100%), *Azotobacter* + *Azospirillum* (50% + 50%), *Azotobacter* + PSB (50% + 50%), RDF +

VAM(50% + 50%) , RDF + *Azotobacter* (50% + 50%), RDF + PSB (50% + 50%) and *Azospirillum* +VAM (50% + 50%). The results revealed that the maximum plant height (54.75cm) and yield (347.53 q/ha) was recorded in the treatment having 50%*Azotobacter* +*Azospirillum* each whereas, maximum number of leaves (21.35cm) was counted in the treatment having *Azotobacter* and PSB at 50% level.

Singh *et al.* (2017) laid out the trial to discover the impact of biofertilizers on yield and nature of broccoli. The biofertilizers viz. *Azospirillum*, PSB, *Azotobacter* and VAM were applied alone and in mixes, inorganic compost as sure control and without manuring as negative control. With this examination, they observed that application of *Azospirillum* + *Azotobacter* significantly increased the curd size (15.17 cm breadth) and curd yield (1.17 kg, 0.93 kg curd with and without guard leaves, respectively) of broccoli as compared other treatments

To study the effect of biofertilizers and organic nutrition on broccoli production Rawat *et al.* (2018) conducted an experiment with ten treatments (Control, recommended dose of fertilizer, Rhizobium, *Azospirillum*, *Azospirillum*, PSB, VAM, FYM, Vermicompost and Farm compost). The experimental result revealed that the use of biofertilizers improved the production of broccoli as compared to control. Among the treatments, plant height was maximum in the treatment having *Azospirillum* application. Similarly, weight of curd with guard leaves and without guard leaves was also recorded in the same treatment and minimum in control. In respect of quality of curd, it was observed that application of inoculants *Azospirillum* significantly increased the curd size (15.48 cm diameter). Among all treatments, application of *Azospirillum* was found better for obtaining better growth, marketable curd yield and quality improvement of broccoli

Shankar *et al.* (2019) conducted an experiment during Rabi season with an aim to study the effect of organic manures and bio-fertilizers on growth, yield and quality of broccoli. Different combinations of the organic manures and biofertilizers like vermicompost, FYM and *Azospirillum* were used and results revealed that the use of organic manures improved the production of broccoli in general as compared to untreated control. Among the treatments, maximum plant height (29.73 cm and 46.67 cm respectively) was recorded under the treatment having 50% NPK + 50% FYM followed by the treatment

with 50% NPK + 50% *Azospirillum*. Yield and plant canopy was maximum (32.27cm) in the treatment (50% NPK + 50% FYM) followed by 31.79cm in treatment (50% Vermicompost + 50% *Azotobacter*). Minimum days (60.66days) was recorded in treatment (50% NPK + 50% FYM) and days taken to curd harvest after curd initiation was recorded minimum (15.91days) in the treatment (50%NPK+50% FYM). Days taken to curd harvest after curd initiation (19.03) was recorded maximum in the Control. Maximum curd weight (513.00 g) was recorded under treatment (50% NPK + 50% FYM) followed by (506.00g). Yield per ha of broccoli was recorded maximum (325.92q/ha) in the treatment with 50% NPK + 50%FYM.

2.2 Effect of bio-pesticides on insect pest and disease management in broccoli

The effects of nuclear polyhedrosis virus (NPV), *Bacillus thuringiensis* (Bt.), and *Beauveria bassiana* on different developmental stages of *Spodoptera litura* were studied by Jayanti and Padmanavan (1996). The results showed that increased concentrations of NPV, *Bacillus thuringiensis*, and *Beauveria bassiana* resulted in higher larval mortality in all *S. litura* instars. With lower microbial concentrations, the percent larval mortality reduced. In comparison to later instars, the early instars had a higher mortality rate. The mortality rate dropped as the larva's age increased. At lower concentrations of NPV Bt and *Beauveria bassiana*, on incubation was seen. A higher pathogen concentration was related to lower population, higher pupal mortality, higher deformed adult emergence, and lower emergence of normal adults in all the instars

Malathi *et al.* (1998) tested the bio-efficacy of *Bacillus thuringiensis* [Dipel, Delfin, Biobit, Biolep, Bioasp], botanical (Neemgold), nematode, *Steinernema feltiae* (Green commando), and endosulfan against cabbage lepidopterous pests in the field. Delfin was found to be very effective in reducing the population of cabbage leaf webbers, *Crociodolomia binotalis* (64.69 percent), and diamondback moths, *Plutella xylostella* (55.40 percent), and Dipel was found to be equally effective in reducing the population of these pests, with 64.54 and 53.38 percent reductions, respectively. The tobacco caterpillar, *Spodoptera litura*, was shown to be resistant to endosulfan, with a decrease of 53.42 percent. All of the pesticides that are tested were found to be safe under field condition.

Liu (1999) evaluated seven formulations of *Bacillus thuringiensis* in lab and field against cabbage looper *Trichoplusia spp.* and diamond back moth *Plutella xylostella* on cabbage. Under field conditions effectiveness of these *Bacillus thuringiensis* formulations varied greatly. When pest pressure was high, all formulations were more effective to *Plutella xylostella*, whereas no differences occurred when pressure was low. Five weekly applications of *Bacillus thuringiensis* formulations significantly reduced larval populations of both pest species. However, application of *Bacillus thuringiensis* alone did not reduce number of larvae below the economic threshold level (1 larva/3 plants).

Kandoria *et al.* (2000) studied the efficacy of different formulations of *Bacillus thuringiensis* against diamondback moth, *Plutella xylostella* on cauliflower and found that Dipel 8 L @ 1.5 l ha⁻¹ resulted in maximum mortality (72.42%) of *Plutella xylostella* after 10 days of treatment

Moorthy and Kumar (2000) utilized a 4.0 percent concentration of neem seed kernel extract (NSKE) to control the insecticide-resistant diamondback moth, *Plutella xylostella* and leaf webber, *C. binotalis* was found efficient against both of them.

To evaluate 5 commercially available *Bacillus thuringiensis* (Bt) formulations, Arora *et al.* (2000) conducted a farmer's field experiment in Punjab, India for their efficacy against the moth *Plutella xylostella* infesting cauliflower. The pest was effectively controlled by 2 applications of Dipel 8L, Biolep, Biobit (all at 0.750 l or kg/ha) as well as Dipel WP and Biotox (at 1.5 kg/ha). Based on these results and findings from previous studies, an integrated pest management system comprising intercropping with Indian mustard and need-based application of biopesticides (Bt and nuclear polyhedrosis virus) was proposed for managing the pest complex in cabbage and cauliflower.

Okoth *et al.* (2002) evaluated efficacy of neem kernel cake powder water extract (NKCP-WE) at 0, 12.5, 25 and 50 g/litre and Dipel (2 %) against diamond back moth on cabbage. All concentrations of NKCP-WE retained larvicidal activity up to 2 weeks. Dipel (2%) treated plants had less DBM larval infestation than the neem treated plants but the NKCP treatment gave better yield.

Wo *et al.* (2002) reported that pakchoi cabbage (*Brassica pekenensis*) when sprayed with Bt. H3136, omethoate or water gave better control of the two pests. *Bacillus thuringiensis* (Bt) H 3136 resulted in 97.5 and 79.8 per cent mortality of *Pieris rapae* and *Plutella xylostella*, respectively, occurring 5 to 7 and 2 to 5 days after treatment.

Kamala *et al.* (2003) applied five sprays of some biopesticides at ten days interval against diamond back moth on cabbage and reported that Abamectin, NSKE and Spinosad gave highest number of marketable heads as well as yield, while Dipel and Neemazal were on par but superior to neem oil soap, pongania oil soap and control. *Bacillus thurnigiensis* product Dipel, Neemazal, neem oil soap and pongania oil soap failed to give satisfactory results.

In an experiment conducted in Udaipur, Rajasthan, during 2001-02, Meena and Sharma (2003) investigated the incidence of diamondback moth *Plutella xylostella* on cabbage and the efficacy of several microbial pesticides against the pest. The cabbage infestation began in the last week of November (1.00 larvae per plant) and peaked in the fourth week of January (806 larvae per plant). The first foliar application of *Bacillus thuringiensis* at 1.00, 1.25, and 1.50 kg/ha; *Beauveria bassiana* at 500, 750, and 1000 g/ha; spinosad at 12.5, 15.0, and 17.5 g/ha; and endosulfan at 2 ml/litre of water was applied 5 weeks after cabbage seedling transplanting, and the second application was applied 15 days later. The most successful insecticidal treatment was two applications of endosulfan, which produced the maximum yield of 134.27 q/ha.

A field application of two botanical insecticide formulations (mixtures of *Piper retrofractum* (Piperaceae) and *Annona squamosa* (Annonaceae) (RS) extracts and *Aglaia odorata* (Meliaceae) and *A. squamosa* (OS) extracts at 0.05% and 0.1% were compared to a synthetic pyrethroid, deltamethrin at 0.04% and a microbial insecticide, *Bacillus thuringiensis* at 0.15%` conducted on cabbage crops in Bogor, West Java, Indonesia by Dadang *et al.* (2009) to check their effectiveness. Results revealed that application of both of these formulations decreased the population of *Crocidolomia pavonana* (F.) and *Plutella xylostella* (L.).It was also found that both these formulations at 0.1% was more effective than synthetic insecticide and did not affect the performance of insect pest natural enemies.

Nath and Singh 2011 examined the impact of vermicompost independently or in combination with various bio-pesticides on infestation of nematode (*Meloidogyne incognita*) and yield of cauliflower. Blending of vermicompost with neem oil (94%) in the soil caused significant decrease in *M. incognita*. Application of vermicompost with bio-pesticides increased the productivity of cauliflower more than 8 times. The outcomes obviously exhibited that the use of vermicompost with plant product is more beneficial in organic farming and supportive to remunerate the inadequacy of supplements in the soil as well as control of the nematodes.

Evans and Hallett (2016) investigated how to control the swede midge (*Contarinia nasturtii* Kieffer) with organically approved azadirachtin, pyrethrin, and spinosad formulations, as well as a commercial biopesticide containing the entomo-pathogenic fungus *Beauveria bassiana*. Pyrethrin and spinosad treatments applied up to 24 hours before *C. nasturtii* exposure reduced oviposition on host plants significantly, but azadirachtin and *B. bassiana* treatments only prevented oviposition when applied 2 hours before exposure. On cauliflower, spinosad had the largest larvae reduction (96%) whereas azadirachtin, *Beauveria bassiana*, and pyrethrin had considerable larval decreased when applied during pre-oviposition and significant mortality was observed when applied post-oviposition.

Singh *et al.* (2019) conducted a field experiment to study the efficacy of neem biopesticides/ products *viz.* neem oil, neem seed kernel extract, neem leaf extract and one synthetic pesticide-Quinalphos 25% EC @2ml/L, for management of larval population of *Spodoptera litura* (Fab.) The results showed that Quinalphos 25% EC showed maximum efficacy in terms of larval population reduction (62.37% and 63.90%) against *Spodoptera litura*. followed by neem oil (58.26% and 57.89%), neem seed kernel extract (54.83% and 55.24%), neem leaf extract (50.70% and 51.42%) and lowest for untreated (14.60% and 12.50%) in first and second spray respectively. Among the bio-pesticides, neem oil showed maximum reduction in larval population of *S. litura* under field condition followed by neem seed kernel and leaf extract.

Singh *et al.* (2021) studied the management of major insect pests of broccoli (*Brassica oleracea* var *italica*) with special reference to diamondback moth (*Plutella*

xylostella) and found that spinosad was found to be the best treatment as compared to others as it recorded the lowest mean larvae population which was followed by NSKE 5%, *Bacillus thuringiensis*, *Metarhizium anisopliae*, Azadirachtin, Karanj oil 1%, while the highest mean larval population was observed in control plot.

2.3 Effect of organic amendments on soil nutrient dynamics

Chaudhary *et al.* (2003) investigated the impact of combining organic manures, biofertilizers, and synthetic fertilizers on soil nutrient status and cauliflower productivity. Results revealed that use of inorganic fertilizers, biofertilizers, and farmyard manure in combination, the organic carbon and available nitrogen status increased significantly. The application of diverse organic and microbiological sources of nutrients in combination with fertilizers boosted soil available nutrients including N, P, and K much more than chemical fertilizers alone. *Azotobacter*, PSB, and farmyard manure, as well as inorganic fertilizers, were found to improve cauliflower plant growth and yield.

Sharma *et al.* (2008) conducted a field experiment to investigate the response of broccoli (*Brassica oleracea* L.var. *italica*) and soil fertility to integrated nutrient management using organic manure and *Azotobacter* along with synthetic fertilizers and found that highest increase in the contents of organic C and available N, P, and K, 36, 32, 79, and 19%, respectively, over their initial status in the soil with an application of 100% NPK + *Azotobacter* inoculation + 20 Mt ha⁻¹ of organic manure

Sur *et al.* (2010) conducted an experiment to study the effect of integrated nutrient management on the availability of N, P, K and cationic micronutrients in soils in relation to 'Green Express' cabbage (*Brassica oleracea* var. *capitata*.) and found highest amount of organic carbon content (0.88%) in the treatment where recommended levels of NPK along with 4 tonnes/ha organic manures and zinc at 0.5 kg/ha as Zn-EDTA was applied.

Sarangthem *et al.* (2011) studied the impact of organic manures on soil properties and yield of cabbage (*Brassica oleracea* L. var. *capitata*) in acid soil. The investigation comprised of two sources of organic manure (vermicompost and FYM) and *Azospirillum* (4kg/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 prevalent

than farmyard manure. The post-harvest organic carbon and available NPK content of soil significantly improved with the application of vermicompost and *Azospirillum*. The concentration of nutrients (NPK) in shoots and roots of cabbage was elevated in the treatment getting vermicompost 3t/ha alongside *Azospirillum* as compared to with FYM treatments.

Bhardwaj *et al* (2012) investigated the effect of bio-organics (biofertilizers, crop residues, FYM) and chemical fertilizers together on yield, physico-chemical, and microbiological properties of soil in a 'French bean-cauliflower'-based cropping system is investigated in the experiment conducted by The results showed significant higher soil available N (351.3 kg/ha) under 75% NPK+biofertilizers, whereas the highest soil available K (268.3 kg /ha) was recorded under 75% NPK + crop residues. Lowest bulk density (1.03 Mg/m), highest water holding capacity (36.5%), soil organic matter (10.6 g/kg), bacterial and fungal in cauliflower

Devi *et al.* (2016) conducted a field study to assess the effect of organic, bio-fertilizers and inorganic amendments on mineral composition and biological properties of soil during cultivation of cauliflower (*Brassica oleracea*). The experiment comprises organic manure (20 t/ha), biofertilizers PSB and *Azotobacter* The recommended dose of N: P: K: B was 100:75:55:1 kg/ha. They reported that that there was no effect of synthetic fertilizers, bio fertilizers and organic manure on soil pH, The organic carbon content and N,P,K of soil after the crop harvest significantly increased in the treatment with recommended dose of N:P:K:+FYM

Devi *et al.* (2018) laid out field experiment was in two consecutive years (2015 and 2016) to evaluate effect of integrated nutrient management (INM) on yield of cauliflower (*Brassica oleracea* var *botrytis*.) and soil fertility. The results revealed that the concentration of nutrients (OC, N, P and K) increased in soil in the treatment 120% NPKM (50:50 of FYM and VC as per N content.

Chapter-3

Materials and Methods

MATERIALS AND METHODS

The present investigation entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**” was carried out at Vegetable Block, Organic Farming Research Centre, Main Campus- Chatha, Jammu (J&K) during winter season 2020-21. The details of the experimental site, materials used and methodology employed during the course of study are discussed in this chapter.

3.1 Experimental site

3.1.1 Location & Climate

Geographically, the experimental site was located at 32° 40' N latitude and 74° 82' E longitude with an altitude of 293 meters above mean sea level. The location falls in the sub-tropical foothill lands of Shivaliks in Jammu district of J&K UT. Chatha, Jammu is bestowed with cool and dry summer season followed by hot and humid monsoon season and cold winters. The annual rainfall of the location ranges between 900mm to 1200mm, out of which 70-75 per cent rainfall is received from June to September, while remaining 25.0 per cent is received in few showers during winter as a result of western disturbances from October to March.

3.1.2 Weather

A perusal of weather data revealed that crop received highest mean weekly maximum temperature of 31.0° C in the 13th standard meteorological week (SMW (March) and lowest mean weekly minimum temperature of 2.9° C in the 52th SMW (December). The total amount of weekly rainfall received during crop growing period was about 183.8 mm which ranged between 0.0 to 88.2 mm. Highest rainfall of 88.2 mm was received by the crop in the 1st (SMW) (January) of 88.2 mm. Maximum relative humidity of 95.9 per cent was recorded in the 7th SMW (February), 2021 and minimum of 39.6 per cent was recorded in the 45th SMW (November), 2020. The average maximum and minimum relative humidity recorded during the entire crop growing

period were 89.9 per cent and 56.7 per cent, respectively. The meteorological data recorded for different weather parameters during crop cycle of broccoli *i.e.*, between 45th to 13st SMW have been depicted in (Figure 3.1, 3.2 & 3.3 and Appendix I) and was acquired from Agro meteorology section, Division of Agronomy, SKUAST-Jammu.

3.2 Collection and preparation of soil samples

Before initiation of experiment, representative soil samples were collected from 15 cm depth of soil. The samples were air dried and sieved through 2 mm sieve and were analyzed for various physico-chemical properties which are listed in Table 3.1

Table 3.1: Physico-chemical properties of experimental field

S. No.	Properties	Optimum Range	Values	Methods employed
1	pH	-	7.79	Glass electrode Black man pH meter (Jackson 1973)
2	EC(dsm ⁻¹)	-	0.24	Solu-Bridge method (Jackson, 1973)
3	Soil Texture	-	-	Loamy texture
4	Organic Carbon (%)	0.65	0.60	Walkley and Black (1934)
5	Available Nitrogen (kg/ha)	240-480	194.7	Alkaline potassium permanganate method (Subbiah and Asija,1956)
6	Available Phosphorus (kg/ha)	11-23	18.68	Olsen method (Olsen <i>et al.</i> , 1954)
7	Available Potassium (kg/ha)	110-280	175.4	Ammonium acetate method (Jackson, 1973)

The soil of the experiment site was loamy in texture, slightly alkaline in pH, low in organic carbon and available nitrogen while medium in phosphorus, potassium with EC in the normal range.

