INFLUENCE OF VERMICOMPOST AND PLANT DENSITY ON GROWTH AND SEED YIELD OF CORIANDER

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INFLUENCE OF VERMICOMPOST AND PLANT DENSITY ON GROWTH AND SEED YIELD OF CORIANDER

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CERTIFICATE

*This is to certify that thesis entitled **"INFLUENCE OF VERMICOMPOST AND PLANT DENSITY ON GROWTH AND SEED YIELD OF CORIANDER"** submitted to the **INSTITUTE OF SEED TECHNOLOGY,** Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in SEED TECHNOLOGY,** embodies the result of a piece of bona fide research work carried out by **MD. FOYSAL HOSSAIN**, Registration No. 13-05355 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated: June, 2020
Place: Dhaka, Bangladesh

Prof. Dr. Jasim Uddain
Supervisor

DEDICATED
TO
MY BELOVED
PARENTS

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ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from September, 2018 to March, 2019 to find out the influence of vermicompost and plant density on growth and quality seed yield of coriander. The variety BARI Dhonia 1 was used in the experiment as the test crop. The experiment consisted of two factors: Factor A: three different plant densities viz. P_1 = 20 plants/m^2, P_2 = 40 plants/m^2, P_3 = 80 plants/m^2 and Factor B: four levels of vermicompost viz. V_0 = 0 t/ha, V_1 = 5 t/ha, V_2 = 10 t/ha and V_3 = 15 t/ha. There were 12 treatment combinations and experiment was setup in Randomized Complete Block Design (RCBD) with three replications. The result indicated significant variations in plant height, number of primary branches per plant, number of umbels per plant, umbellate per umbel, number of seeds per plant, dry seed weight per plant, dry seed weight per plot, seed yield, germination percentage, electric conductivity test value, seedling root length and shoot length due to different plant density and/or vermicompost application. Results also revealed that, 40 plant/m^2 (P_2) treatment significantly influenced the morphological characters, yield contributing characters and seed quality of coriander. The highest germination percentage (77.33 %) was also obtained from this treatment but 80 plant/m^2 (P_3) treatment significantly influenced on yield which gives highest seed yield (2.66 t ha^{-1}) due to its high plant density. Results also revealed that, application of 15 t ha^{-1} vermicompost (V_3) treatment significantly influenced the morphological characters, yield contributing characters, yield and seed quality of coriander. The highest seed yield (2.71 t ha^{-1}) and germination percentage (78.66 %) was also obtained from this treatment. Among the treatment combination, P_3V_3 (80 plant/m^2 with 15 t/ha vermicompost) treatment seemed to be more promising for obtaining higher yield (3.33 t ha^{-1}) but application of 15 t ha^{-1} of vermicompost with 40 plants m^{-2} (P_2V_3) combination seemed to be more suitable for getting quality seed production of coriander. .

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
Cm	Centi-meter
CV	Coefficient of variation
^{o}C	Degree Celsius
d.f.	Degrees of freedom
DAS	Days After Sowing
EC	Electrical Conductivity
et al.	And others
FAO	Food and Agriculture Organization
G	Gram
Ha	Hectare
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
Mg	Milligram
m^2	Meter Squares
MP	Muriate of Potash
%	Per cent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Coriander (*Coriandrum sativum* L.) belonging to the family of Apiaceae is an important spice crop in Bangladesh which is normally cultivated in winter (*rabi*) season. In Bengali it is known as '*Dhonia'*. Coriander is native to South Europe and the Mediterranean region, and is extensively grown in Russia, Bulgaria, Mexico, USA, Argentina, China, Romania, Italy, Japan, Hungary, Poland, Czech, Morocco and India and has been cultivated since human antiquity (Tiwari and Agarwal, 2004). It is also described as a native to southern Europe and Asia Minor. Preciously Italy is presumed as the native place of coriander (Thumburaj and Singh, 2004).

The entire plant of young coriander is used as appetizer in preparing fresh chutneys and sauces. Leaves are used to flavour food, curries, soups, fish sauce, and cream sauce for chicken, tomato soup, pickling sausages, bakery preparations, liqueurs, gins and meat. Seeds are used in pastry, cookies, cakes, soups, sausage, pickles, curries, in preparation of curry powder. They are also used in seasonings for sausage and other meat products. (Janardhonan and Thopil, 2004; Tiwari and Agarwal, 2004). Pharmaceutical use of coriander is to mask the taste of other medicinal compounds or to calm the irritating effects on the stomach that some medicines cause (Sharma and Sharma, 2004). Coriander leaves and seeds are valued as food mainly for its high Vit. A and Vit. C. Its leaves contain 88% water, 32 kcal, 6.0 g CHO, 2.7 protein, 0.5 g fat, 1.0 g fiber and 1.7 g ash , 150 mg. C, 0.01 mg B1, 0.01 mg B2, 1.0 mg Niacin, 150 mg Ca, 55 mg P, 540 mg K, 6 mg Fe per 100 g fresh weight of leave and 10, 000 I.U. Vit. A (Rubatzky *et al.*, 1999). On the contrary coriander seed contains 11.4% water, 22.7 g CHO, 11.5 g protein, 19.1 g fat, 28.4 g fiber, 500 mg P, 12 mg Vit. C per 100 g of fresh seed, 175 IU Vit. A (Pruthi, 1998).