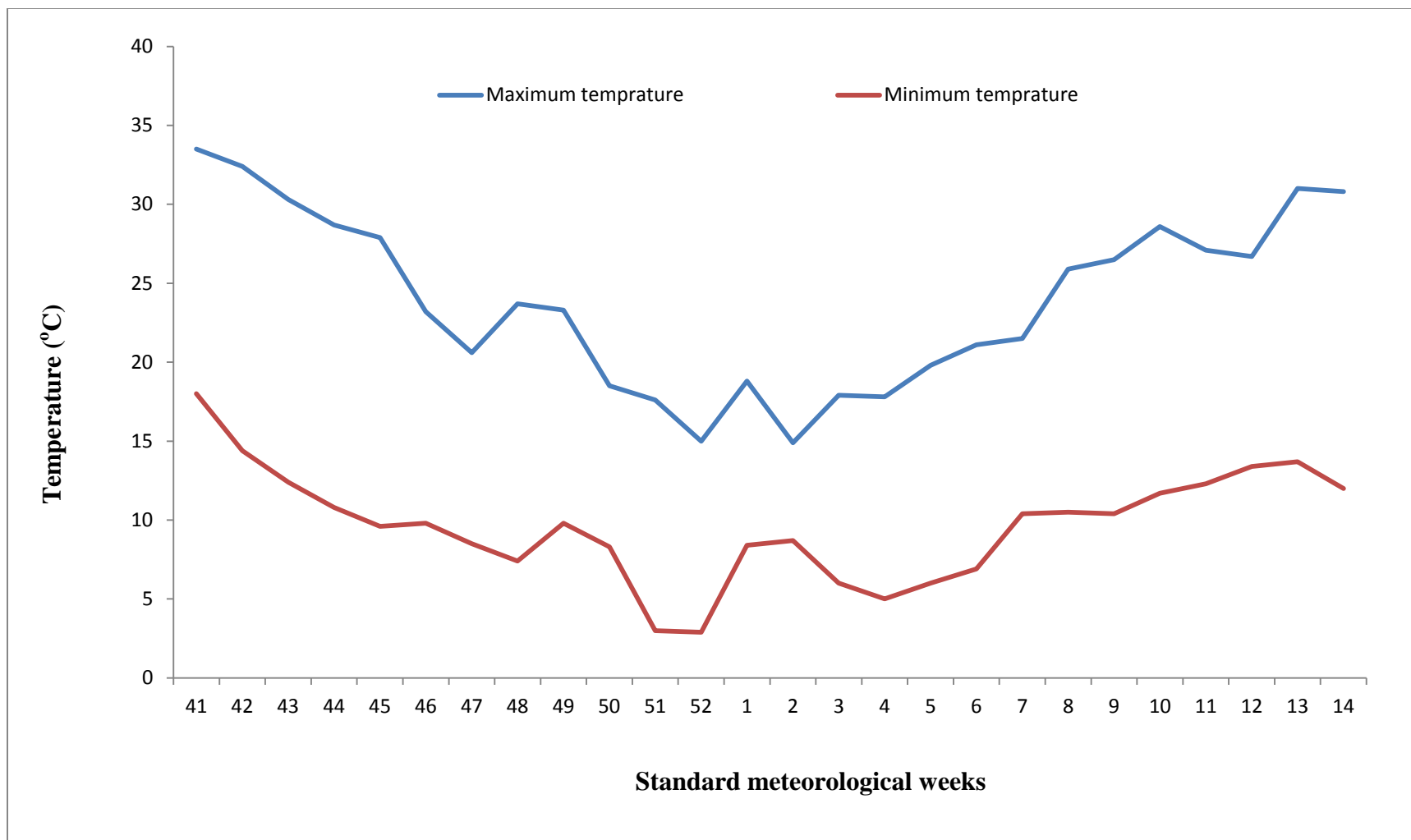


Fig 3.1: Standard mean weekly data of temperature (° C) during the entire growing period of broccoli in *Rabi* season (2020-21)

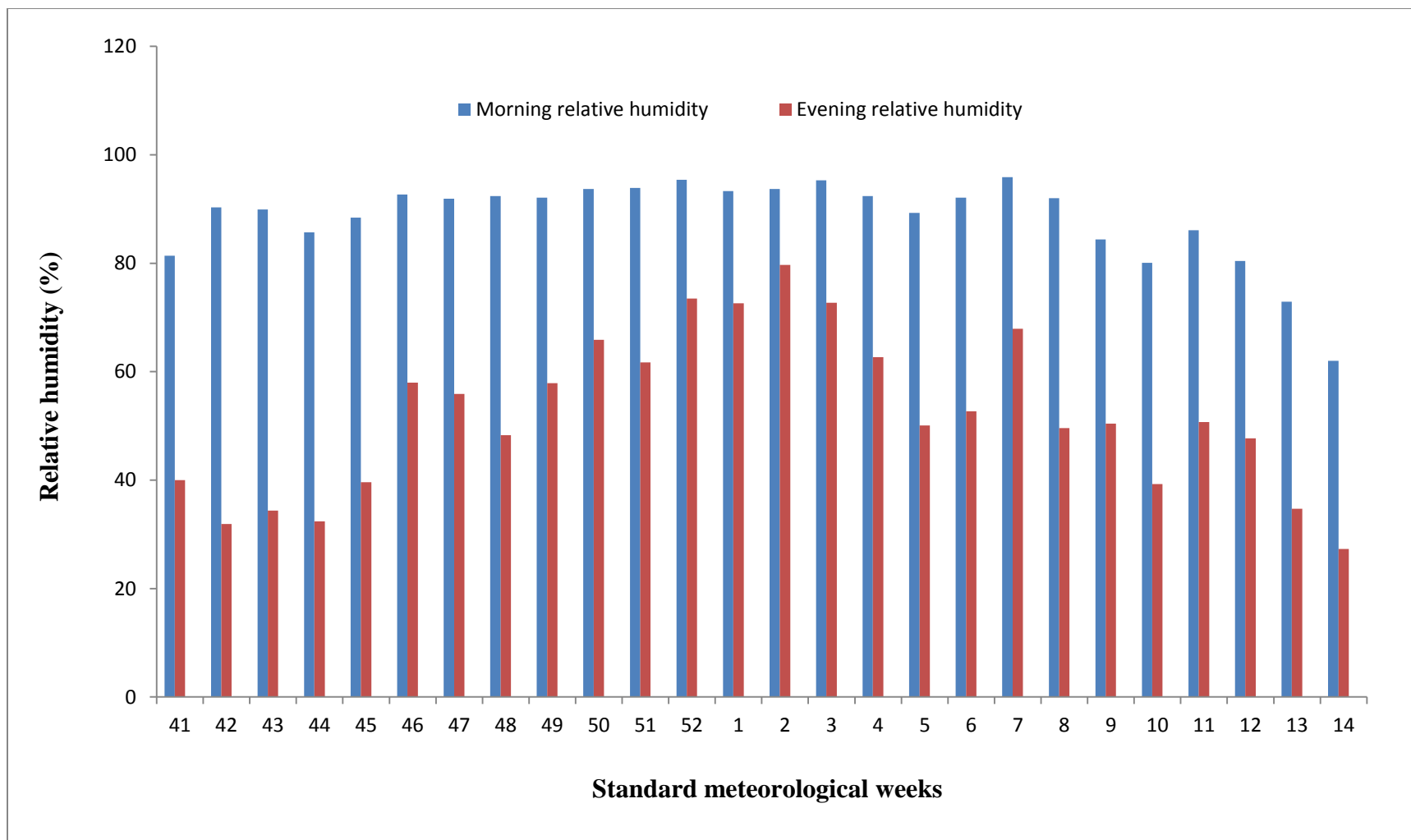


Fig 3.2: Standard mean weekly weather data of relative humidity (%) during the entire growing period of broccoli in *Rabi* season (2020-21)

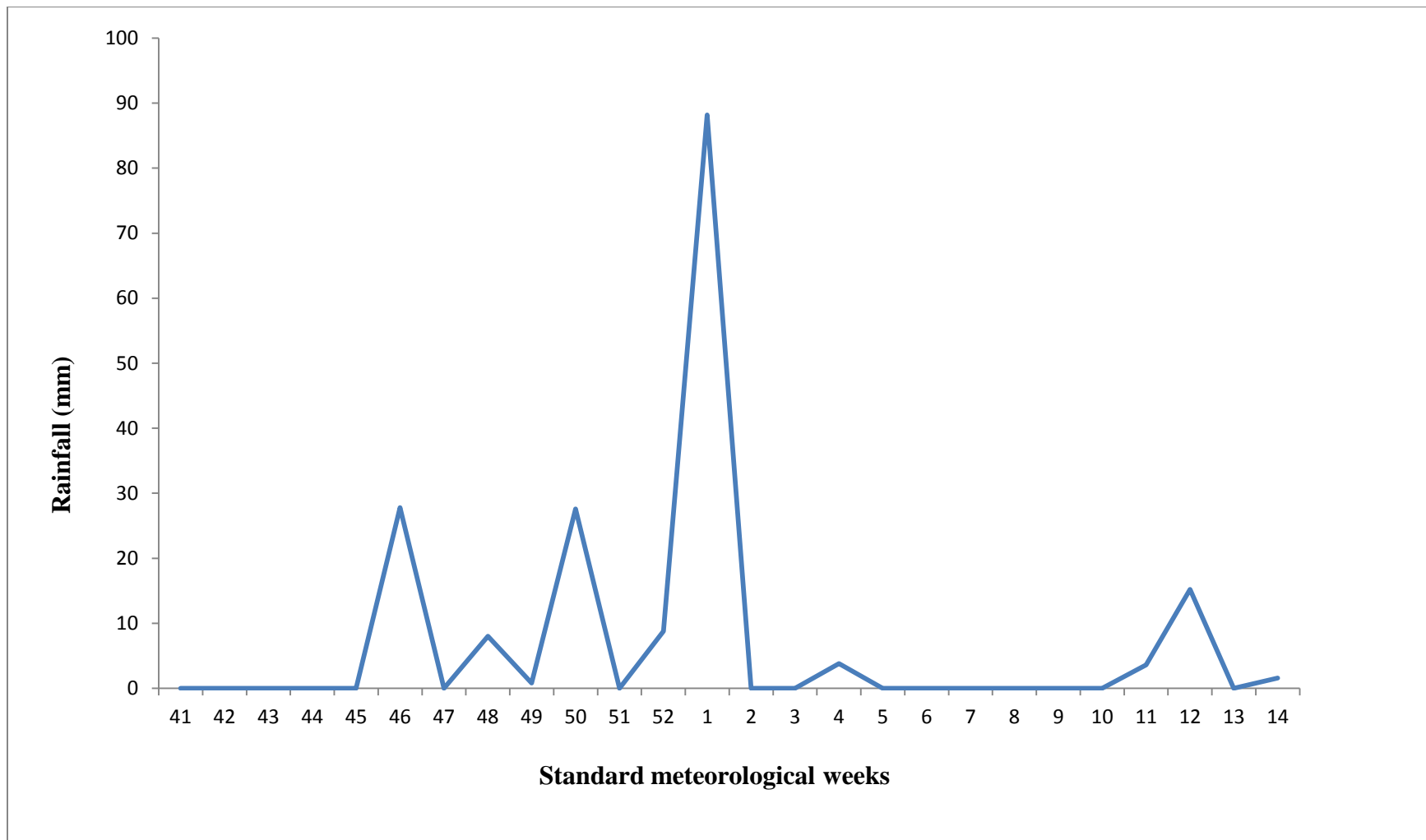


Fig 3.3: Standard mean weekly weather data of actual rainfall (mm) during the entire growing period of broccoli in *Rabi* season (2020-21)

3.3 Field history

The previously sown crop on the same field was rainy season okra which was uprooted from the field on 2nd week of October 2020.

3.4 Cultural practices

3.4.1 Land preparation

The experimental land was prepared by ploughing with tiller and levelled properly with rotavator. Subsequently, plots of convenient size of 3.0 m x 3.0 m were prepared during the 3rd fortnight of October, 2020.

3.4.2 Seed sowing and transplanting

Seeds of variety Jammu Broccoli 07 were sown in raised nursery beds of about 2.0 meter long, 1.0 meter width and 15 cm above ground level on 30th October 2020. The seed beds were covered with local mulching material to faster seed germination. Seedlings were ready for transplanting 30 days after sowing. These healthy seedling of uniform shape and size were transplanting in well prepared experimental plots of size was 3 m × 3 m on ridges at a spacing of 60 x 45 cm. accommodating 30 plants per plot. Standard cultural and management practices were adopted to raise a healthy broccoli crop.

3.4.3 Application of manures and biofertilizers

The bulk organic manures like FYM was incorporated into the prepared plots @ 20 t/ha for efficient decomposition. Vermicompost was applied in split doses i.e 1st at the time of transplanting, 2nd dose was applied at the time of earthing up operation and 3rd dose was given at the time of flowering and pod filling.

For biofertilizers like *Azotobacter*, PSB, PMB, *Azospirillum* and Organic Liquid Consortia-NPK, procured from IFFCO were applied as seedling dip treatment. The biofertilizers were mixed with 10% solution of jaggary and the roots were dipped for half an hour before transplantation in the main field.

Table 3.2: Doses of biofertilizers and organic manures used in the experiment/ha

Biofertilizers and organic manures	Dosage/ha
FYM	20.0 T
Vermicompost	5.0 T
<i>Azospirillum</i>	0.5 kg
<i>Azotobacter</i>	0.5 kg
PSB	1.0 l
PMB	750 ml
Organic Liquid Consortia-NPK	1.0 l

3.4.4 Application of biopesticides

Application of biopesticides like Neem oil, *Beauveria bassiana*, NSKE (5%) and *Bacillus thuringiensis* (Bt) was done at vegetative, curd maturity and pod formation stages, after appearance of initial symptoms.

Table 3.3: Doses of biopesticides /ha

Biopesticides	Dosage/ha
NSKE (5%)	25.0 kg
Neem oil (0.5%)	2.5 l
<i>Baeuveria bassiana</i>	2.0 kg
<i>Bacillius thuringiensis</i>	2.0 kg

3.4.5 Aftercare and harvesting

Intercultural operations were done regularly to keep the field weed free and all the bunds and channels were cleared from time to time. The first irrigation was provided immediately after the transplanting and subsequent prophylactic sprays of bio-pesticides were given to the crop to check important insect pest and diseases. Harvesting data was

recorded when 50% of the curd attained market maturity i.e., in the month of January 2021. Harvesting was done manually with the help of sickle and all the yield related data was recorded from the harvested crop as per the technical programme.

3.4 Technical Programme

Name of crop	:	Broccoli (<i>Brassica oleracea</i> var. <i>italica</i>)
Variety	:	Jammu Broccoli-07
Season	:	Winter season (2020-21)
Design	:	RCBD Factorial (3-factors)
Sowing date	:	October, 2020
Biofertilizers	:	03
Organic manures	:	02
Bio-pesticides	:	02
Number of replications	:	03
Date of harvesting	:	March 2021

3.5 Treatment details

A. Organic amendments

1. *Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria (B₁)
2. *Azospirillum* + Phosphate Solubilising Bacteria (B₂)
3. Organic Liquid consortia-NPK (B₃)

B. Organic Manures

1. Vermicompost (M₁)
2. FYM (M₂)

C. Bio pesticides

1. Neem oil + *Baevuveria bassiana* (P₁)
2. NSKE (5%) + *Baccillus thuringensis* (Bt) (P₂)

3.5.1 Treatments combinations

S.No.	Treatment Combinations
1	$B_1 + M_1 + P_1$
2	$B_2 + M_1 + P_1$
3	$B_3 + M_1 + P_1$
4	$B_1 + M_2 + P_1$
5	$B_2 + M_2 + P_1$
6	$B_3 + M_2 + P_1$
7	$B_1 + M_1 + P_2$
8	$B_2 + M_1 + P_2$
9	$B_3 + M_1 + P_2$
10	$B_1 + M_2 + P_2$
11	$B_2 + M_2 + P_2$
12	$B_3 + M_2 + P_2$

3.6 Observations recorded

Five plants were randomly selected per treatment per plot in all the three replications and tagged to record the necessary observations as given below:

3.6.1 Growth parameters

3.6.1.1 Plant height (cm)

Plant height is an important index for studying the growth and development of crop plant was measured in centimeters from ground level to the upper surface (tip) of the plant at time of curd maturity.

3.6.1.2 Plant spread (cm²)

Plant spread was measured from North to South and East to West of plant at the time of curd maturity in centimeter square

3.6.1.3 Days to 50% curd initiation (DAT)

Days from the date of transplanting till 50% of the plant showed curd initiation were counted from the tagged plants per treatment per replication.

3.6.1.4 Days to 50% central curd maturity (DAT)

Days from the date of transplanting till 50% of central curd matured per treatment per replication were counted in each replication.

3.6.2 Yield parameters

3.6.2.1 Curd weight (g)

Weight of broccoli heads was recorded from tagged plants from each treatment in all the replications and their mean was calculated.

3.6.2.2 Weight of lateral shoots per plant (g)

It was recorded by harvesting lateral shoots in 2 intervals after the central curd was harvested from the tagged plants and their mean was calculated and recorded.

3.6.2.3 Yield (q/ha)

Yield per hectare was calculated on the basis of yield per plot of all treatments and 10% deduction was made to adjust gross area as under:

Conversion factor (q/ha) = 100/plot size

Yield (q/ha) = yield (kg per plot) x conversion factor (q/ha)

3.6.3 Seed quality parameters

3.6.3.1 Days to 50% flowering (DAT)

They were recorded from the date of transplanting till 50% of the plants showed flowering per replication.

3.6.3.2 Days to 50% seed setting (DAT)

Seed setting in the plants were recorded from the date of transplanting till 50% of the plant showed seed set per treatment per replication.

3.6.3.3 Number of pods per plant

All the pods from 5 tagged plants were counted from each treatment replication and their mean was calculated.

3.6.3.4 Seed weight per plant (g)

All the pods were threshed to extract seeds from each treatment and the weight was then recorded on balance in grams.

3.6.3.5 Seed yield/ha (kg)

The threshed seed of crop obtained from each plot was weighed out separately and finally converted into kg ha¹ by multiplying with conversion factor given below:

$$\text{Seed yield (kg ha}^1\text{)} = \frac{\text{Yield obtained from net plot (kg)}}{\text{Area of net plot} \times 100} \times 10000$$

3.7 Soil parameters

The soil samples were collected from the experimental field up to 15 cm depth before sowing and after harvesting of the crop. Initial and final properties of soil viz, pH, EC, Organic Carbon, available Nitrogen, Phosphorus and Potassium were calculated using the standard methods. The samples were dried under shade and passed through 2 m sieve and analyzed.

3.7.1 Soil pH

It was determined by suspension of soil and water (1:2) using glass-calomel electrode method (Jackson, 1973).

3.7.2 Soil EC (dsm^{-1})

EC was determined by salt bridge measurement from the suspension used for pH determination (Jackson, 1973).

3.7.3 Organic carbon (%)

Organic carbon was determined by Walkley and Black's rapid titration method (Jackson, 1973)

3.7.3 Nitrogen availability in soil (kg ha^{-1})

Available nitrogen was determined by modified alkaline potassium permanganate method as described by Subbiah and Asija, 1956.

3.7.4 Phosphorus availability in soil (kg ha^{-1})

Available phosphorus was determined using 0.5 M sodium bicarbonate ($\text{pH} = 8.5$) extractable P method described by Olsen *et al.*, (1954). The intensity of colour developed by stannous chloride was measured at 660 nm on spectrophotometer

3.7.5 Potassium availability in soil (kg ha^{-1})

Available K was extracted with neutral normal ammonium acetate solution method as described by Jackson, 1973

3.8 Insect pest and disease parameters

3.8.1 Cabbage semi-looper and cabbage butterfly infestation

The populations of cabbage semi-looper and cabbage butterfly were recorded 1 day before spraying, 1, 3, 7 and 15 days after each spraying as procedure followed in population dynamics experiment. The population was counted from 5 plants from each of replicate.

3.8.2 Curd rot and black rot incidence

The curd and black rot incidence were recorded one day before spraying, 1, 3, and 7 and 15 days after each spraying as procedure followed in population dynamics

experiment. The population was counted from tagged plants per treatment from each replication.

3.8.3 Statistical analysis

For calculating various statistical parameters, analysis was performed using MS-Excel and OPSTAT for all the characters. The mean values of the data were subjected to analysis of variance and ANOVA was set for Randomized Complete Block Design according to Gomez and Gomez (1984).

Chapter-4

Results

RESULTS

The results obtained during the course of field experiment entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var *italica*) under Organic Management**” conducted during the winter season of 2020-21 have been described in this chapter the observations regarding different parameters of study were analyzed statistically and have been represented with the help of graphs and Tables under following headings:

4.1 Growth traits

The growth of broccoli was measured in terms of plant height, plant spread, days to 50% curd initiation and days to 50% curd maturity.

4.1.1 Plant height (cm)

Plant height is a major index of growth and development which represents the buildup of the plant over a given period of time. The data regarding plant height as affected by bio-fertilizers, organic manures and bio-pesticides was measured at curd maturity stage and is summarized in the Table 4.1 and Appendix II.

4.1.1.1 Individual effect of biofertilizers, organic manures and biopesticides on plant height

Individual application of biofertilizers, organic manures and biopesticides showed a significant influence on plant height of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum plant height of 49.48 cm which was statistically highest as compared to B₂ (47.03 cm) and B₃ (42.04 cm). In case of organic manures maximum plant height (49.64 cm) was recorded in M₂ i.e. (FYM) which was statistically highest as compared to M₁ (43.06 cm). In case of biopesticides maximum plant height (48.21 cm) was recorded

in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (44.49 cm).

4.1.1.2 Interactive effect of biofertilizers, organic manures and biopesticides on plant height

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to plant height except the interaction between organic manures and biopesticides. Among the interaction of biofertilizers and organic manures, B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the maximum plant height of 52.29 cm which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum plant height was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) (50.98 cm) which was statistically highest as compared to all other combinations. The interaction between organic manures and biopesticides showed non-significant influence on plant height.

Among the interaction of biofertilizers, organic manures and biopesticides, maximum plant height was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (54.79 cm) which were statistically highest as compared to all other combinations.

4.1.2 Plant spread (cm²)

The data regarding plant spread as affected by biofertilizers, organic manures and biopesticides was measures at curd maturity stage and is summarized in the Table 4.2 and Appendix III.

4.1.2.1 Individual effect of biofertilizers, organic manures and biopesticides on plant spread

Individual application biofertilizers, organic manures and biopesticides showed a significant influence on plant spread of broccoli. Among biofertilizers, B₁ i.e.

(*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) maximum plant spread of 2473.83 cm² was recorded which was statistically highest as compared to B₂ (2358.83cm²) and B₃ (2124.83 cm²). In case of organic manures maximum plant spread (2482.00 cm²) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (2156.00 cm²). In case of Bio-pesticides maximum plant spread (2413.97 cm²) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (2224.36 cm²).

4.1.2.2 Interactive effect of biofertilizers, organic manures and biopesticides on plant spread

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to plant spread except the interaction between manures and biopesticides. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the maximum plant spread of 2614.33 cm² which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum plant spread (2548.83 cm²) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations. The interaction between organic manures and biopesticides showed non-significant influence on plant spread.

Among the interaction of biofertilizers, organic manures and biopesticides maximum plant spread was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (2739.33 cm²) which were statistically highest as compared to all other combinations.

4.1.3 Days to 50% curd initiation (DAT)

The data regarding days to 50% curd initiation as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.3 and Appendix IV.

4.1.3.1 Individual effect of biofertilizers, organic manures and biopesticides on days to 50% curd initiation

Biofertilizers, organic manures and biopesticides application showed a significant influence on days to 50% curd initiation of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded minimum days to 50% curd initiation (64.75 days) which was statistically lowest as compared to B₂ (68.50 days) and B₃ (71.50 days). In case of organic manures minimum days to 50% curd initiation (66.67 days) was recorded in M₂ i.e (FYM) which was statistically lowest compared to M₁ (69.83 days). In case of Bio-pesticides minimum days to 50% curd initiation (65.83 days) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically lowest compared to P₂ (70.67 days).

4.1.3.2 Interactive effect of biofertilizers, organic manures and biopesticides on days to 50% curd initiation

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to days to 50% curd initiation on broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the minimum days to 50% curd initiation (64.50 days) which was statistically lowest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, minimum days to 50% curd initiation (62.50 days) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically lowest compared to all other combinations. In case of interaction between organic manures and biopesticides, minimum days to 50% curd initiation (63.00 days) was recorded in M₂ x P₁ i.e which was statistically lowest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides minimum days to 50% curd initiation was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (62.00 days) which were statistically lowest compared to all other combinations.

4.1.4 Days to 50% curd maturity (DAT)

The data regarding Days to 50% curd maturity as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.4 and Appendix V.

4.1.4.1 Individual effect of biofertilizers, organic manures and biopesticides on days to 50% curd maturity

Biofertilizers, organic manures and biopesticides application showed a significant influence on days to 50% curd maturity of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded minimum days to 50% curd maturity (79.75 days) which was statistically lowest as compared to B₂ (83.50 days) and B₃ (86.50 days). In case of organic manures minimum days to 50% curd maturity (81.67) was recorded in M₂ i.e. (FYM) which was statistically lowest as compared to M₁ (84.83 days). In case of Bio-pesticides minimum days to 50% curd maturity (80.83 days) was recorded in P₁ i.e. (Neem oil + *Baeuveria bassiana*) which was statistically lowest as compared to P₂ (85.67 days).

4.1.4.2 Interactive effect of biofertilizers, organic manures and biopesticides on days to 50% curd maturity

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to Days to 50% curd maturity on broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the minimum days to 50% curd maturity (79.50 days) which was statistically lowest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, minimum days to 50% curd maturity (77.50 days) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically lowest as compared to all other combinations. In case of interaction between organic manures and biopesticides, minimum days to 50% curd maturity (78.00 days) was recorded in M₂ x P₁ i.e. which was statistically lowest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides minimum days to 50% curd maturity was recorded in $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (77.00 days) which were statistically lowest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

Table 4.1: Effect of biofertilizers, organic manures and biopesticides on plant height (cm)

B x M						
	M₁		M₂		Mean	
B₁	46.67		52.29		49.48	
B₂	44.93		49.13		47.03	
B₃	37.58		47.51		42.54	
Mean	43.06		49.64			
	SE(m)±		CD(0.05)			
B	0.75		2.20			
M	0.612		1.79			
B x M	1.06		3.11			
B x P						
	P₁		P₂		Mean	
B₁	50.98		47.98		49.48	
B₂	46.86		47.19		47.03	
B₃	46.79		38.29		42.54	
Mean	48.21		44.49			
	SE(m)±		CD(0.05)			
P	0.61		1.80			
B x P	1.06		3.11			
M x P						
	P₁		P₂		Mean	
M₁	44.78		41.33		43.06	
M₂	51.64		47.64		49.64	
Mean	48.21		44.49			
	SE(m)±		CD(0.05)			
M x P	0.86		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	47.17	54.79	43.59	50.13	43.58	50.01
P₂	46.17	49.79	46.26	48.13	31.58	45.01
	SE(m)±		CD(0.05)			
B x M x P	1.5		4.40			
CV	8.64					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁**= Vermicompost, **M₂**= FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.2: Effect of biofertilizers, organic manures and biopesticides on plant spread (cm²)

B x M						
	M₁		M₂		Mean	
B₁	2333.33		2614.33		2473.83	
B₂	2261.33		2456.33		2358.83	
B₃	1874.33		2375.33		2124.83	
Mean	2156.33		2482.00			
	SE(m)±		CD(0.05)			
B	37.609		110.331			
M	30.707		90.085			
B x M	53.187		156.031			
B x P						
	P₁		P₂		Mean	
B₁	2548.83		2398.83		2473.83	
B₂	2358.00		2359.67		2358.83	
B₃	2335.08		1914.58		2124.83	
Mean	2413.97		2224.36			
	SE(m)±		CD(0.05)			
P	30.707		90.085			
B x P	53.187		156.031			
M x P						
	P₁		P₂		Mean	
M₁	2245.94		2066.72		2156.33	
M₂	2582.00		2382.00		2482.00	
Mean	2413.97		2224.36			
	SE(m)±		CD(0.05)			
M x P	43.427		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	2358.33	2739.33	2209.67	2506.33	2169.83	2500.33
P₂	2308.33	2489.33	2313.00	2406.33	1578.83	2250.33
	SE(m)±		CD(0.05)			
B x M x P	75.218		220.662			
CV	8.44					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

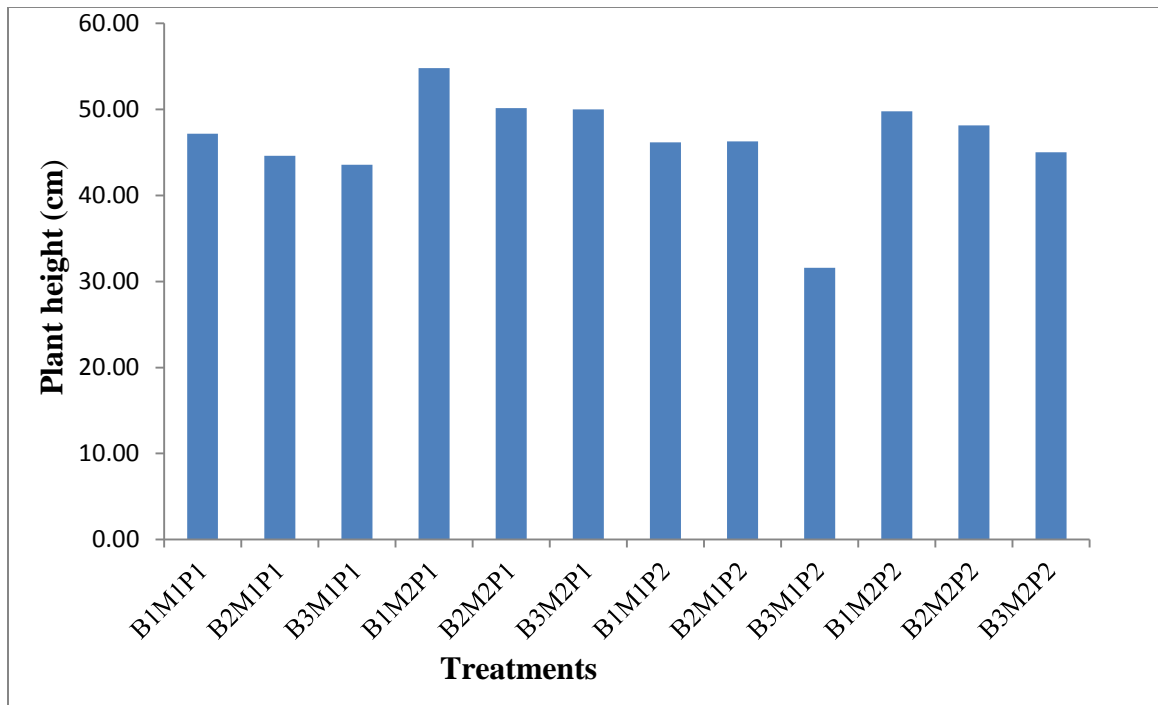


Fig 4.1: Effect of biofertilizers, organic manures and biopesticides on plant height (cm)

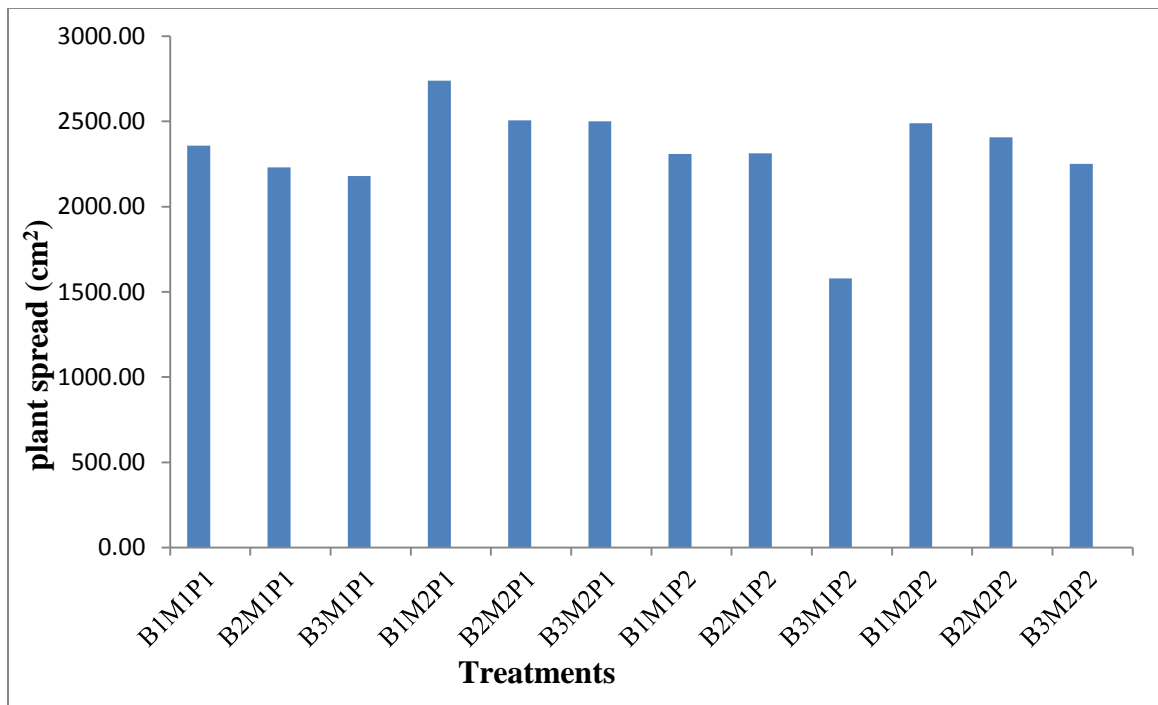


Fig 4.2: Effect of biofertilizers, organic manures and biopesticides on plant spread (cm²)

Table 4.3: Effect of biofertilizers, organic manures and biopesticides on days to 50% curd initiation (DAT)

B x M						
	M₁		M₂		Mean	
B₁	65.00		64.50		64.75	
B₂	70.50		66.50		68.50	
B₃	74.00		69.00		71.50	
Mean	69.83		66.67			
	SE(m)±		CD(0.05)			
B	0.61		1.78			
M	0.49		1.45			
B x M	0.86		2.51			
B x P						
	P₁		P₂		Mean	
B₁	62.50		67.00		64.75	
B₂	67.00		70.00		68.50	
B₃	68.00		75.00		71.50	
Mean	65.83		70.67			
	SE(m)±		CD(0.05)			
P	0.49		1.45			
B x P	0.86		2.51			
M x P						
	P₁		P₂		Mean	
M₁	68.67		71.00		69.83	
M₂	63.00		70.33		66.67	
Mean	65.83		70.67			
	SE(m)±		CD(0.05)			
M x P	0.70		2.05			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	63.00	62.00	70.00	64.00	73.00	63.00
P₂	67.00	67.00	71.00	69.00	75.00	74.00
	SE(m)±		CD(0.05)			
B x M x P	1.21		3.55			
CV	6.36					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.4: Effect of biofertilizers and organic manures on days to 50% curd maturity (DAT)

B x M						
	M₁		M₂		Mean	
B₁	80.00		79.50		79.75	
B₂	85.50		81.50		83.50	
B₃	89.00		84.00		86.50	
Mean	84.83		81.67			
	SE(m)±		CD(0.05)			
B	0.61		1.78			
M	0.49		1.45			
B x M	0.86		2.51			
B x P						
	P₁		P₂		Mean	
B₁	77.50		82.00		79.75	
B₂	82.00		85.00		83.50	
B₃	83.00		90.00		86.50	
Mean	80.83		85.67			
	SE(m)±		CD(0.05)			
P	0.49		1.45			
B x P	0.86		2.51			
M x P						
	P₁		P₂		Mean	
M₁	83.67		86.00		84.83	
M₂	78.00		85.33		81.67	
Mean	80.83		85.67			
	SE(m)±		CD(0.05)			
M x P	0.70		2.05			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	78.00	77.00	85.00	79.00	88.00	78.00
P₂	82.00	82.00	86.00	84.00	90.00	89.00
	SE(m)±		CD(0.05)			
B x M x P	1.21		3.55			
CV	5.36					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁**= Vermicompost, **M₂**= FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

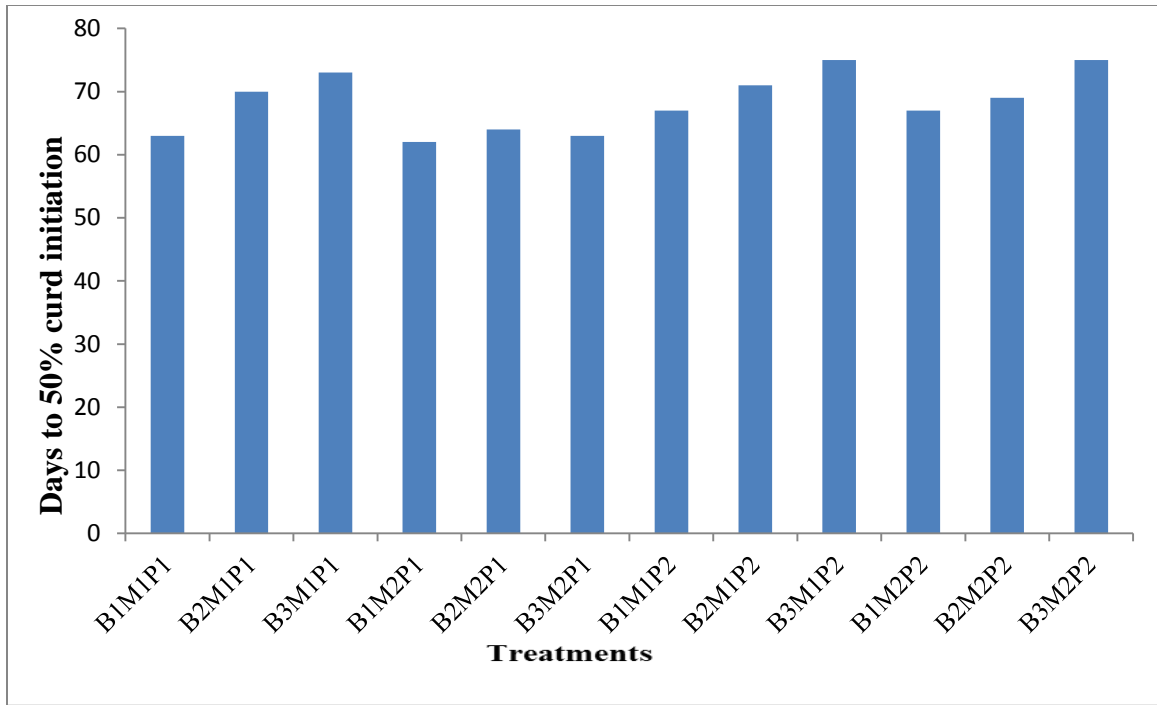


Fig 4.3: Effect of biofertilizers, organic manures and biopesticides on days to 50% curd initiation (DAT)

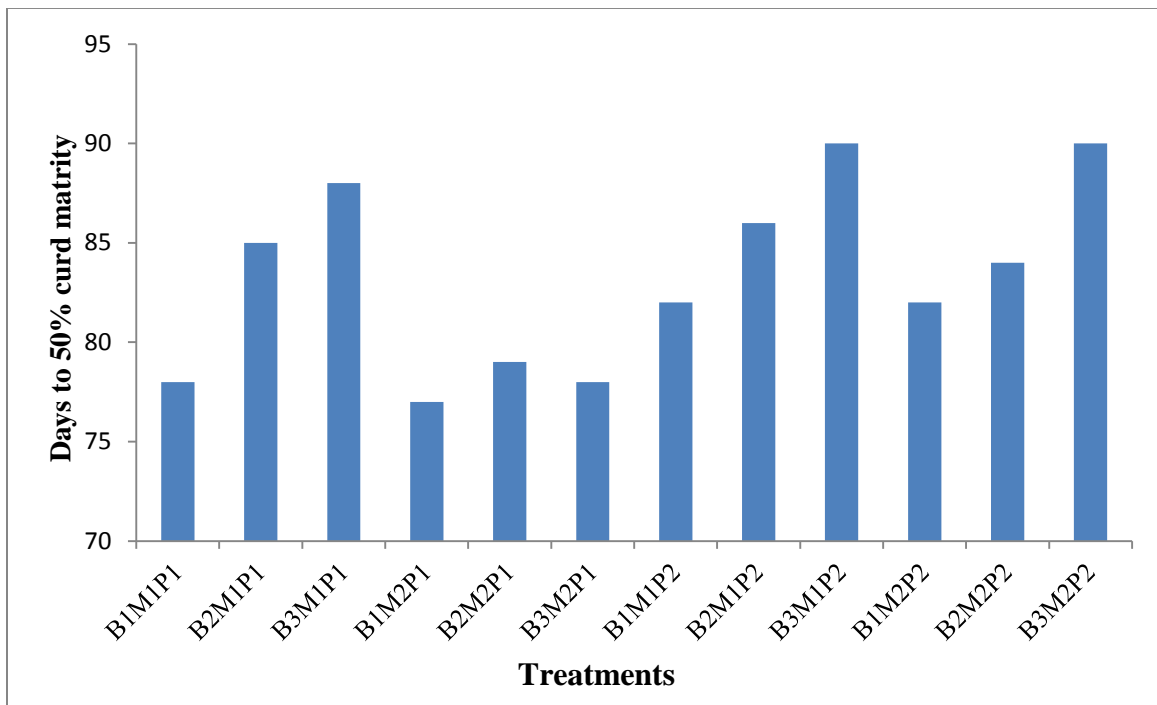


Fig 4.4: Effect of biofertilizers, organic manures and biopesticides on days to 50% curd maturity (DAT)

4.2 Yield traits

The yield of broccoli was measured in terms of curd weight, weight of lateral shoots/plant and curd yield.

4.2.1 Curd weight (g)

The data regarding curd weight as affected by biofertilizers, organic manures and biopesticides was measured at curd maturity stage and is summarized in the Table 4.5 and Appendix VI.

4.2.1.1 Individual effect of biofertilizers, organic manures and biopesticides on curd weight

Individual application of Biofertilizers, organic manures and biopesticides showed a significant influence on curd weight of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum curd weight (291.61 g) which was statistically highest as compared to B₂ (277.79 g) and B₃ (250.00 g). In case of organic manures maximum curd weight (297.73 g) was recorded in M₂ i.e. (FYM) which was statistically highest as compared to M₁ (248.59 g). In case of biopesticides maximum curd weight (289.85 g) was recorded in P₁ i.e. (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (256.42 g).

4.1.4.2 Interactive effect of biofertilizers, organic manures and biopesticides on curd weight

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to curd weight on broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) recorded the maximum curd weight of 313.72 g which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum curd weight (305.86 g) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest

as compared to all other combinations. In case of interaction between organic manures and biopesticides, maximum curd weight (309.62 g) was recorded in $M_2 \times P_1$ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides maximum curd weight of 328.72 g was recorded in $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) which were statistically highest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

4.2.2 Weight of lateral shoots/plant (g)

The data regarding weight of lateral shoots/plant as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.6 and Appendix VII.