In Bangladesh, the average area of coriander seed is around 20.26 thousand ha of land and production 19.30 thousand metric tons, whereas, the average area of coriander leaf is around 7.38 thousand acres of land and production 5.49 thousand metric tons, in 2017-18 (DAE, 2019). For seed production, Shariatpur district stands first in terms of area (2.64 thousand ha) but in case of production, Tangail district stand first (2.31 thousand metric tons) among other districts of Bangladesh. The average yield (825 kg/ha) of coriander is low whereas the research yield is 1.5 t/ha (SAARC Ag. Centre, 2006). One of the most important reasons of low yield is the application of imbalanced and improper fertilization. In order to achieve optimal growth and increase the quality and quantity of coriander, it is necessary to supply nitrogen during the growing season (Omidbygi, 2005). Although nitrogen fertilizers have a key role in enhancing the yield of medicinal plants, but inappropriate use of it causes ecological and human health risk, depletion of nonrenewable resources and reduce the resistance of plants to pests and diseases (Brandt, 2008; Shivaputra *et al.,* 2004).

Application of organic manure and biostimulant such as vermicompost (VC) and nitrogen fixing bacteria has led to quality increasing in agricultural products (Sanchez *et al.,* 2008; Velmurugan *et al.,* 2008). Vermicomposts are the products of the degradation of organic matter through interactions between earthworms and microorganisms. Vermicomposts (VC) contains most nutrients in the available forms such as nitrates, phosphates, exchangeable calcium and soluble potassium (Atiyeh *et al.,* 2002). The application of vermicompost not only add plant nutrients and growth regulators but also increase soil water retention, microbial population, humic substances of the soils, mineralization and release of nutrients. Besides, vermicompost also improves soil aeration, reduction of soil erosion, reduces evaporation losses of water, accelerates the process of hummification, stimulates, the microbial activity, deodourification of obnoxious smell, destruction of pathogen, detoxification of pollutant soils etc. (Manna and Hazra, 1996).

Plant density per unit area is important in terms of the number of seeds sown per square meter, the weight of 1000 fruits and branching ability of coriander. The Caucasian types have an especially high plasticity and use the available space. These types can either be cultivated with wide distances, allowing mechanical or hand hoeing between the plants (Diederichsen, 1996). Akbarinia *et al.,* (2006) in a study on the effect of nitrogen rates and plant densities on fruit yield, essential oil percent and yield of coriander fruits concluded that fruit and essential oil yield were higher in 30 plants m^{-2} densities, while essential oil percent was higher in 30 and 40 plants m^{-2} densities. Nevertheless, Ghobadi and Ghobadi (2010) and Dierchesen (1996) reported the highest fruit yield of coriander at density 50 plants m^{-2}.

Keeping all the points in mind mentioned above, the present piece of research work was under taken with the following objectives:

i. To find out the optimum plant density on growth and seed yield of coriander,
ii. To optimize the different level of vermicompost on growth and seed yield of coriander, and
iii. To determine the combined effect of plant density and vermicompost on growth and seed yield of coriander.

CHAPTER II

REVIEW OF LITERATURE

Coriander is one of the most important spice crops all over the world including Bangladesh. The yield of coriander depends on many factors such as land topography, soil fertility, soil productivity, environment (light, temperature, moisture, humidity and rainfall), and cultural practices. Different types of fertilizers play an important role on its growth, yield and quality. The present study has been taken to investigate effect of vermicompost and plant density on growth, quality seed yield of coriander (*Coriandrum sativum* L.). In this chapter an attempt had been made to collect related research findings of the present study. Some literature related to the "Influence of vermicompost and plant density on growth and quality seed yield of coriander" are reviewed below-

2.1 Chemical composition of vermicompost

Vermicompost is made up primarily of carbon (C), hydrogen (H) and oxygen (O), and contains nutrients like as NO_3, PO_4, Ca, K, Mg, S and micronutrients which exhibit similar effects on plant growth and yield as inorganic fertilizers when applied to soil (Orozco *et al.*, 1996; Singh *et al.*, 2008). Similarly, vermicompost contains a high proportion of humic substances (humic acids, fulvic acids and humin) which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeast (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids (Theunissen, 2010).