4.2.2.1 Individual effect of biofertilizers, organic manures and biopesticides on weight of lateral shoots/plant

Individual application of biofertilizers, organic manures showed a significant influence on weight of lateral shoots/plant of broccoli. However, non-significant influence was recorded by the individual application of biopesticides on weight of lateral shoots/plant of broccoli. Among biofertilizers, B_1 i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded maximum weight of lateral shoots/plant (152.18 g) which was statistically highest as compared to B_2 (144.58 g) and B_3 (131.38 g). In case of organic manures maximum weight of lateral shoots/plant (148.92 g) was recorded in M_2 i.e (FYM) which was statistically highest as compared to M_1 (137.17 g).

4.2.2.2 Interactive effect of biofertilizers, organic manures and biopesticides on weight of lateral shoots/plant

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to weight of lateral shoots/plant of broccoli. Among the interaction of biofertilizers and organic manures $B_1 \times M_2$ i.e. (*Azotobacter* +

Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the maximum weight of lateral shoots/plant (156.86 g) which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum weight of lateral shoots/plant (152.93 g) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations of biofertilizers and biopesticides. In case of interaction between organic manures and biopesticides, maximum weight of lateral shoots/plant (154.92 g) was recorded in M₂ x P₁ i.e which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides maximum weight of lateral shoots/plant (164.36 g) was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) which were statistically highest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

4.2.3 Yield (q/ha)

The data regarding yield as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.7 and Appendix VIII.

4.2.3.1 Individual effect of biofertilizers, organic manures and biopesticides on yield

Individual application of biofertilizers, organic manures and biopesticides showed a significant influence on yield of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded maximum Yield (97.20 q/ha) which was statistically highest as compared to B₂ (92.60 q/ha) and B₃ (83.33 q/ha). In case of organic manures maximum yield (99.24 q/ha) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (82.25 q/ha). In case of Biopesticides maximum yield (96.62 q/ha) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (85.47 q/ha).

4.1.3.2 Interactive effect of biofertilizers, organic manures and biopesticides on yield

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to yield of broccoli. Among the interaction of biofertilizers and organic manures $B_1 \times M_2$ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) \times (FYM) showed the maximum Yield (104.37 q/ha) which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum yield (101.95 q/ha) was recorded in $B_1 \times P_1$ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium mobilizing Bacteria) \times (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations. In case of interaction between organic manures and biopesticides, maximum yield (103.21 q/ha) was recorded in $M_2 \times P_1$ i.e (FYM) \times (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides, maximum yield was recorded in $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) \times (FYM) \times (Neem oil + *Baeuveria bassiana*) (109.57 q/ha) which were statistically highest as compared to all other combinations.

Table 4.5: Effect of biofertilizers, organic manures and biopesticides on Curd weight (g)

B x M						
	M₁		M₂		Mean	
B₁	269.50		313.72		291.61	
B₂	261.16		294.43		277.79	
B₃	214.96		285.04		250.00	
Mean	248.54		297.73			
	SE(m)±		CD(0.05)			
B	4.50		13.20			
M	3.68		10.78			
B x M	6.37		18.67			
B x P						
	P₁		P₂		Mean	
B₁	305.86		277.36		291.61	
B₂	282.93		272.66		277.79	
B₃	280.75		219.25		250.00	
Mean	289.85		256.42			
	SE(m)±		CD(0.05)			
P	3.68		10.78			
B x P	6.37		18.67			
M x P						
	P₁		P₂		Mean	
M₁	270.07		227.01		248.54	
M₂	309.62		285.84		297.73	
Mean	289.85		256.42			
	SE(m)±		CD(0.05)			
M x P	5.20		15.25			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	283.00	328.72	265.76	300.09	261.46	300.04
P₂	256.00	298.72	256.56	288.76	168.46	270.04
	SE(m)±		CD(0.05)			
B x M x P	9.00		26.41			
CV	8.57					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

Table 4.6: Effect of biofertilizers, organic manures and biopesticides on weight of lateral shoots/plant (g)

B x M						
	M₁		M₂		Mean	
B₁	147.50		156.86		152.18	
B₂	142.78		146.38		144.58	
B₃	120.23		142.52		131.38	
Mean	137.17		148.92			
	SE(m)±		CD(0.05)			
B	2.25		6.60			
M	1.84		5.39			
B x M	3.18		9.33			
B x P						
	P₁		P₂		Mean	
B₁	152.93		151.43		152.18	
B₂	142.08		149.08		144.58	
B₃	140.38		122.38		131.38	
Mean	145.13		140.96			
	SE(m)±		CD(0.05)			
P	1.84		NS			
B x P	3.18		9.33			
M x P						
	P₁		P₂		Mean	
M₁	135.34		139.00		137.17	
M₂	154.92		142.92		148.92	
Mean	145.13		140.96			
	SE(m)±		CD(0.05)			
M x P	2.60		7.62			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	141.50	164.36	133.78	150.38	130.73	150.02
P₂	153.50	149.36	153.78	144.38	109.73	135.02
	SE(m)±		CD(0.05)			
B x M x P	4.50		13.20			
CV	8.17					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

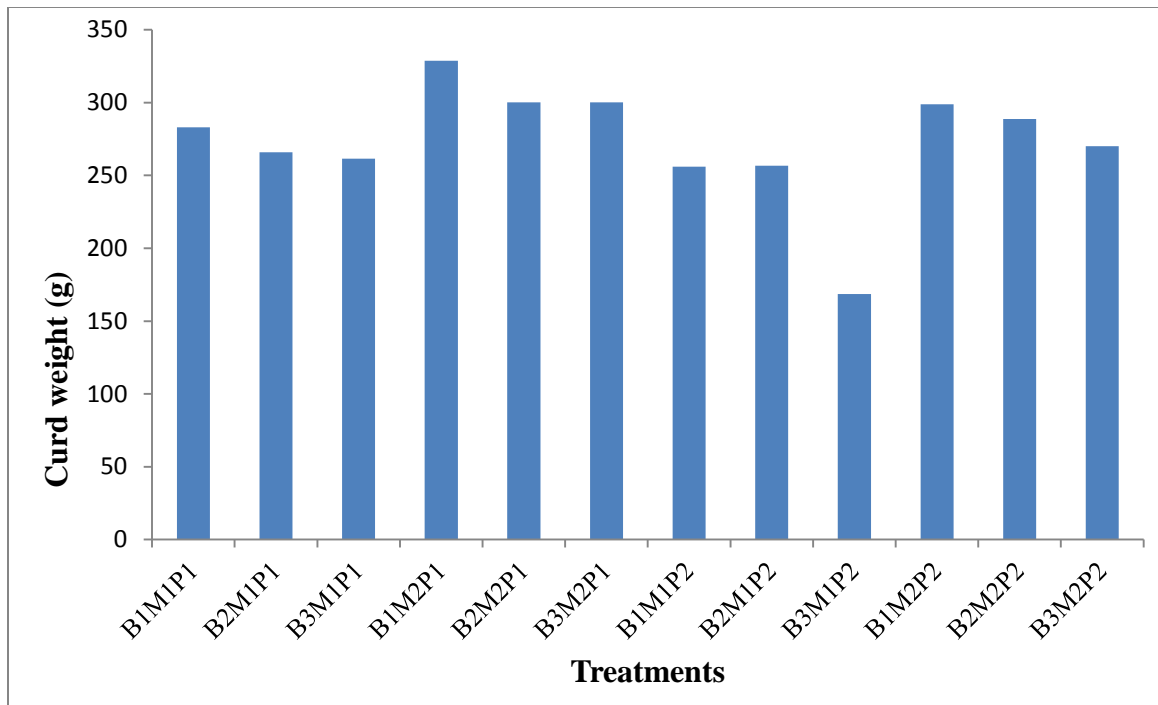


Fig 4.5: Effect of biofertilizers, organic manures and biopesticides on Curd weight/plant (g)

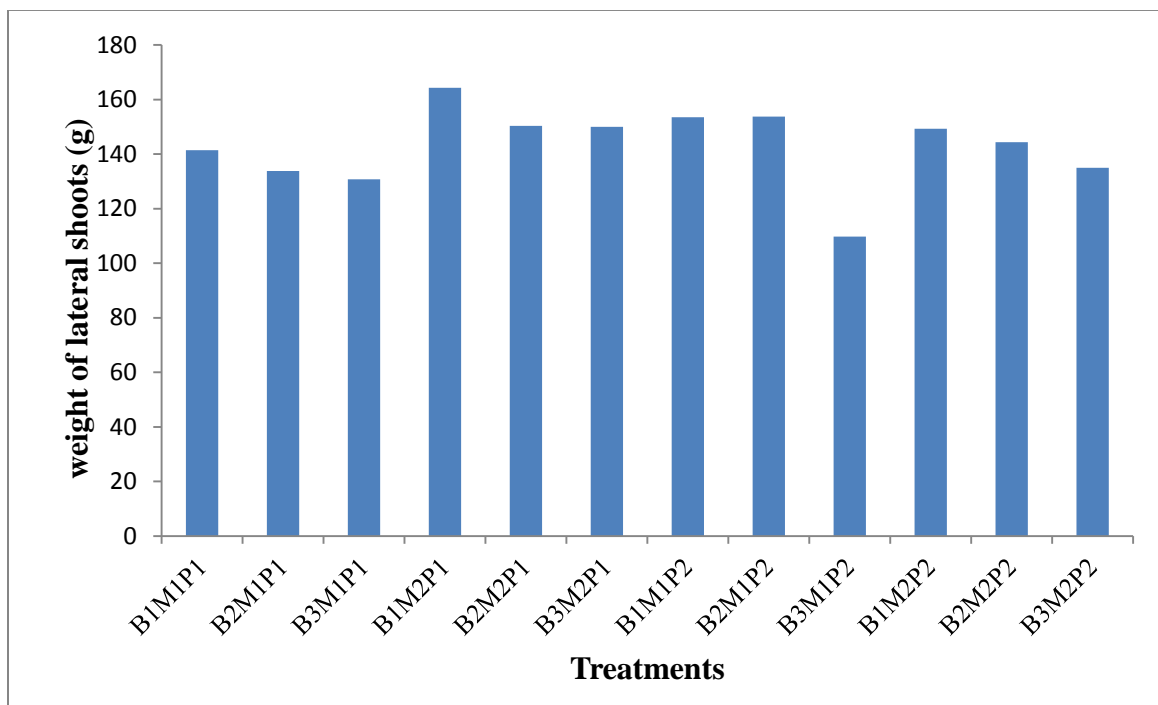


Fig 4.6: Effect of biofertilizers, organic manures and biopesticides on weight of lateral shoots/plant (g)

Table 4.7: Effect of biofertilizers, organic manures and biopesticides on Yield of broccoli (q/ha)

B x M						
	M₁		M₂		Mean	
B₁	89.83		104.57		97.20	
B₂	87.05		98.14		92.60	
B₃	71.65		95.01		83.33	
Mean	82.85		99.24			
	SE(m)±		CD(0.05)			
B	1.50		4.40			
M	1.23		3.59			
B x M	2.12		6.22			
B x P						
	P₁		P₂		Mean	
B₁	101.95		92.45		97.20	
B₂	94.31		90.89		92.60	
B₃	93.58		73.08		83.33	
Mean	96.62		85.47			
	SE(m)±		CD(0.05)			
P	1.23		3.59			
B x P	2.12		6.22			
M x P						
	P₁		P₂		Mean	
M₁	90.02		75.67		82.85	
M₂	103.21		95.28		99.24	
Mean	96.62		85.47			
	SE(m)±		CD(0.05)			
M x P	1.73		5.08			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	94.33	109.57	88.59	100.03	87.15	100.01
P₂	85.33	99.57	85.52	96.25	56.15	90.01
	SE(m)±		CD(0.05)			
B x M x P	3.00		8.80			
CV	9.36					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

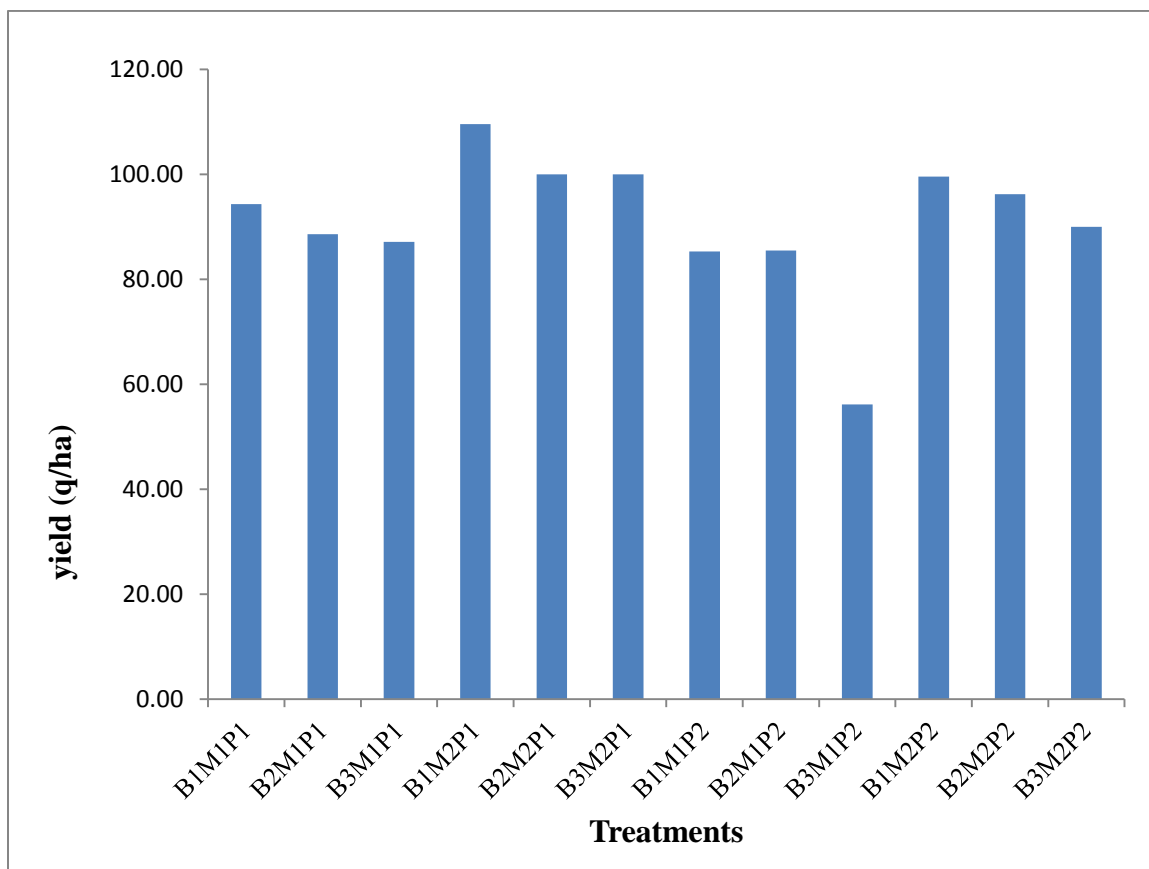


Fig 4.7: Effect of biofertilizers, organic manures and biopesticides on curd yield (q/ha)

4.3 Seed quality traits

The Seed quality of broccoli was measured in terms of days to 50% flowering, days to 50% seed setting, number of pods/plant, seed weight/plant and seed yield.

4.3.1 Days to 50% flowering (DAT)

The data regarding Days to 50% flowering as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.8 and Appendix IX.

4.3.1.1 Individual effect of biofertilizers, organic manures and biopesticides on days to 50% flowering

Individual application biofertilizers, organic manures and biopesticides application showed a significant influence on days to 50% flowering of broccoli among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded minimum number of days to 50% flowering (104.75 days) which was statistically lowest as compared to B₂ (108.50 days) and B₃ (111.50 days). In case of organic manures minimum number of days to 50% flowering (106.67 days) was recorded in M₂ i.e (FYM) which was statistically lowest compared to M₁ (109.83 days). In case of biopesticides minimum on days to 50% flowering (105.83 days) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically lowest compared to P₂ (110.67 days).

4.3.1.2 Interactive effect of biofertilizers, organic manures and biopesticides on days to 50% flowering

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to days to 50% flowering on broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the minimum number of days to 50% flowering (104.50 days) which was statistically at par with the B₁ x M₁ and B₂ X M₂ and statistically lowest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, minimum number of days to 50% flowering (102.50 days) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria*

bassiana) which was statistically lowest compared to all other combinations. In case of interaction between organic manures and biopesticides, minimum days to 50% flowering (103.00 days) was recorded in $M_2 \times P_1$ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically lowest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides minimum days to 50% flowering was recorded in $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (102.00 days) which was statistically at par with $B_1 \times M_1 \times P_1$, $B_2 \times M_2 \times P_1$ and $B_3 \times M_2 \times P_1$ lowest as compared to all other combinations.

4.3.2 Days to 50% seed setting (DAT)

The data regarding days to 50% seed setting as affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.9 and Appendix X.

4.3.2.1 Individual effect of biofertilizers, organic manures and biopesticides on days to 50% seed setting

Individual application biofertilizers, organic manures and biopesticides showed a significant influence on days to 50% seed setting of broccoli. Among biofertilizers, B_1 i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded minimum number of days to 50% seed setting (122.75 days) which was statistically lowest as compared to B_2 (126.50 days) and B_3 (129.50 days). In case of organic manures minimum number of days to 50% seed setting (124.67 days) was recorded in M_2 i.e (FYM) which was statistically lowest as compared to M_1 (127.83 days). In case of Bio-pesticides minimum on days to 50% seed setting (123.83 days) was recorded in P_1 i.e (Neem oil + *Baeuveria bassiana*) which was statistically lowest as compared to P_2 (123.83 days).

4.3.2.2 Interactive effect of biofertilizers, organic manures and biopesticides on days to 50% seed setting

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to days to 50% seed setting on broccoli. Among the interaction of biofertilizers and organic manures $B_1 \times M_2$ i.e. (*Azotobacter* +

Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the minimum number of days to 50% seed setting (122.50 days) which was statistically lower as compared to other combinations. In case of interaction between biofertilizers and biopesticides, minimum number of days to 50% seed setting (120.50 days) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically lowest compared to all other combinations of biofertilizers and biopesticides. In case of interaction between organic manures and biopesticides, minimum number of days to 50% seed setting (121.00 days) was recorded in M₂ x P₁ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically lowest as compared to all other combinations.

4.3.3 Number of pods/plant

The data regarding number of pods/plant as affected by biofertilizers, organic manures and biopesticides was measured at curd maturity stage and is summarized in the Table 4.10 and Appendix XI.

4.3.3.1 Individual effect of biofertilizers, organic manures and biopesticides on number of pods/plant

Individual application of biofertilizers, organic manures and biopesticides showed a significant influence on number of pods/plant of broccoli. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum number of pods/plant (583.22) which was statistically highest as compared to B₂ (555.59) and B₃ (500.00). In case of organic manures maximum number of pods/plant (595.46) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (497.08). In case of Bio-pesticides maximum number of pods/plant (579.69) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (512.85).

4.3.3.2 Interactive effect of biofertilizers, organic manures and biopesticides on number of pods/plant

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to number of pods/plant of broccoli. Among the

interaction of biofertilizers and organic manures $B_1 \times M_2$ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the maximum number of pods/plant (627.44) which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum number of pods/plant (611.72) was recorded in $B_1 \times P_1$ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations. In case of interaction between organic manures and biopesticides, maximum number of pods/plant (619.24) was recorded in $M_2 \times P_1$ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides maximum number of pods/plant was recorded in $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (657.44) which were statistically highest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

4.3.4 Seed weight/plant (g)

The data regarding number of pods/plant as affected by biofertilizers, organic manures and biopesticides was measures at curd maturity stage and is summarized in the Table 4.11 and Appendix XII.

4.3.4.1 Individual effect of biofertilizers, organic manures and biopesticides on seed weight/plant

Individual application of biofertilizers, organic manures and biopesticides showed a significant influence on seed weight/plant of broccoli. Among biofertilizers, B_1 i.e. (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum seed weight/plant of 16.66 g which was statistically highest as compared to B_2 (16.11 g) and B_3 (15.00)g. In case of organic manures maximum seed weight/plant (16.91 g) was recorded in M_2 i.e (FYM) which was statistically highest as compared to M_1 (14.94 g). In case of Bio-pesticides maximum number of seed

weight/plant (16.59 g) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (15.26 g).