Vermicompost is a nutritive 'organic fertilizer' rich in NKP (nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25%), micronutrients, beneficial soil microbes like 'nitrogen-fixing bacteria' and 'mycorrhizal fungi' and are scientifically proving as ‘miracle growth promoters & protectors’ (Nardi *et al.*, 2004). Weber *et al.* (2007) reports as high as 7.37% nitrogen (N) and 19.58% phosphorus as P_2O_5 in worms vermicast. Atiyeh *et al.* (2000) showed that exchangeable potassium (K) was over 95% higher in vermicompost. There are also good amount of calcium (Ca), magnesium (Mg), zinc (Zn) and manganese (Mn).

Table 1: Properties and nutrient value of compost

1. Biological Properties	**Amount/quantity**
(a) Total bacteria count/g of compost	10^4
(b) *Actinomycetes*/g of compost	10^4
(c) Fungi/g of compost	10^6
(d) *Azotobacter*/mg of compost	10^6
(e) Root nodule bacteria (*Rhizobium*)	10^4
(f) Phosphate solubilizers	10^6
(g) *Nitrobacter*/g of compost	10^2

2. **Chemical Properties**	**Amount/quanitiy**
(a) pH	7-8.2
(b) Organic carbon	16.0%
(c) Nitrogen	1.50-2.00%
(d) Phosphorus	1.25%
(e) Potassium	1.05-1.20%
(f) Calcium	1-2%
(g) Magnesium	0.7%
(h) Sulphates	0.5%

(i)	Iron	0.6%
(j)	Zinc	300-700 ppm
(k)	Manganese	250-740 ppm
(l)	Copper	200-375 ppm

Source: Sinha (2008)

Additionally, vermicompost contain enzymes like amylase, lipase, cellulase and chitinase, which continue to break down organic matter in the soil (to release the nutrients and make it available to the plant roots) even after they have been excreted (Krishnamoorthy and Vajrabhiah, 1986). Annual application of adequate amount of vermicompost also lead to significant increase in soil enzyme activities such as 'urease', 'phosphomonoesterase', 'phosphodiesterase' and 'arylsulphatase'. The soil treated with vermicompost has significantly more electrical conductivity (EC) and near neutral pH (Palanichamy, 2011).

2.2 Effect of vermicompost on growth attributes

Ramesh *et al.* (2006) reported that among different sources of nutrient application chemical fertilizers registered higher number of seeds plant^{-1} in coriander which were at par with cattle dung. Application of vermicompost, phospho-compost and poultry manure showed superiority over control but remain at par with each other.

Gowda *et al.* (2008) conducted an field experiment on coriander and reported that application of vermicompost @ 3.8 t ha^{-1} + poultry manure @ 2.45 t ha^{-1} gave significantly higher plant height, number of leaves, test weight, straw and seed yield as well as protein content in seed as compared to control.

2.3 Effect of vermicompost on yield attributes and yield

Vadiraj *et al.* (1998) from Sakaleshpur (Karnataka) reported that the application of vermicompost at 15 t ha^{-1} significantly increased herbage yield of coriander which was comparable to applying chemical fertilizers at 20:20:40, NPK kg ha^{-1}. They reported that the herbage yield was maximum (6075.5 kg ha^{-1}) at 60th day after sowing in plots treated with 15 t ha^{-1} vermicompost. The study also indicated that application of vermicompost @ 15-20 t ha^{-1} not only increase herbage and seed yield but also seed weight.

Pitchay and Perez (2008) reported that coir substrate amended with 20%-40% compost in basil and 10%-20% compost in coriander produced shoot and root fresh weights of seedlings over conventionally grown cuttings.

Dadiga *et al.* (2015) carried out the present investigation to assess the influence of organic and inorganic sources of nutrients on growth, yield attributed traits and yield economic of coriander (*Coriandrum sativum* L.). The experimental material was comprised of twelve treatments. The maximum plant height recorded with vermicompost @ 5 t ha^{-1} + 100 % RDF, while the minimum with poultry manure @ 2.5 t ha^{-1} + 50 % RDF.

2.4 Effect of vermicompost on content and uptake of NPK

Rajkhowa *et al.* (2003) reported significant increase in uptake of N and P in coriander with application of vermicompost @ 2.5 t ha^{-1} along with 100 to 75% fertilizer over control.

Vasanthi and Subramanian (2004) reported highest N, P and K concentration and uptake in coriander under the treatment that received vermicompost @ 2 t ha^{-1} along with 100 % recommended dose of N, P and K.