4.3.4.2 Interactive effect of biofertilizers, organic manures and biopesticides on seed weight/plant

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to seed weight/plant of broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the maximum seed weight/plant (17.55 g) which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum seed weight/plant (17.23 g) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations. In case of interaction between organic manures and biopesticides, maximum seed weight/plant (17.38 g) was recorded in M₂ x P₁ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides maximum seed weight/plant was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (18.15 g) which were statistically highest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

4.3.5 Seed yield (kg/ha)

The data regarding number of pods/plant as affected by biofertilizers, organic manures and biopesticides was measures at curd maturity stage and is summarized in the Table 4.12 and Appendix XII.

4.3.5.1 Individual effect of biofertilizers, organic manures and biopesticides on seed yield

Individual application of biofertilizers, organic manures and biopesticides showed a significant influence on seed yield of broccoli. Among biofertilizers, B₁ i.e.

(*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum seed yield of 555.48 kg/ha which was statistically highest as compared to B₂ (537.06 kg/ha) and B₃ (500.00 kg/ha). In case of organic manures maximum seed yield (563.64 kg/ha) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (498.5 kg/ha). In case of Bio-pesticides maximum number of seed yield (553.13 kg/ha) was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to P₂ (508.56 kg/ha).

4.3.5.2 Interactive effect of biofertilizers, organic manures and biopesticides on seed yield

All the interactions between biofertilizers, organic manures and biopesticides showed significant results with respect to seed yield of broccoli. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the maximum seed yield (584.96 kg/ha) which was statistically highest as compared to other combinations. In case of interaction between biofertilizers and biopesticides, maximum seed yield (574.48 kg/ha) was recorded in B₁ x P₁ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium mobilizing Bacteria) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations. In case of interaction between organic manures and biopesticides, maximum seed yield (579.49 kg/ha) was recorded in M₂ x P₁ i.e (FYM) x (Neem oil + *Baeuveria bassiana*) which was statistically highest as compared to all other combinations.

Among the interaction of biofertilizers, organic manures and biopesticides maximum seed yield was recorded in B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) (604.96 kg/ha) which were statistically highest as compared to all other combinations of biofertilizers, organic manures and biopesticides.

Table 4.8: Effect of biofertilizers, organic manures and biopesticides on days to 50% flowering (DAT)

B x M						
	M₁		M₂		Mean	
B₁	105.00		104.50		104.75	
B₂	110.50		106.50		108.50	
B₃	114.00		109.00		111.50	
Mean	109.83		106.67			
	SE(m)±		CD(0.05)			
B	0.61		1.78			
M	0.49		1.45			
B x M	0.86		2.51			
B x P						
	P₁		P₂		Mean	
B₁	102.50		107.00		104.75	
B₂	107.00		110.00		108.50	
B₃	108.00		115.00		111.50	
Mean	105.83		110.67			
	SE(m)±		CD(0.05)			
P	0.49		1.45			
B x P	0.86		2.51			
M x P						
	P₁		P₂		Mean	
M₁	108.67		111.00		109.83	
M₂	103.00		110.33		106.67	
Mean	105.83		110.67			
	SE(m)±		CD(0.05)			
M x P	0.70		2.05			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	103.00	102.00	110.00	104.00	113.00	103.00
P₂	107.00	107.00	111.00	109.00	115.00	114.00
	SE(m)±		CD(0.05)			
B x M x P	1.21		3.55			
CV	6.21					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.9: Effect of biofertilizers, organic manures and biopesticides on days to 50 % seed setting (DAT)

B x M						
	M₁		M₂		Mean	
B₁	123.00		122.50		122.75	
B₂	128.50		124.50		126.50	
B₃	132.00		127.00		129.50	
Mean	127.83		124.67			
	SE(m)±		CD(0.05)			
B	0.61		1.78			
M	0.49		1.45			
B x M	0.86		2.51			
B x P						
	P₁		P₂		Mean	
B₁	120.50		125.00		122.75	
B₂	125.00		128.00		126.50	
B₃	126.00		133.00		129.50	
Mean	123.83		128.67			
	SE(m)±		CD(0.05)			
P	0.49		1.45			
B x P	0.86		2.51			
M x P						
	P₁		P₂		Mean	
M₁	126.67		129.00		127.83	
M₂	121.00		128.33		124.67	
Mean	123.83		128.67			
	SE(m)±		CD(0.05)			
M x P	0.70		2.05			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	121.00	120.00	128.00	122.00	131.00	121.00
P₂	125.00	125.00	129.00	127.00	133.00	133.00
	SE(m)±		CD(0.05)			
B x M x P	1.21		3.55			
CV	7.64					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

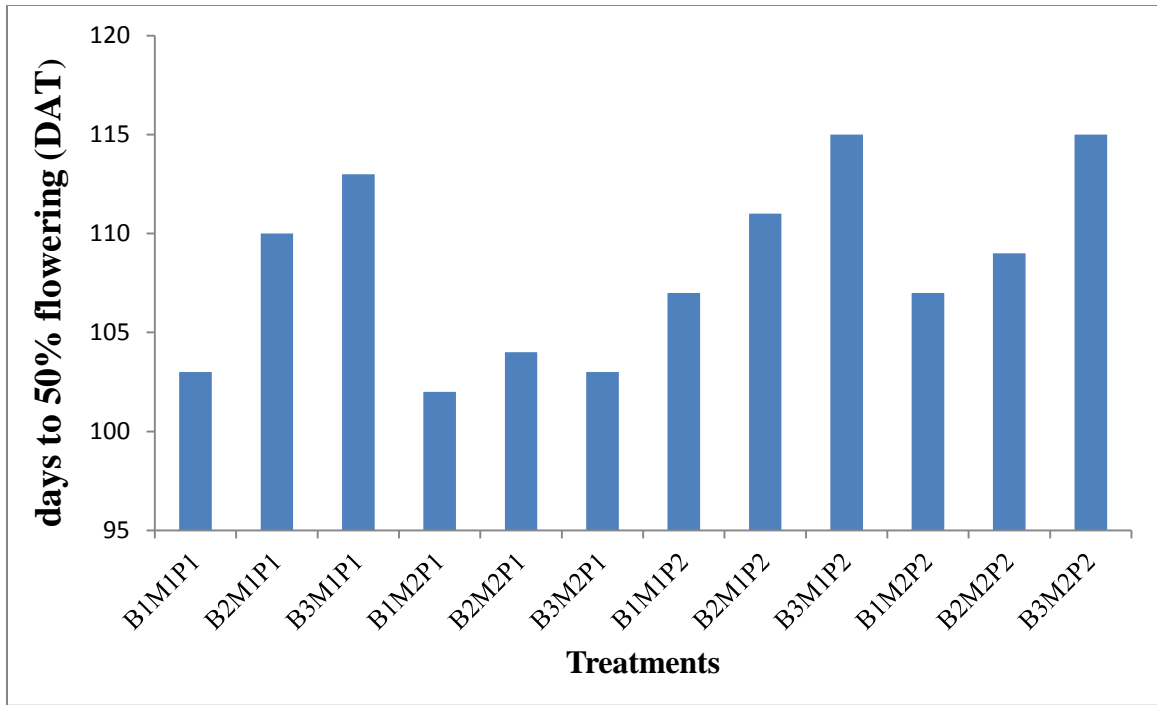


Fig 4.8: Effect of biofertilizers, organic manures and biopesticides on days to 50% flowering (DAT)

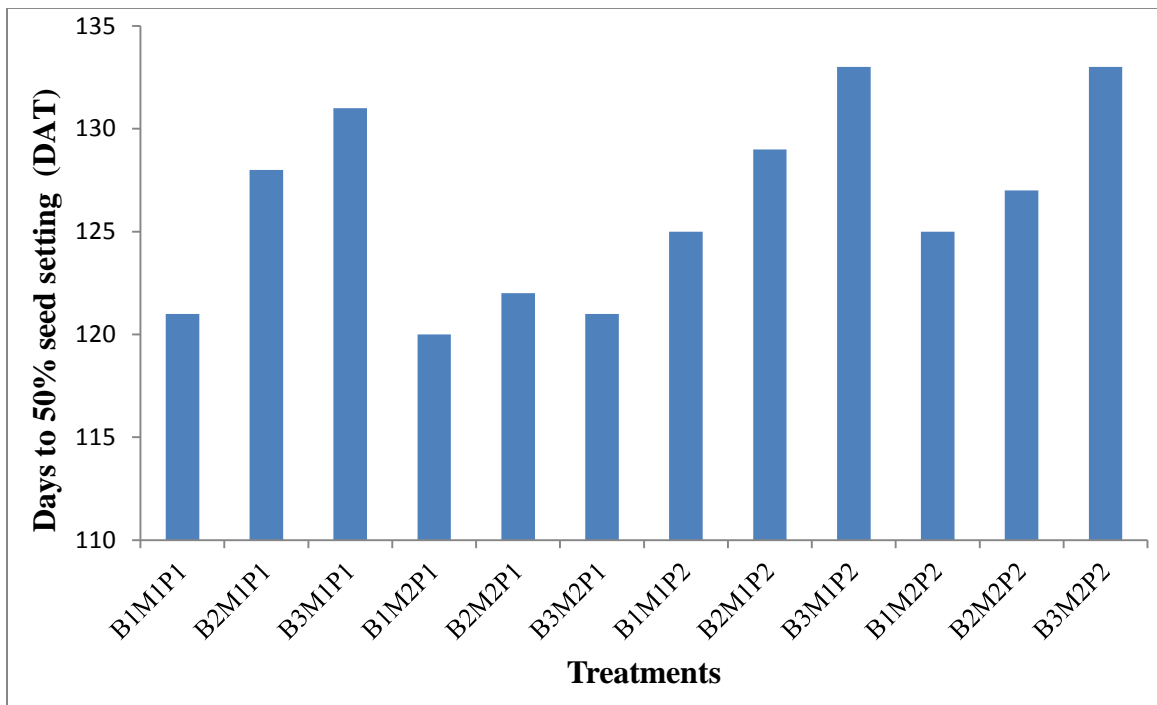


Fig 4.9: Effect of biofertilizers, organic manures and biopesticides on days to 50% seed setting (DAT)

Table 4.10: Effect of biofertilizers and organic manures on number of pods/plant

B x M						
	M₁		M₂		Mean	
B₁	539.00		627.44		583.22	
B₂	522.32		588.85		555.59	
B₃	429.92		570.08		500.00	
Mean	497.08		595.46			
	SE(m)±		CD(0.05)			
B	9.00		26.40			
M	7.35		21.56			
B x M	12.73		37.34			
B x P						
	P₁		P₂		Mean	
B₁	611.72		554.72		583.22	
B₂	565.85		545.32		555.59	
B₃	561.50		438.50		500.00	
Mean	579.69		512.85			
	SE(m)±		CD(0.05)			
P	7.35		21.56			
B x P	12.73		37.34			
M x P						
	P₁		P₂		Mean	
M₁	540.15		454.01		497.08	
M₂	619.24		571.68		595.46	
Mean	579.69		512.85			
	SE(m)±		CD(0.05)			
M x P	10.39		30.49			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	566.00	657.44	531.52	600.19	522.92	600.08
P₂	512.00	597.44	513.12	577.52	336.92	540.08
	SE(m)±		CD(0.05)			
B x M x P	18.00		52.81			
CV	9.34					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.11: Effect of biofertilizers, organic manures and biopesticides on seed weight/plant (g)

B x M						
	M₁		M₂		Mean	
B₁	15.78		17.55		16.66	
B₂	15.45		16.78		16.11	
B₃	13.60		16.40		15.00	
Mean	14.94		16.91			
	SE(m)±		CD(0.05)			
B	0.18		0.53			
M	0.15		0.43			
B x M	0.26		0.75			
B x P						
	P₁		P₂		Mean	
B₁	17.23		16.09		16.66	
B₂	16.32		15.91		16.11	
B₃	16.23		13.77		15.00	
Mean	16.59		15.26			
	SE(m)±		CD(0.05)			
P	0.15		0.43			
B x P	0.26		0.75			
M x P						
	P₁		P₂		Mean	
M₁	15.80		14.08		14.94	
M₂	17.38		16.43		16.91	
Mean	16.59		15.26			
	SE(m)±		CD(0.05)			
M x P	0.21		0.61			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	16.32	18.15	15.63	17.00	15.46	17.00
P₂	15.24	16.95	15.26	16.55	11.74	15.80
	SE(m)±		CD(0.05)			
B x M x P	0.36		1.06			
CV	11.26					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁**= Vermicompost, **M₂**= FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

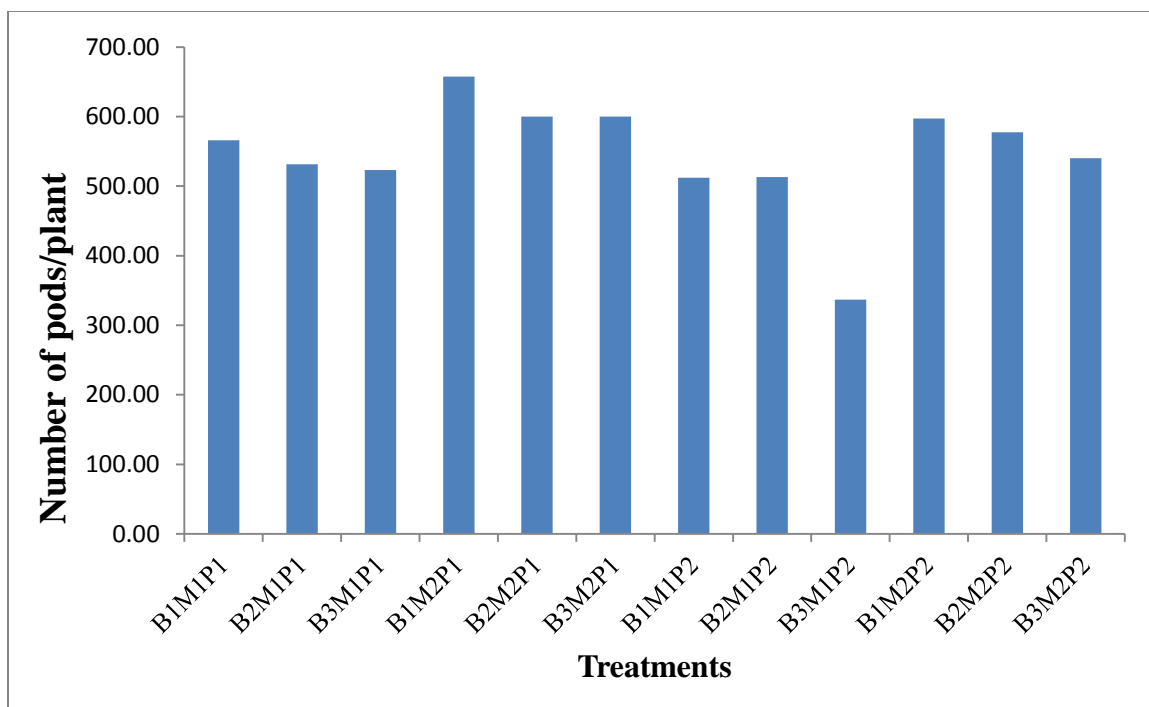


Fig 4.10: Effect of biofertilizers, organic manures and biopesticides on no. of pods/plant

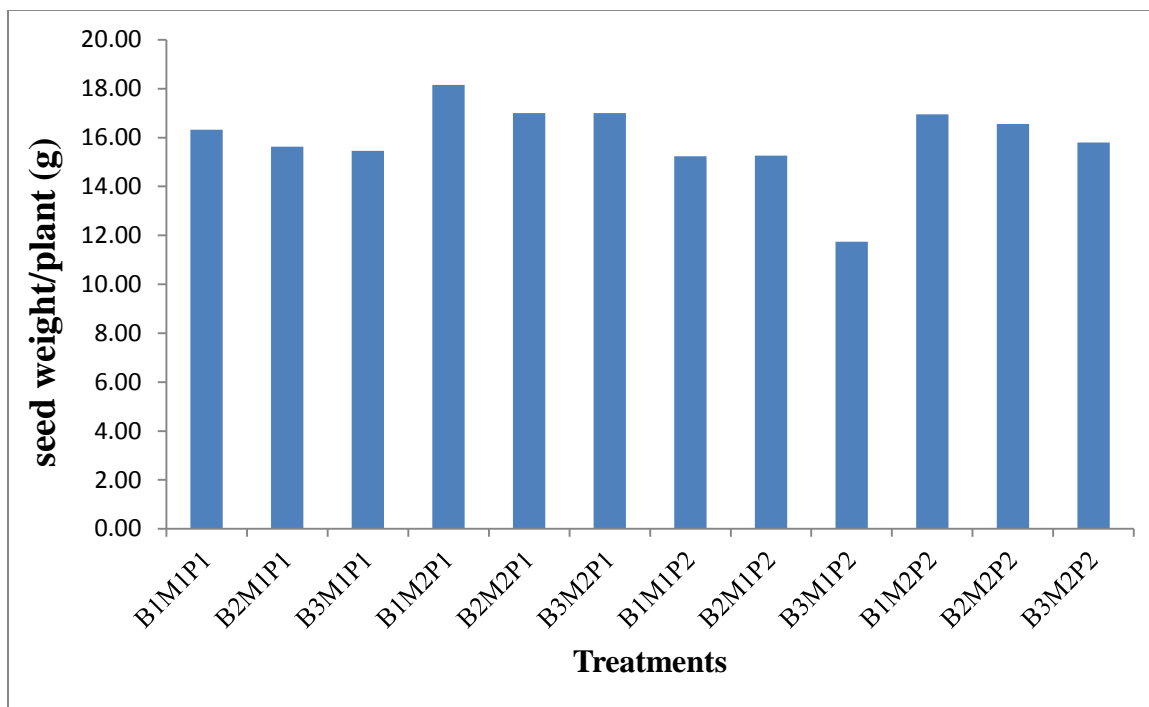


Fig 4.11: Effect of biofertilizers, organic manures and biopesticides on seed weight/plant (g)

Table 4.12: Effect of biofertilizers, organic manures and biopesticides on seed yield (kg/ha)

B x M						
	M₁		M₂		Mean	
B₁	526.00		584.96		555.48	
B₂	514.88		559.24		537.06	
B₃	453.28		546.72		500.00	
Mean	498.05		563.64			
	SE(m)±		CD(0.05)			
B	6.00		17.61			
M	4.90		14.38			
B x M	8.49		24.90			
B x P						
	P₁		P₂		Mean	
B₁	574.48		536.48		555.48	
B₂	543.90		530.21		537.06	
B₃	541.00		459.00		500.00	
Mean	553.13		508.56			
	SE(m)±		CD(0.05)			
P	4.90		14.38			
B x P	8.49		24.90			
M x P						
	P₁		P₂		Mean	
M₁	526.76		469.34		498.05	
M₂	579.49		547.79		563.64	
Mean	553.13		508.56			
	SE(m)±		CD(0.05)			
M x P	6.93		20.33			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	544.00	604.96	521.01	566.79	515.28	566.72
P₂	508.00	564.96	508.75	551.68	391.28	526.72
	SE(m)±		CD(0.05)			
B x M x P	12.00		35.21			
CV	11.26					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

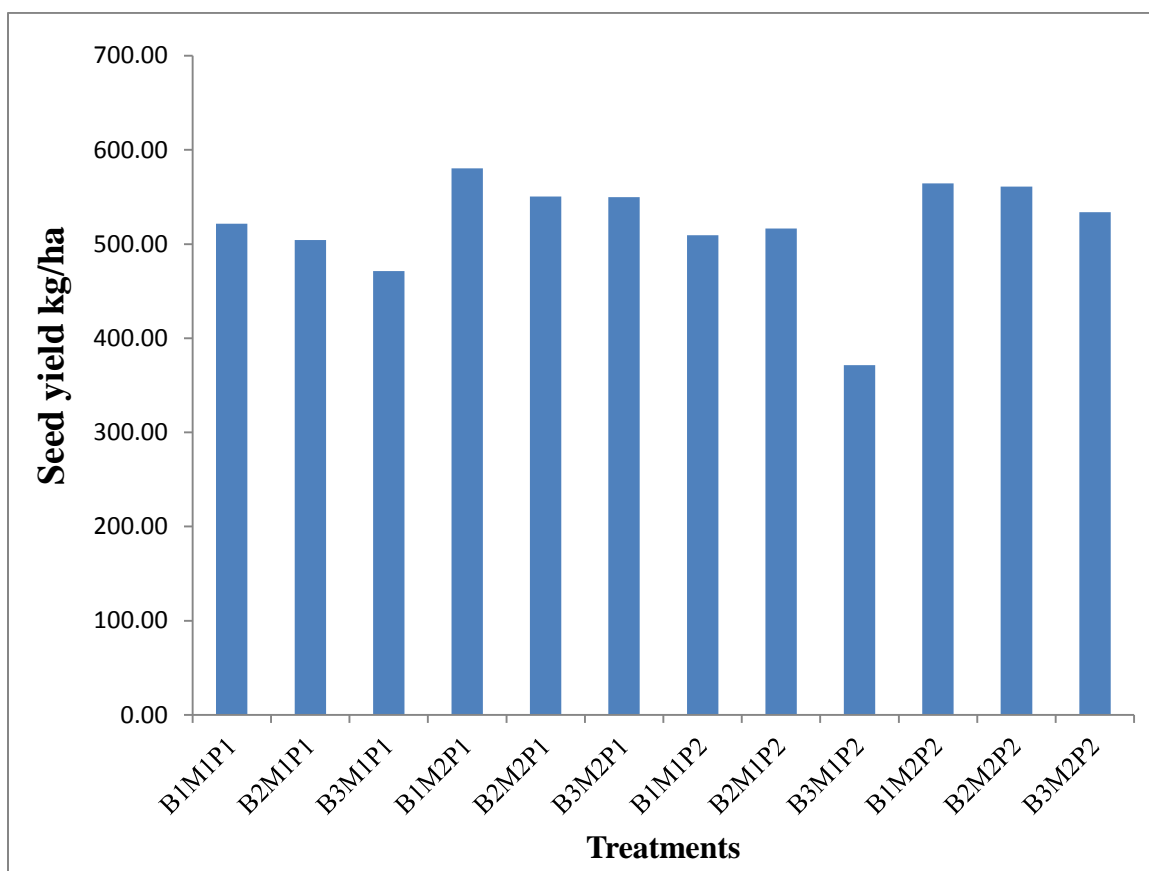


Fig 4.12: Effect of biofertilizers, organic manures and biopesticides on Seed yield kg/ha

4.4 Soil parameters

The soil parameters was measured after the harvest of the crop in terms of soil pH, soil EC, soil organic carbon, nitrogen availability in soil, phosphorus availability in soil, potassium availability in soil.

4.4.1 Soil pH

The data regarding soil pH as affected by biofertilizers, organic manures and biopesticides was measures after crop harvest and is summarized in the Table 4.13 and Appendix XIV.

4.4.1.1 Individual effect of biofertilizers, organic manures and biopesticides on soil pH

Individual application of biofertilizers, organic manures and biopesticides showed a non-significant influence on soil pH.

4.4.1.2 Interactive effect of biofertilizers, organic manures and biopesticides on seed yield

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to soil pH.

4.4.2 Soil EC (ds/m)

The data regarding soil EC as affected by biofertilizers, organic manures and biopesticides was measures after crop harvest and is summarized in the Table 4.14 and Appendix XV.

4.4.2.1 Individual effect of biofertilizers, organic manures and biopesticides on soil EC

Individual application of biofertilizers, organic manures and biopesticides showed a non-significant influence on soil EC.

4.4.2.2 Interactive effect of biofertilizers, organic manures and biopesticides on soil EC

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to soil EC.

4.4.3 Organic carbon (%)

The data regarding soil EC as affected by biofertilizers, organic manures and biopesticides was measured after crop harvest and is summarized in the Table 4.15 and Appendix XVI.

4.4.3.1 Individual effect of biofertilizers, organic manures and biopesticides on organic carbon

Individual application of biofertilizers, organic manures and biopesticides showed a non-significant influence on organic carbon.

4.4.3.2 Interactive effect of biofertilizers, organic manures and biopesticides on organic carbon

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to organic carbon.

4.4.4 Nitrogen availability in soil (kg/ha)

The data regarding nitrogen availability in soil affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.16 and Appendix XVII.

4.4.4.1 Individual effect of biofertilizers, organic manures and biopesticides on soil available nitrogen

Individual application of biofertilizers, organic manures showed a significant influence on soil available nitrogen. However, non-significant influence was recorded by the individual application of biopesticides on soil available nitrogen. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded maximum soil available nitrogen of 219.65 kg/ha which

was statistically highest as compared to B₂ (217.44 kg/ha) and B₃ (216.09 kg/ha). In case of organic manures maximum soil available nitrogen (218.56 kg/ha) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (216.90 kg/ha).

4.4.4.2 Interactive effect of biofertilizers, organic manures and biopesticides on soil available nitrogen

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to soil available nitrogen except the interaction B x M. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) showed the maximum soil available nitrogen (220.33 kg/ha) which was statistically highest as compared to other combinations.

4.4.5 Phosphorus availability in soil (kg/ha)

The data regarding phosphorus availability in soil affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.17 and Appendix XVIII

4.4.5.1 Individual effect of biofertilizers, organic manures and biopesticides on soil available phosphorus

Individual application of biofertilizers, organic manures showed a significant influence on soil available phosphorus. However, non-significant influence was recorded by the individual application of biopesticides on soil available phosphorus. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded maximum soil available nitrogen of 29.70 kg/ha which was statistically highest as compared to B₂ (27.49 kg/ha) and B₃ (26.14 kg/ha). In case of organic manures maximum soil available phosphorus (28.56 kg/ha) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (27.00 kg/ha).

4.4.5.2 Interactive effect of biofertilizers, organic manures and biopesticides on soil available phosphorus

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to soil available phosphorus except the

interaction B x M. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the maximum soil available phosphorus (30.33 kg/ha) which was statistically highest as compared to other combinations.

4.4.6 Potassium availability in soil (kg/ha)

The data regarding potassium availability in soil affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.18 and Appendix XIX.

4.4.6.1 Individual effect of biofertilizers, organic manures and biopesticides on soil available potassium

Individual application of biofertilizers, organic manures showed a significant influence on soil available potassium. However, non-significant influence was recorded by the individual application of biopesticides on soil available potassium. Among biofertilizers, B₁ i.e. (*Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria) recorded maximum soil available potassium of 199.65 kg/ha which was statistically highest as compared to B₂ (197.44 kg/ha) and B₃ (196.09 kg/ha). In case of organic manures maximum soil available potassium (198.56 kg/ha) was recorded in M₂ i.e (FYM) which was statistically highest as compared to M₁ (196.90 kg/ha).

4.4.6.2 Interactive effect of biofertilizers, organic manures and biopesticides on soil available potassium

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to soil available potassium except the interaction B x M. Among the interaction of biofertilizers and organic manures B₁ x M₂ i.e. (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) showed the maximum soil available potassium (200.33 kg/ha) which was statistically highest as compared to other combinations.

Table 4.13: Effect of biofertilizers, organic manures and biopesticides on soil pH

B x M						
	M₁		M₂		Mean	
B₁	7.47		7.45		7.46	
B₂	7.48		7.47		7.48	
B₃	7.48		7.37		7.43	
Mean	7.48		7.43			
	SE(m)±		CD(0.05)			
B	0.058		NS			
M	0.047		NS			
B x M	0.082		NS			
B x P						
	P₁		P₂		Mean	
B₁	7.43		7.48		7.46	
B₂	7.57		7.38		7.48	
B₃	7.38		7.47		7.43	
Mean	7.46		7.44			
	SE(m)±		CD(0.05)			
P	0.047		NS			
B x P	0.082		NS			
M x P						
	P₁		P₂		Mean	
M₁	7.46		7.50		7.48	
M₂	7.47		7.39		7.43	
Mean	7.46		7.44			
	SE(m)±		CD(0.05)			
M x P	0.067		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	7.4	7.5	7.6	7.5	7.4	7.4
P₂	7.6	7.4	7.4	7.4	7.6	7.4
	SE(m)±		CD(0.05)			
B x M x P	0.115		NS			
CV	1.25					

Note- Biofertilizer (B): B₁ = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), B₂=*Azospirillum* + Phosphate Solubilizing Bacteria, B₃=Liquid consortia-NPK,

Organic manures (M): M₁= Vermicompost, M₂= FYM,

Biopesticides (P): P₁= Neem oil + *Baeuveria bassiana*, P₂= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.14: Effect of biofertilizers, organic manures and biopesticides on soil EC

B x M						
	M₁		M₂		Mean	
B₁	0.27		0.27		0.27	
B₂	0.29		0.27		0.28	
B₃	0.29		0.26		0.28	
Mean	0.28		0.27			
	SE(m)±		CD(0.05)			
B	0.007		NS			
M	0.006		NS			
B x M	0.01		NS			
B x P						
	P₁		P₂		Mean	
B₁	0.29		0.26		0.27	
B₂	0.28		0.28		0.28	
B₃	0.28		0.27		0.28	
Mean	0.28		0.27			
	SE(m)±		CD(0.05)			
P	0.006		NS			
B x P	0.01		NS			
M x P						
	P₁		P₂		Mean	
M₁	0.29		0.28		0.28	
M₂	0.28		0.26		0.27	
Mean	0.28		0.27			
	SE(m)±		CD(0.05)			
M x P	0.008		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	0.28	0.29	0.27	0.28	0.31	0.26
P₂	0.27	0.25	0.30	0.25	0.28	0.27
	SE(m)±		CD(0.05)			
B x M x P	0.014		NS			
CV	1.25					

Note- Biofertilizer (B): B₁ = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), B₂=*Azospirillum* + Phosphate Solubilizing Bacteria, B₃=Liquid consortia-NPK,

Organic manures (M): M₁= Vermicompost, M₂= FYM,

Biopesticides (P): P₁= Neem oil + *Baeuveria bassiana*, P₂= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.15: Effect of biofertilizers and organic manures on organic carbon (%)

B x M						
	M₁		M₂		Mean	
B₁	0.66		0.67		0.66	
B₂	0.64		0.66		0.65	
B₃	0.65		0.64		0.64	
Mean	0.65		0.66			
	SE(m)±		CD(0.05)			
B	0.006		NS			
M	0.005		NS			
B x M	0.009		NS			
B x P						
	P₁		P₂		Mean	
B₁	0.69		0.65		0.67	
B₂	0.66		0.65		0.65	
B₃	0.64		0.65		0.65	
Mean	0.66		0.65			
	SE(m)±		CD(0.05)			
P	0.005		NS			
B x P	0.009		NS			
M x P						
	P₁		P₂		Mean	
M₁	0.66		0.65		0.65	
M₂	0.67		0.65		0.66	
Mean	0.66		0.65			
	SE(m)±		CD(0.05)			
M x P	0.007		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	0.68	0.69	0.65	0.67	0.64	0.65
P₂	0.65	0.66	0.64	0.66	0.67	0.64
	SE(m)±		CD(0.05)			
B x M x P	0.012		NS			
CV	1.05					

Note- Biofertilizer (B): B₁ = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), B₂=*Azospirillum* + Phosphate Solubilizing Bacteria, B₃=Liquid consortia-NPK,

Organic manures (M): M₁= Vermicompost, M₂= FYM,

Biopesticides (P): P₁= Neem oil + *Baeuveria bassiana*, P₂= NSKE +*Baccillus thuringensis* (Bt)

Table 4.16: Effect of biofertilizers, organic manures and biopesticides on soil available nitrogen (kg/ha)

B x M						
	M₁		M₂		Mean	
B₁	218.97		220.33		219.65	
B₂	216.37		218.52		217.44	
B₃	215.37		216.82		216.09	
Mean	216.90		218.56			
	SE(m)±		CD(0.05)			
B	0.23		0.67			
M	0.19		0.55			
B x M	0.32		0.94			
B x P						
	P₁		P₂		Mean	
B₁	219.55		219.75		219.65	
B₂	217.22		217.67		217.44	
B₃	216.12		216.07		216.09	
Mean	217.63		217.83			
	SE(m)±		CD(0.05)			
P	0.19		NS			
B x P	0.32		NS			
M x P						
	P₁		P₂		Mean	
M₁	216.73		217.07		216.09	
M₂	218.52		218.59		218.56	
Mean	217.63		217.83			
	SE(m)±		CD(0.05)			
M x P	0.26		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	218.97	220.13	215.87	218.57	215.37	216.87
P₂	218.97	220.53	216.87	218.47	215.37	216.77
	SE(m)±		CD(0.05)			
B x M x P	0.46		NS			
CV	2.61					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

Table 4.17: Effect of biofertilizers, organic manures and biopesticides on soil available phosphorus (kg/ha)

B x M						
	M₁		M₂		Mean	
B₁	29.07		30.33		29.70	
B₂	26.47		28.52		27.49	
B₃	25.47		26.82		26.14	
Mean	27.00		28.56			
	SE(m)±		CD(0.05)			
B	0.23		0.66			
M	0.19		0.54			
B x M	0.32		0.94			
B x P						
	P₁		P₂		Mean	
B₁	29.65		29.75		29.70	
B₂	27.32		27.67		27.49	
B₃	26.22		26.07		26.14	
Mean	27.73		27.83			
	SE(m)±		CD(0.05)			
P	0.19		NS			
B x P	0.32		NS			
M x P						
	P₁		P₂		Mean	
M₁	26.93		27.07		27.00	
M₂	28.52		28.59		28.56	
Mean	27.73		27.83			
	SE(m)±		CD(0.05)			
M x P	0.26		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	29.17	30.13	26.07	28.57	25.57	26.87
P₂	28.97	30.53	26.87	28.47	25.37	26.77
	SE(m)±		CD(0.05)			
B x M x P	0.45		NS			
CV	2.03					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁**= Vermicompost, **M₂**= FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂**= NSKE +*Baccillus thruingenesis* (Bt)

Table 4.18: Effect of biofertilizers and organic manures on soil available potassium (kg/ha)

B x M						
	M₁		M₂		Mean	
B₁	198.97		200.33		199.65	
B₂	196.37		198.52		197.44	
B₃	195.37		196.82		196.09	
Mean	196.90		198.56			
	SE(m)±		CD(0.05)			
B	0.22		0.66			
M	0.18		0.54			
B x M	0.32		0.94			
B x P						
	P₁		P₂		Mean	
B₁	199.55		199.75		199.65	
B₂	197.22		197.67		197.44	
B₃	196.12		196.07		196.09	
Mean	197.63		197.83			
	SE(m)±		CD(0.05)			
P	0.18		NS			
B x P	0.32		NS			
M x P						
	P₁		P₂		Mean	
M₁	196.73		197.07		196.90	
M₂	198.52		198.59		198.56	
Mean	197.63		197.83			
	SE(m)±		CD(0.05)			
M x P	0.26		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	198.97	200.13	195.87	198.57	195.37	196.87
P₂	198.97	200.53	196.87	198.47	195.37	196.77
	SE(m)±		CD(0.05)			
B x M x P	0.45		NS			
CV	2.45					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

4.5 Disease and insect pest parameters

The important diseases like curd and black rot and insect pests like cabbage semi-looper and cabbage butterfly incidence were taken into account for the study.

4.5.1 Cabbage semi-looper infestation (%)

The data regarding cabbage semi-looper population affected by biofertilizers, organic manures and biopesticides was summarized in the Table 4.19 and Appendix XX.

4.5.1.1 Individual effect of biofertilizers, organic manures and biopesticides on cabbage semi-looper infestation

Individual application of biofertilizers, organic manures showed a non-significant influence on cabbage semi-looper infestation. However, significant influence was recorded by the individual application of biopesticides on cabbage semi-looper population. Among biopesticides, maximum decrease in the cabbage semi-looper infestation was recorded in P₂ i.e (NSKE +*Bacillus thuringensis*) (35.32 %) which was statistically highest as compared to P₁ (22.00 %).

4.5.1.2 Interactive effect of biofertilizers, organic manures and biopesticides on cabbage semi-looper infestation

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to cabbage semi-looper population.

4.5.2 Cabbage butterfly infestation (%)

The data regarding cabbage butterfly population affected by biofertilizers, organic manures and biopesticides was summarized in the Table 4.20 and Appendix XXI.

4.5.2.1 Individual effect of biofertilizers, organic manures and biopesticides on cabbage butterfly infestation

Individual application of biofertilizers, organic manures showed a non-significant influence on butterfly infestation. However, significant influence was recorded by the individual application of biopesticides on butterfly population. Among biopesticides,

maximum decrease in the cabbage semi-looper population was recorded in P₂ i.e (NSKE + *Baccillus thuringensis*) (52.90 %) which was statistically highest as compared to P₁ (31.30 %).

4.5.2.2 Interactive effect of biofertilizers, organic manures and biopesticides on cabbage butterfly infestation

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to cabbage semi-looper infestation.

4.5.3 Curd rot incidence (%)

The data regarding curd rot incidence affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.21 and Appendix XXII.

4.5.3.1 Individual effect of biofertilizers, organic manures and biopesticides on Curd rot incidence

Individual application of biofertilizers, organic manures showed a non-significant influence on curd rot incidence. However, significant influence was recorded by the individual application of biopesticides on curd rot incidence. Among biopesticides, maximum decrease in the curd rot incidence was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) (47.90%) which was statistically highest as compared to P₁ (28.60%).

4.5.3.2 Interactive effect of biofertilizers, organic manures and biopesticides on curd rot incidence

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to curd rot incidence.

4.5.4 Black rot incidence (%)

The data regarding black rot incidence affected by biofertilizers, organic manures and biopesticides is summarized in the Table 4.22 and Appendix XXIII.

4.5.4.1 Individual effect of biofertilizers, organic manures and biopesticides on black rot incidence

Individual application of biofertilizers, organic manures showed a non-significant influence on black rot incidence. However, significant influence was recorded by the individual application of biopesticides on curd rot incidence. Among biopesticides, maximum decrease in the black rot incidence was recorded in P₁ i.e (Neem oil + *Baeuveria bassiana*) (67.60%) which was statistically highest as compared to P₂ (38.50%).

4.5.4.2 Interactive effect of biofertilizers, organic manures and biopesticides on black rot incidence

All the interactions between biofertilizers, organic manures and biopesticides showed non-significant results with respect to black rot incidence.

Table 4.19: Effect of biofertilizers, organic manures and biopesticides on reduction of cabbage semi-looper population (%)

B x M						
	M₁		M₂		Mean	
B₁	28.49		27.92		28.20	
B₂	28.33		29.75		29.04	
B₃	28.74		28.72		28.73	
Mean	28.52		28.79			
	SE(m)±		CD(0.05)			
B	2.025		NS			
M	1.654		NS			
B x M	2.864		NS			
B x P						
	P₁		P₂		Mean	
B₁	20.56		35.85		28.20	
B₂	22.66		35.41		29.04	
B₃	22.77		34.70		28.73	
Mean	22.00		35.32			
	SE(m)±		CD(0.05)			
P	1.654		4.85			
B x P	2.864		NS			
M x P						
	P₁		P₂		Mean	
M₁	21.343		35.695		28.519	
M₂	22.648		34.941		28.794	
Mean	21.995		35.318			
	SE(m)±		CD(0.05)			
M x P	2.338		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	19.86	21.24	20.41	24.91	23.74	21.78
P₂	37.11	34.58	36.23	34.58	33.73	35.65
	SE(m)±		CD(0.05)			
B x M x P	4.05		NS			
CV	16.23					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

Table 4.20: Effect of biofertilizers, organic manures and biopesticides on reduction of cabbage butterfly population (%)

B x M						
	M₁		M₂		Mean	
B₁	41.00		39.10		40.10	
B₂	43.90		39.30		41.60	
B₃	43.20		46.00		44.60	
Mean	42.70		41.50			
	SE(m)±		CD(0.05)			
B	0.03		NS			
M	0.025		NS			
B x M	0.043		NS			
B x P						
	P₁		P₂		Mean	
B₁	30.60		49.60		40.10	
B₂	30.10		53.10		41.60	
B₃	33.20		55.90		44.60	
Mean	31.30		52.90			
	SE(m)±		CD(0.05)			
P	0.025		7.30			
B x P	0.043		NS			
M x P						
	P₁		P₂		Mean	
M₁	30.90		54.50		42.70	
M₂	31.70		51.20		41.50	
Mean	31.30		52.90			
	SE(m)±		CD(0.05)			
M x P	0.035		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	29.30	31.80	28.30	31.80	34.90	31.50
P₂	52.80	46.30	59.50	46.80	51.40	60.50
	SE±		CD(0.05)			
B x M x P	0.061		NS			
CV	14.64					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

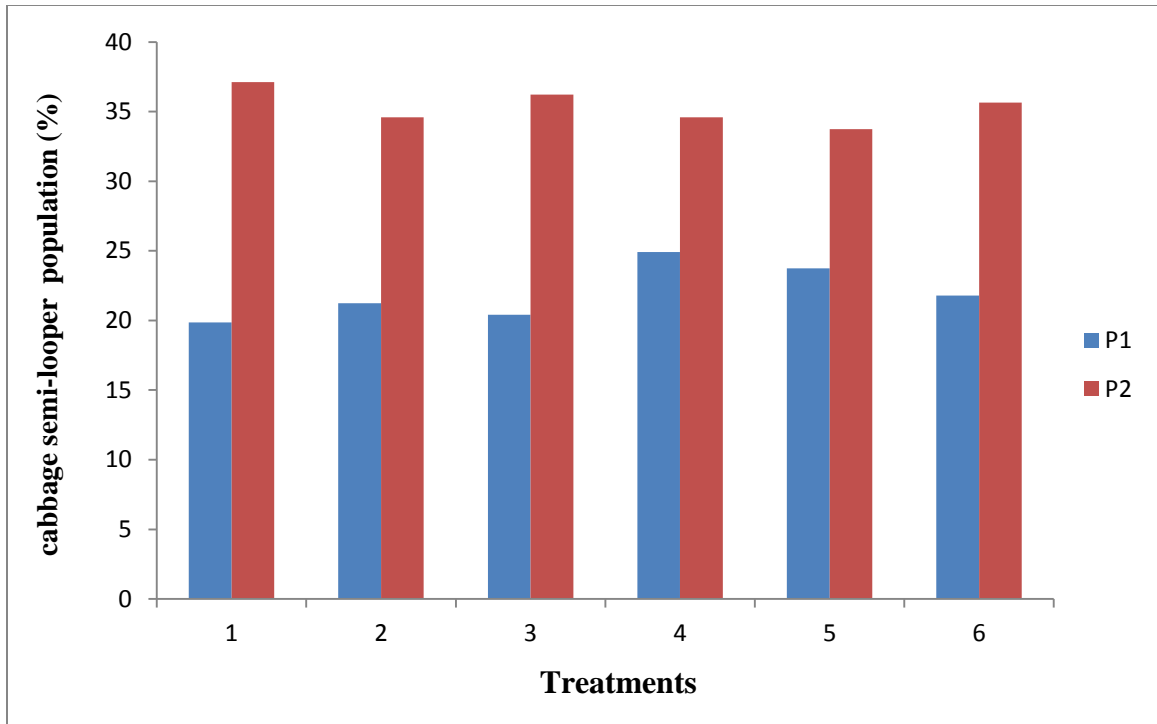


Fig 4.13: Effect of biopesticides on reduction of cabbage semi-looper population (%)

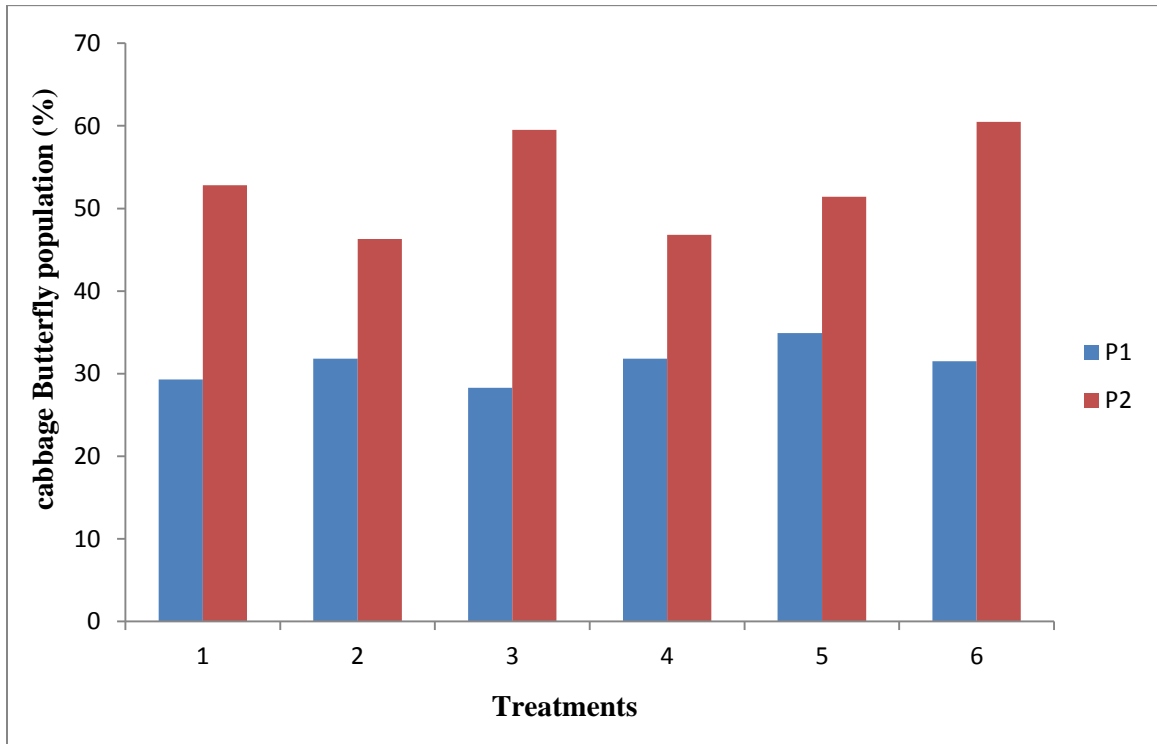


Fig 4.14: Effect of biopesticides on reduction of cabbage butterfly population (%)

Table 4.21: Effect of biofertilizers, organic manures and biopesticides on reduction of curd rot incidence (%)

B x M						
	M₁		M₂		Mean	
B₁	37.70		36.10		36.90	
B₂	39.50		36.10		37.80	
B₃	39.20		40.90		40.00	
Mean	38.80		37.70			
	SE(m)±		CD(0.05)			
B	0.027		NS			
M	0.022		NS			
B x M	0.038		NS			
B x P						
	P₁		P₂		Mean	
B₁	46.00		27.80		36.90	
B₂	47.90		27.60		37.80	
B₃	49.70		30.40		40.00	
Mean	47.90		28.60			
	SE(m)±		CD(0.05)			
P	0.022		6.50			
B x P	0.038		NS			
M x P						
	P₁		P₂		Mean	
M₁	49.30		28.30		38.80	
M₂	46.50		28.90		37.70	
Mean	47.90		28.60			
	SE(m)±		CD(0.05)			
M x P	0.031		NS			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	48.70	43.40	52.70	43.20	46.50	52.90
P₂	26.80	28.90	26.30	28.90	31.90	28.90
	SE(m)±		CD(0.05)			
B x M x P	0.054		NS			
CV	10.55					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

Table 4.22: Effect of biofertilizers, organic manures and biopesticides on reduction of black rot incidence (%)

B x M						
	M₁		M₂		Mean	
B₁	49.90		46.80		48.40	
B₂	56.80		48.20		52.50	
B₃	54.20		62.60		58.40	
Mean	53.70		52.50			
	SE(m)±		CD(0.05)			
B	0.043		NS			
M	0.035		NS			
B x M	0.06		NS			
B x P						
	P₁		P₂		Mean	
B₁	58.70		38.10		48.40	
B₂	68.30		36.70		52.50	
B₃	76.00		40.80		58.40	
Mean	67.60		38.50			
	SE(m)±		CD(0.05)			
P	0.035		10.20			
B x P	0.06		NS			
M x P						
	P₁		P₂		Mean	
M₁	69.70		37.70		53.70	
M₂	65.60		39.40		52.50	
Mean	67.60		38.50			
	SE(m)±		CD(0.05)			
M x P	0.049		N/S			
B x M x P						
	B₁		B₂		B₃	
	M₁	M₂	M₁	M₂	M₁	M₂
P₁	63.60	53.80	80.20	56.40	65.30	86.70
P₂	36.30	39.90	33.50	39.90	43.20	38.40
	SE(m)±		CD(0.05)			
B x M x P	0.085		NS			
CV	9.65					

Note- Biofertilizer (B): **B₁** = (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria), **B₂**=*Azospirillum* + Phosphate Solubilizing Bacteria, **B₃**=Liquid consortia-NPK,

Organic manures (M): **M₁** = Vermicompost, **M₂** = FYM,

Biopesticides (P): **P₁**= Neem oil + *Baeuveria bassiana*, **P₂** = NSKE +*Baccillus thruingenesis* (Bt)

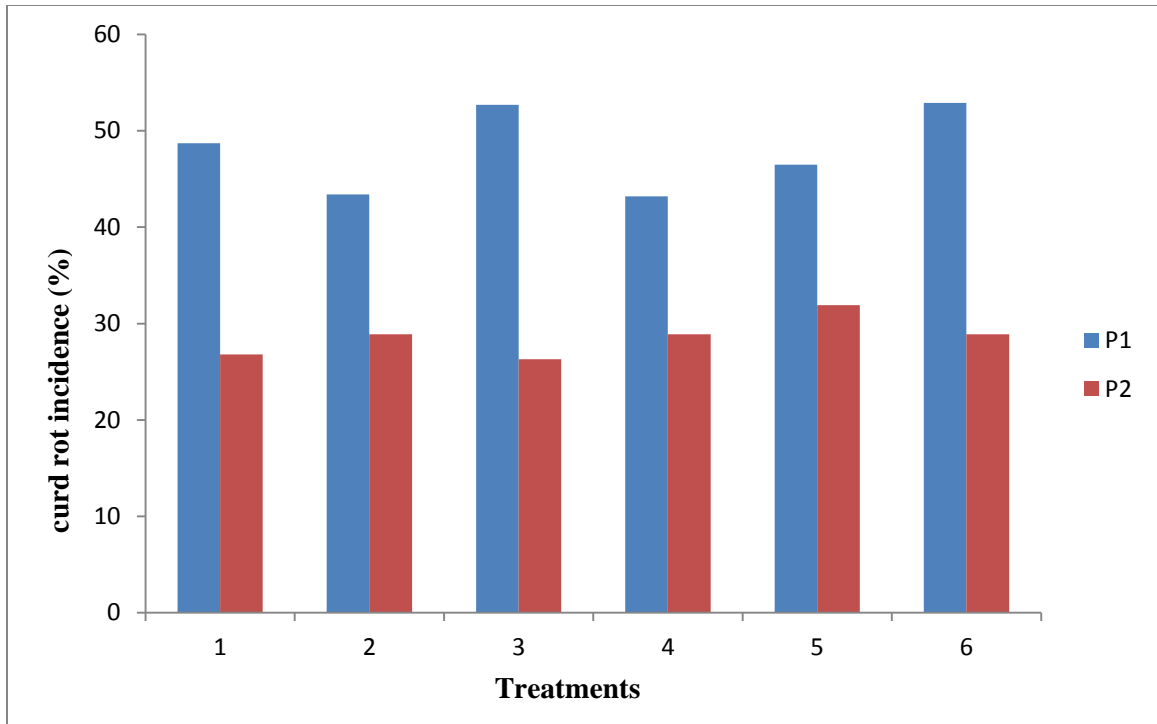


Fig 4.15: Effect of biopesticides on reduction of curd rot incidence (%)

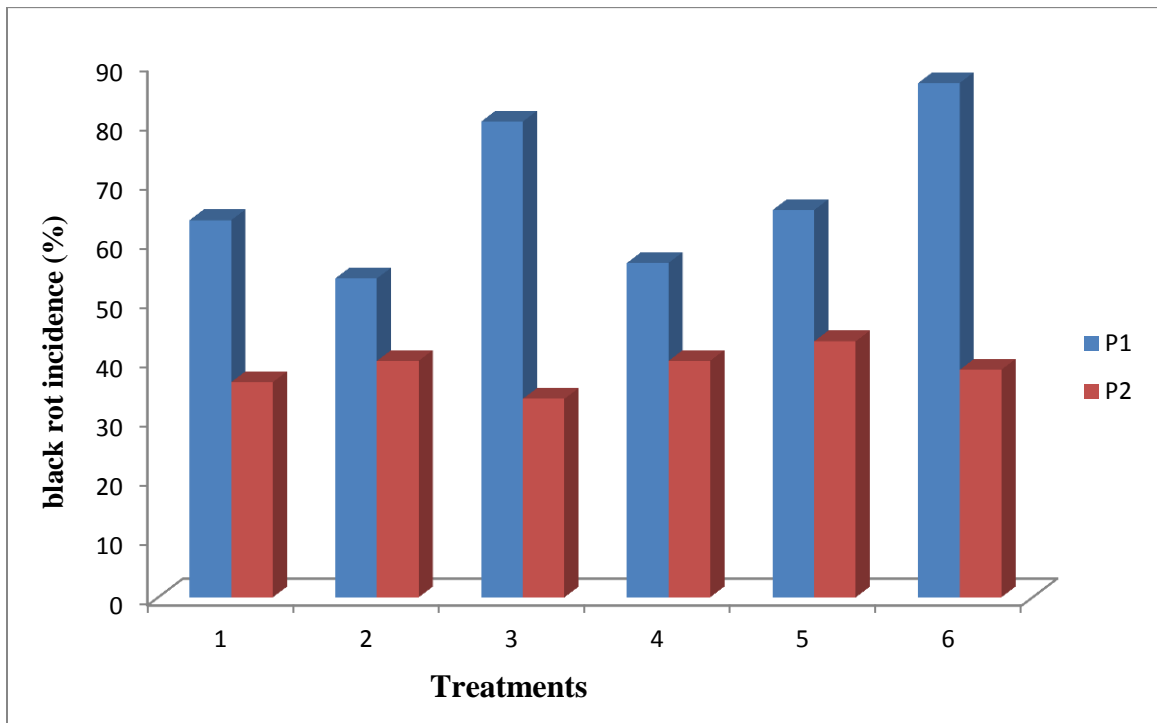


Fig 4.16: Effect of biopesticides on reduction of black rot incidence (%)

Chapter-5

Discussion

DISCUSSION

The field investigation entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**” was carried out at Vegetable Block, Organic Farming Research Centre, Main Campus- Chatha, Jammu (J&K) during *Rabi* season 2020-21. The significant findings which emerged during the course of experimentation are discussed below with their possible explanation and scientific evidence in order to determine the cause and effect relationship among different treatments in relation to various growth, morphological, seed quality, soil nutrients dynamics and insect pests and disease attributes.

5.1 Weather and crop growth

In addition to various crop management practices, weather prevailing during the crop growth period also showed significant effect on growth and development of the crop. The meteorological data taken during the *rabi* season of 2020-21 as depicted in fig.1 and incorporated in Appendix-I, indicated that the total amount of weekly rainfall received during crop growing period was about 183.8 mm which ranged between 0.0 to 88.2 mm. Highest rainfall of 88.2 mm was received by the crop in the 1st (SMW) (January) of 88.2 mm. Maximum relative humidity of 95.9 per cent was recorded in the 7th SMW (February), 2021 and minimum of 39.6 per cent was recorded in the 45th SMW (November),2020. The average maximum and minimum relative humidity recorded during the entire crop growing period were 89.9 per cent and 56.7 per cent, respectively. Average temperature prevailing during the crop growing season ranged from 9.9-24.3⁰ C. All these weather parameters were optimum for the growth and development of the crop. Similar results regarding the weather parameters on growth and development of broccoli were observed by Kaluzewicz *et al.* (2009).

5.2 Morphological parameters

Plant growth is predominantly controlled by the genetic makeup of the plant but they can also be altered by manipulating their environment. Biofertilizers, organic manures and biopesticides showed a significant influence on plant height and spread of broccoli. Among biofertilizers, treatments having *Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria recorded maximum plant height and spread. This might be due to ability of biofertilizers to help in secretions of growth promoting substances which may lead to better root development, transportation of water and proper uptake and decomposition of nutrients. Similar effect of biofertilizers on plant height plant spread was observed by Bhardwaj *et al* (2007) and Magd *et al* (2006) in broccoli. In case of organic manures maximum plant height and spread was recorded in the treatments having (FYM). This might be due to ability of FYM to improve soil conditions which further affect the water holding capacity of soil, availability of micronutrients and other major nutrients in the soil. These results are in accordance with the results of Choudhary *et al* (2012). In case of the biopesticides maximum plant height and spread was recorded in the treatments having Neem oil + *Baeuveria bassiana*. This might be due to reduction in the occurrence of diseases and insect and pest population to such a threshold level that it does not cause hindrance in growth and development of crop.

Significant effect was recorded on days to 50% curd initiation and maturity. Among biofertilizers, treatments having *Azotobacter* + Phosphate Solubilising Bacteria +Potassium Mobilising Bacteria recorded minimum days to 50% curd initiation and maturity. This might be due to action of *Azotobacter* which helped in increasing the availability of nitrogen which is a major constituent of chlorophyll and protein and thus plays vital role in growth and development of the crop. Similar results were observed by Chatterjee *et al* (2005). In case of organic manures minimum days to 50% curd initiation and maturity was recorded in FYM treatment. This might be due to the improvement of soil health by ensuring proper aeration in soil and improving the water holding capacity of the soil by FYM. Similar effect of FYM on days to 50% curd initiation and curd maturity was observed by Kumar *et al* (2013) increase in antioxidant levels by the

application of organic manures was reported by Sanwal (2006) improvement in the level of active compounds like carotene antioxidants etc. by the application of organic manures has been suggested by Leclere *et al* (1991) in carrot. In case of Bio-pesticides minimum days to 50% curd initiation and curd maturity was recorded in treatment having Neem oil + *Baeuveria bassiana*. This might be due to vital role played by biopesticides in decreasing disease occurrence and insect pest population so that it does not affect growth and development of the crop

5.3 Yield parameters

Biofertilizers, organic manures and biopesticides showed a significant influence on yield attributing traits. Among biofertilizers, treatments having *Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria recorded maximum curd weight and weight of lateral shoots/plant. This may be due to the increase in the availability of nitrogen due to the action of *Azotobacter* coupled with PSB which helped in solubilizing and increasing availability of phosphorus from insoluble or fixed phosphorus to the plant which led to proper growth of plant thus obtaining. Thus obtaining higher curd weight these findings corroborate the results as reported by Lal *et al* (2015), Pathak and Ram (2002) reported yield improvement in broccoli, cabbage, tomato and capsicum through application of biofertilizers, Mehrotra and Lohri (1971) also reported 45% increase in yield of cabbage when inoculated with *Azotobacter* similar trend was also reported by Chatto *et al.* (1997) Pandey and Kumar (1989), Sood and Vidyasagar (2007), Gupta *et al* (2010) and Kumar *et al* (2006), Singh *et al* 2014 studied the effect of biofertilizers on yield and biomolecules of anticarcinogenic vegetable broccoli found maximum functional groups in the biofertilizers treatment having *Azospirillum*+ *azotobacter* (% each) followed by the treatment *Azospirillum* + PSB 50% each. Improvement in yield and quality has been improved. Greenwood *et al* (1980), Dufault (1998) who explained the yield and other quality attributes were influenced by nutrient management and various specific in nitrogenous nutrition and Sarkar *et al* (2010). In case of organic manures maximum curd weight and weight of lateral shoots/plant was recorded in treatments having (FYM). This may be due to ability of FYM to increase water holding capacity and availability of major micro and macronutrients in the soil

similarly increase in antioxidant levels by the application of organic manures was reported by Sanwal *et al* (2006). In case of biopesticides maximum curd weight and weight of lateral shoots/plant was recorded in treatments having (Neem oil + *Baeuveria bassiana*) this may be due to action of pesticides in decreasing the population of disease causing pathogen which further helps in proper growth and development of curds and lateral shoots of broccoli

Significantly higher yield was observed in the interaction as well as individually having (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria), (FYM) and in (Neem oil + *Baeuveria bassiana*) which might be due to higher curd weight and weight of lateral shoots/plant in these treatments. Adequate availability of macronutrients and micronutrients, increased microbial activity and production of growth promoting substances might have contributed towards higher yield of broccoli similar results was obtained Chatterjee *et al* (2005)

5.4 Seed quality parameters

Biofertilizers, organic manures and biopesticides showed a significant influence on days to 50% flowering, days to 50% seed setting, number of pods/plant, seed weight/plant and seed yield. Among biofertilizers, treatments having (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded minimum days to 50% flowering, days to 50% seed setting, maximum number of pods/plant, seed weight/plant and seed yield. In case of organic manures minimum days to 50% flowering, days to 50% seed setting, maximum number of pods/plant, seed weight/plant and seed yield was recorded in treatments having (FYM) this might be due to improvement in seed yield and it attribute could be due to the stimulatory effect of biofertilizers and FYM resulting in activation of other microorganisms leading to better root development, more nutrient uptake more photosynthetic activity better food accumulation besides N fixing ability of biofertilizers the results are in cobbration with Chatoo *et al.* 2012 and Kumar *et al.* 2006 who reported enhanced quality parameters in cabbage cv golden acre by the application of biofertilizers and chemical N. In case of biopesticides minimum days to 50% flowering, seed setting, maximum number of pods/plant, seed weight/plant and seed yield was recorded in treatments having (Neem oil + *Baeuveria bassiana*) this may be

due to action of pesticides in decreasing the population of disease causing pathogen which further helps in proper growth and development of the plants .

5.5 Soil parameters

The available NPK status of the soil as recorded after the harvest of the crop was found to be significant. Among biofertilizers, treatment having (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) recorded maximum available N, P and K in the soil. This might be partially due to application of organic matter releasing nitrogen from mineralization Maiti *et al* (2003) and partially due to positive interaction effect between biofertilizers and FYM Chand *et al* (2002) reported 8-10% available N status in the soil due to application of organic matter and inorganic chemical fertilizers in mint mustard cropping system in P and K in soil might be explained by the release of P from applied organic matter after mineralization and K due to positive interaction in biofertilizers similar findings have been reported by Tiwari *et al* (2002) who also observed improved P and K content due to the application of FYM @15tonn/Ha increase in soil available nitrogen, phosphorus and potassium similar results were observed by Bhardwaj *et al.* (2007) In case of organic manures maximum available N P K in the soil was recorded in M₂ i.e (FYM) which may be due to increase in soil available nutrients due to application of FYM which might also attribute to greater multiplication of microbes.

5.6 Insect- pests and disease management

The efficacy of biopesticides in controlling important insect pest and disease like cabbage butterfly (*Pieris brassicae*) and semi-looper (*Trichoplusia spp*) and diseases like curd rot (*Alternaria brassicae*) and black rot (*Xanthomonas compestris*) on broccoli was evaluated under organic management. All the combinations of biopesticides were found effective in reducing larval population and in reducing disease incidence when applied during vegetative stage, maturity stage and pod formation stage.

Maximum decrease in the cabbage semi-looper (35.0%) and cabbage-butterfly population (52.0%) was recorded after 15 days of spray with (NSKE (5%) +*Baccillus thuringensis*) which was statistically highest as compared to other treatment. Maximum

decrease in the curd rot and black rot was recorded in treatment having (Neem oil + *Baeuveria bassiana*) which was statistically highest as compare to other treatment This might be due to the synergistic effect of neem and *Bacillus thuringiensis* t to check larval survival and its conversion to pupal stage, however none of the neem treatment were phytotoxic to the plants. These results can be corabrated with the findings of Okoth *et al* (2002) who found all the the neem treatment larvicidal in controlling the DBM in cabbage as compared to Dipel 2x- treated plants. Similar findings have been reported by Verma and Sandhu (1967), Ho and Ng 1970, Fagoonee (1987), Vollinger (1987) and Isman *et al* (1990). also reported suceptibility of *H.armigera*, lepidoptran pest to *Bacillus thuringiensis*.

Chapter-6

Summary and Conclusions

SUMMARY AND CONCLUSIONS

The present investigation entitled “**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**” was carried out at Vegetable Block, Organic Farming Research Centre, Main Campus- Chatha, Jammu (J&K) during winter season 2020-21 with the following objectives:

- I. To study the effect of organic amendments on seed yield and quality parameters of broccoli
- II. To study the effect of organic amendments on major insect pest and disease of broccoli
- III. To study the effect of organic amendments on soil nutrient dynamics.

To achieve the above objectives, the experiment was conducted in RCBD (factorial) consisting of 3 factors viz., biofertilizers at three levels (B), organic manures (M) and bio-pesticides (P) each at two levels respectively. There were 12 treatment combinations which were tried on to the crop with three replications. Application of biofertilizers was done as seedling dip whereas FYM was applied as basal dose to the crop. Vermicompost was applied at the time of earthing up operations and bio pesticides were sprayed at different stages of crop growth. Initially the experimental field was slightly alkaline in reaction (pH, 7.79), but low in organic carbon (0.60 %), available nitrogen (194.7 kg/ha) and available potassium (175.4 kg/ha) but medium in phosphorus (18.1kg/ha).

The findings from the present investigation are summarized as under:

Morphological parameters

Among all treatments, maximum growth parameters i.e plant height, plant spread, days to 50% curd initiation and days to 50% curd maturity were recorded in the interaction treatment of B₁ x M₂ x P₁ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria

+Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) which were statistically highest as compared to all other combinations, while the lowest values was recorded under the interaction of $B_3 \times M_1 \times P_2$ i.e (Liquid consortia-NPK) x (Vermicompost) x (NSKE +*Baccillus thuringensis*)

Yield parameters

Maximum yield parameters like curd weight, weight of lateral shoots/plant and curd yield. Were recorded in the interaction of $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) which were statistically highest as compared to other combinations, while the lowest values were recorded in the interaction of $B_3 \times M_1 \times P_2$ i.e (Liquid consortia-NPK) x (Vermicompost) x (NSKE +*Baccillus thuringensis*)

Seed parameters

Seed quality parameters viz. days to 50% flowering, days to 50% seed setting, number of pods/plant, seed weight/plant and seed yield was recorded significantly maximum in interaction of $B_1 \times M_2 \times P_1$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria +Potassium Mobilizing Bacteria) x (FYM) x (Neem oil + *Baeuveria bassiana*) as compared to $B_3 \times M_1 \times P_2$ i.e (Liquid consortia-NPK) x (Vermicompost) x (NSKE + *Baccillus thuringensis*) where lowest values were recorded.

Soil parameters

Soil parameters viz. nitrogen availability, phosphorus availability and potassium availability in soil were recorded maximum in the treatment interaction of $B_1 \times M_2$ i.e (*Azotobacter* + Phosphate Solubilizing Bacteria + Potassium Mobilizing Bacteria) x (FYM) which were statistically highest as compared to rest of the treatments.

Insect pest and disease management

Biopesticides like (Neem oil + *Baeuveria bassiana*) recorded maximum effectiveness for disease management in broccoli. Whereas spray schedule of (NSKE +*Baccillus thuringensis*) was found effective for management of important pests like cabbage butterfly and cabbage semi-loopers.

CONCLUSIONS

Based on one year study, it can be concluded that application of bio-fertilizer like (*Azotobacter* + Phosphate Solubilising Bacteria + Potassium Mobilising Bacteria) application in combination as seedling dip treatment to crop followed by FYM and spray schedule of bio-pesticides like (Neem oil @ 0.5% + *Baeuveria bassiana*) was found effective, individually as well as in combination, to influence growth, yield and seed quality parameters of broccoli under organic management.

With respect to insect pest and diseases, application of Neem oil 0.5% + *Baeuveria bassiana* at curd initiation and maturity stages, recorded lowest incidence of curd rot and black rot whereas NSKE 5% + *Baccillus thruingenesis* (Bt) recorded lowest incidence of cabbage semi-looper and butterfly population in broccoli under organic management .

On soil nutrient dynamics, significant effect on available N, P and K was recorded in the same treatment having bio-fertilizers and organic manures



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Appendices

APPENDIX – I

Various weekly weather parameters recorded during crop growing period (*Rabi-2020-21*)

SMW	Date and month	Max. Temp. (°C)	Min. Temp. (°C)	Morning RH (%)	Evening RH (%)	Rainfall (mm)
41	5-11 Oct	33.5	18.0	81.4	40.0	0.0
42	12-18 Oct	32.4	14.4	90.3	31.9	0.0
43	19-25 Oct	30.3	12.4	89.9	34.4	0.0
44	26-1 Nov	28.7	10.8	85.7	32.4	0.0
45	2-8 Nov	27.9	9.6	88.4	39.6	0.0
46	9-15 Nov	23.2	9.8	92.7	58.0	27.8
47	16-22 Nov	20.6	8.5	91.9	55.9	0.0
48	23-29 Nov	23.7	7.4	92.4	48.3	8.0
49	30-6 Dec	23.3	9.8	92.1	57.9	0.8
50	7-13 Dec	18.5	8.3	93.7	65.9	27.6
51	14-20 Dec	17.6	3.0	93.9	61.7	0.0
52	21-27 Dec	15.0	2.9	95.4	73.5	8.8
1	4-10 Jan	18.8	8.4	93.3	72.6	88.2
2	11-17 Jan	14.9	8.7	93.7	79.7	0.0
3	18-24 Jan	17.9	6.0	95.3	72.7	0.0
4	25-31 Jan	17.8	5.0	92.4	62.7	3.8
5	1-7 Feb	19.8	6.0	89.3	50.1	0.0
6	8-14 Feb	21.1	6.9	92.1	52.7	0.0
7	15-21 Feb	21.5	10.4	95.9	67.9	0.0
8	22-28 Feb	25.9	10.5	92.0	49.6	0.0
9	1-7 Mar	26.5	10.4	84.4	50.4	0.0
10	8-14 Mar	28.6	11.7	80.1	39.3	0.0
11	15-21 Mar	27.1	12.3	86.1	50.7	3.6
12	22-28 Mar	26.7	13.4	80.4	47.7	15.2
13	29-4 Apr	31.0	13.7	72.9	34.7	0.0
14	5-11 Apr	30.8	12.0	62.0	27.3	1.6

Source: Agrometeorology observatory, SKUAST- J, Chatha

APPENDIX – II

Analysis of variance for plant height of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	218.12		
Biofertilizers (A)	2	311.229	155.614	23.063
Organic manure (B)	1	403.229	403.229	59.761
Int A X B	2	48.905	24.452	3.624
Biopesticides (C)	1	117.456	117.456	17.408
Int A X C	2	127.617	63.808	9.457
Int B X C	1	0.224	0.224	0.033
Int A X B X C	2	51.545	25.772	3.82
Error	22	148.443	6.747	
Total	35	1426.77		

APPENDIX – III

Analysis of variance for plant spread of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	545243.17		
Biofertilizers (A)	2	778029.50	389,014.75	23.058
Organic manure (B)	1	1008016.00	1,008,016.00	59.748
Int A X B	2	122310.50	61,155.25	3.625
Biopesticides (C)	1	293583.36	293,583.36	17.402
Int A X C	2	319091.72	159,545.86	9.457
Int B X C	1	616.694	616.69	0.037
Int A X B X C	2	128,808.39	64,404.19	3.817
Error	22	371,163.17	16,871.05	23.058
Total	35	3566862.5		

APPENDIX – IV

Analysis of variance for days to 50% curd initiation of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	29.167		
Biofertilizers (A)	2	273.5	136.75	31.069
Organic manure (B)	1	110.25	110.25	25.048
Int A X B	2	40.5	20.25	4.601
Biopesticides (C)	1	182.25	182.25	41.406
Int A X C	2	37.5	18.75	4.26
Int B X C	1	42.25	42.25	9.599
Int A X B X C	2	36.5	18.25	4.146
Error	22	96.833	4.402	
Total	35	848.75		

APPENDIX – V

Analysis of variance for days to 50% curd maturity of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	327.17		
Biofertilizers (A)	2	273.50	136.75	31.07
Organic manure (B)	1	110.25	110.25	25.05
Int A X B	2	40.50	20.25	4.60
Biopesticides (C)	1	182.25	182.25	41.41
Int A X C	2	37.50	18.75	4.26
Int B X C	1	42.25	42.25	9.60
Int A X B X C	2	36.50	18.25	4.15
Error	22	96.83	4.40	
Total	35	1146.75		

APPENDIX – VI

Analysis of variance for curd weight/plant of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	7884.05		
Biofertilizers (A)	2	11106.52	5,553.26	22.844
Organic manure (B)	1	23269.96	23,269.96	95.725
Int A X B	2	1718.37	859.185	3.534
Biopesticides (C)	1	9079.01	9,079.01	37.348
Int A X C	2	4788.41	2,394.21	9.849
Int B X C	1	1150.85	1,150.85	4.734
Int A X B X C	2	1878.56	939.279	3.864
Error	22	5348.04	243.093	
Total	35	66223.77		

APPENDIX – VII

Analysis of variance for curd weight of lateral shoots/plant of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	1962.84		
Biofertilizers (A)	2	2800.83	1,400.42	23.057
Organic manure (B)	1	1424.31	1,424.31	23.45
Int A X B	2	440.354	220.177	3.625
Biopesticides (C)	1	100.2	100.2	1.65
Int A X C	2	1148.75	574.374	9.457
Int B X C	1	441.421	441.421	7.268
Int A X B X C	2	463.701	231.851	3.817
Error	22	1336.23	60.738	
Total	35	10118.64		

APPENDIX – VIII

Analysis of variance for yield of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	876.115		
Biofertilizers (A)	2	1234.16	617.081	22.851
Organic manure (B)	1	2585.70	2,585.70	95.749
Int A X B	2	190.797	95.398	3.533
Biopesticides (C)	1	1008.88	1,008.88	37.359
Int A X C	2	531.945	265.973	9.849
Int B X C	1	127.722	127.722	4.73
Int A X B X C	2	208.865	104.432	3.867
Error	22	594.112	27.005	
Total	35	7358.3		

APPENDIX – IX

Analysis of variance for days to 50% flowering of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	613.17		
Biofertilizers (A)	2	273.50	136.75	31.07
Organic manure (B)	1	110.25	110.25	25.05
Int A X B	2	40.50	20.25	4.60
Biopesticides (C)	1	182.25	182.25	41.41
Int A X C	2	37.50	18.75	4.26
Int B X C	1	42.25	42.25	9.60
Int A X B X C	2	36.50	18.25	4.15
Error	22	96.83	4.40	
Total	35	1432.75		

APPENDIX – X

Analysis of variance for days to 50% seed setting of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	1,227.17		
Biofertilizers (A)	2	273.50	136.75	31.07
Organic manure (B)	1	110.25	110.25	25.05
Int A X B	2	40.50	20.25	4.60
Biopesticides (C)	1	182.25	182.25	41.41
Int A X C	2	37.50	18.75	4.26
Int B X C	1	42.25	42.25	9.60
Int A X B X C	2	36.50	18.25	4.15
Error	22	96.83	4.40	
Total	35	2,046.75		

APPENDIX – XI

Analysis of variance for no. of pods/plant of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	31536.21		
Biofertilizers (A)	2	44426.08	22,213.04	22.84
Organic manure (B)	1	93079.86	93,079.86	95.73
Int A X B	2	6873.48	3,436.74	3.53
Biopesticides (C)	1	36316.02	36,316.02	37.35
Int A X C	2	19153.64	9,576.82	9.85
Int B X C	1	4603.41	4,603.41	4.73
Int A X B X C	2	7514.23	3,757.12	3.86
Error	22	21392.17	972.37	
Total	35	26895.10		

APPENDIX – XII

Analysis of variance for seed weight/plant of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	12.616		
Biofertilizers (A)	2	17.772	8.886	22.85
Organic manure (B)	1	37.233	37.233	95.741
Int A X B	2	2.748	1.374	3.533
Biopesticides (C)	1	14.528	14.528	37.358
Int A X C	2	7.659	3.829	9.847
Int B X C	1	1.839	1.839	4.73
Int A X B X C	2	3.008	1.504	3.867
Error	22	8.556	0.389	
Total	35	105.96		

APPENDIX – XIII

Analysis of variance for seed yield of broccoli

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	14018.87		
Biofertilizers (A)	2	19747.96	9,873.98	22.86
Organic manure (B)	1	41372.92	41,372.92	95.76
Int A X B	2	3051.19	1,525.60	3.53
Biopesticides (C)	1	16143.48	16,143.48	37.37
Int A X C	2	8509.58	4,254.79	9.85
Int B X C	1	2042.03	2,042.03	4.73
Int A X B X C	2	3343.64	1,671.82	3.87
Error	22	9504.72	432.03	
Total	35	117734.37		

APPENDIX – XIV

Analysis of variance for Soil pH

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.000		
Biofertilizers (A)	2	0.000	0.000	0.095
Organic manure (B)	1	0.000	0.000	0.061
Int A X B	2	0.001	0.000	1.264
Biopesticides (C)	1	0.000	0.000	0.007
Int A X C	2	0.001	0.001	1.884
Int B X C	1	0.001	0.001	2.624
Int A X B X C	2	0.002	0.001	2.475
Error	22	0.007	0.000	
Total	35	0.011		

APPENDIX – XV

Analysis of variance for soil Ec

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0		
Biofertilizers (A)	2	0.000	0.000	0.080
Organic manure (B)	1	0.000	0.000	0.078
Int A X B	2	0.001	0.000	1.045
Biopesticides (C)	1	0.000	0.000	0.721
Int A X C	2	0.001	0.001	1.687
Int B X C	1	0.001	0.001	2.010
Int A X B X C	2	0.002	0.001	2.969
Error	22	0.007	0.000	
Total	35	0.011		

APPENDIX – XVI

Analysis of variance for soil available OC

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.007		
Biofertilizers (A)	2	0.003	0.001	3.070
Organic manure (B)	1	0.000	0.000	0.842
Int A X B	2	0.001	0.001	1.368
Biopesticides (C)	1	0.001	0.001	1.766
Int A X C	2	0.003	0.001	3.103
Int B X C	1	0.000	0.000	0.841
Int A X B X C	2	0.001	0.000	1.004
Error	22	0.010	0.000	
Total	35	0.026		

APPENDIX – XVII

Analysis of variance for soil available nitrogen

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.53		
Biofertilizers (A)	2	75.82	37.91	60.99
Organic manure (B)	1	35.68	35.68	57.40
Int A X B	2	6.58	3.29	5.29
Biopesticides (C)	1	2.46	2.46	3.95
Int A X C	2	4.22	2.11	3.40
Int B X C	1	0.72	0.72	1.16
Int A X B X C	2	0.19	0.09	0.15
Error	22	13.67	0.62	
Total	35	139.86		

APPENDIX – XVIII

Analysis of variance for soil available phosphorus

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.63		
Biofertilizers (A)	2	76.03	38.01	61.89
Organic manure (B)	1	32.49	32.49	52.89
Int A X B	2	6.32	3.16	5.14
Biopesticides (C)	1	1.78	1.78	2.89
Int A X C	2	4.07	2.03	3.31
Int B X C	1	0.87	0.87	1.42
Int A X B X C	2	0.43	0.21	0.35
Error	22	13.51	0.61	
Total	35	136.11		

APPENDIX – XIX

Analysis of variance for soil available potassium

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	0.54		
Biofertilizers (A)	2	75.84	37.92	61.08
Organic manure (B)	1	35.71	35.71	57.52
Int A X B	2	6.55	3.28	5.28
Biopesticides (C)	1	2.47	2.47	3.99
Int A X C	2	4.21	2.10	3.39
Int B X C	1	0.69	0.69	1.11
Int A X B X C	2	0.21	0.11	0.17
Error	22	13.66	0.62	
Total	35	139.88		

APPENDIX – XX

Analysis of variance for cabbage semi-looper population

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	35.84		
Biofertilizers (A)	2	4.26	2.13	0.043
Organic manure (B)	1	0.69	0.69	0.014
Int A X B	2	6.38	3.19	0.065
Biopesticides (C)	1	1597.48	1597.48	32.460
Int A X C	2	18.51	9.25	0.188
Int B X C	1	9.54	9.54	0.194
Int A X B X C	2	41.53	20.77	0.422
Error	22	1082.70	49.21	
Total	35	2796.92		

APPENDIX – XXI

Analysis of variance for cabbage butterfly population

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	53.03		
Biofertilizers (A)	2	124.07	62.04	0.55
Organic manure (B)	1	1.60	1.60	0.01
Int A X B	2	47.39	23.69	0.21
Biopesticides (C)	1	3826.37	3826.37	33.98
Int A X C	2	21.85	10.92	0.10
Int B X C	1	84.62	84.62	0.75
Int A X B X C	2	455.36	227.68	2.02
Error	22	2477.17	112.60	
Total	35	7091.45		

APPENDIX – XXII

Analysis of variance for curd rot incidence

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	78.70		
Biofertilizers (A)	2	606.19	303.10	1.39
Organic manure (B)	1	12.13	12.13	0.06
Int A X B	2	451.37	225.68	1.03
Biopesticides (C)	1	7620.61	7620.61	34.89
Int A X C	2	345.76	172.88	0.79
Int B X C	1	76.56	76.56	0.35
Int A X B X C	2	1253.98	626.99	2.87
Error	22	4805.82	218.45	
Total	35	15251.11		

APPENDIX – XXIII

Analysis of variance for black rot incidence

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated
Replication	2	18.84		
Biofertilizers (A)	2	62.49	31.25	0.35
Organic manure (B)	1	10.86	10.86	0.12
Int A X B	2	40.38	20.19	0.23
Biopesticides (C)	1	3339.88	3339.88	37.57
Int A X C	2	6.94	3.47	0.04
Int B X C	1	25.90	25.90	0.29
Int A X B X C	2	192.35	96.17	1.08
Error	22	1955.60	88.89	
Total	35	5653.25		

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Certificate-IV

Certified that all the necessary corrections as suggested by the external examiner and the advisory committee have been duly incorporated in the thesis entitled "**Studies on Seed Production of Broccoli (*Brassica oleracea* var. *italica*) under Organic Management**", submitted by **Mr. Amit Kumar**, Registration No. **J-19-M-696**.

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