Choudhary (2007) conducted a field experiment on coriander and found that N, P and K uptake in seed increased significantly with an increasing levels of vermicompost.

The response of organic manure and fertilizers on yield and nutrient uptake of ginger was studied by Dharade *et al.* (2009) and reported that the use of 50 percent N through RD + 25 FYM t ha^{-1} fertilization to crop was beneficial in terms of net returns. The highest uptake of N was recorded due to application of RDF + 50 per cent N through poultry manure, whereas, the uptake of P and K were highest under the treatment having RDF + 25 t FYM ha^{-1} followed by the application of 50 per cent N through RDF + 50 percent N through either poultry manure or vermicompost.

2.5 Effect of vermicompost on protein and volatile oil content

Mathur (2000) observed significantly higher protein content in coriander with application of 20 kg N ha^{-1} through vermicompost over rest of the treatments.

Vasanthi and Subramanian (2004) conducted a field experiment on coriander and found highest oil content under the treatments received vermicompost @ 2 t ha^{-1} along with 100% recommended level of NPK over 100% NPK, 100% NPK through different combinations of chemical fertilizers.

2.6 Effect of vermicompost on soil physico-chemical properties

Bellaki *et al.* (1998) observed a significant lower bulk density with the application of various organic materials to meet 50 percent nitrogen along with 50 per cent NPK. Application of vermicompost to soil resulted in increased N, P, K, Fe, Mn, Cu, Zn, organic carbon content and CEC values and decreased bulk density of soil.

Vasanthi and Kumarswamy (1999) reported that the organic carbon content of soil increased significantly with application of vermicompost over control.

Srikanth *et al.* (2000) reported that incorporation of various composts resulted in a significant increase in organic carbon over control. Reduction in soil pH at harvest of the crop was also recorded under soils amended with compost and inorganic fertilizer treatment.

Nehra and Grewal (2001) reported that the application of vermicompost @ 15 t ha^{-1} significantly increased organic carbon, available N, P and K content in soil over control.

Rajkhowa *et al.* (2003) studied the effect of vermicompost alone or in combination with fertilizers on the performance of coriander cv. Paratap on loamy soil of Jorhat, Assam and observed that vermicompost alone or in combination with fertilizers improved the available N, P, K and organic carbon content of the soil over control.

Bellaki *et al.* (1998) observed a significant lower bulk density with the application of various organic materials to meet out 50 per cent nitrogen along with 50 percent NPK, whereas, application of vermicompost to soil resulted in increased N, P, K, Fe, Mn, Cu, Zn, organic carbon content and CEC values and decreased bulk density of soil.

Maheshwarappa *et al.* (1999) reported that organic manures like, FYM and vermicompost application alone and FYM + NPK application decreased the bulk density, improved soil porosity and water holding capacity to a greater extent. Organic carbon content of soil also increased to a greater extent under FYM and vermicompost treated plots compared to composted coir pith and NPK alone and control.

Nethra *et al.* (1999) reported an improvement in soil pH towards neutrality with vermicompost application. The maximum available nitrogen content (493.31 kg ha^{-1}) was observed in the plots receiving application of vermicompost @ 5 t ha^{-1} and 10 % N, P and K by coriander.

Vasanthi and Kumarswamy (1999) reported that organic carbon content of soil increased significantly with application of vermicompost over control.

2.7 Effect of vermicompost on seed quality of coriander

Darzi *et al.* (2015) reported that, percent essential oil of coriander was higher (0.53%) at 6 ton/ha vermicompost application. It was also reported that the seed yield also higher 3500 kg/ha at 6 ton/ha vermicompost application.

Singh *et al.* (2009) showed that, two year pooled data clearly revealed that phosphorus and sulphur enriched compost or vermicompost by HGPR and gypsum gave statistically at par (17.01 and 17.60 q/ha) seed yield of coriander to direct application of phosphatic fertilizer and gypsum (16.26 and 16.31 q/ha). Results clearly indicate that enrichment of organic manure (FYM and vermicompost) with HGPR, gypsum and bio inoculants gave more economic return (2.06 and 2.16). Similar results were also observed in stover yield. Essential oil and protein content were maximum in P and S enriched compost or vermicompost.

Shirkhodaei and Darzi (2014) revealed that, vermicompost had significant effects on studied traits, as the highest gamma terpinene percent, camphor percent and geranyl acetate percent in essential oil were obtained after applying 6 ton/ha vermicompost. The minimum geraniol percent and maximum linalool oxide percent in essential oil were obtained after applying 3 ton/ha vermicompost. Biofertilizer, also showed significant effects on linalool oxide percent, camphor percent and geraniol percent in essential oil.

Ayanoglu *et al.* (2002) reported that, the plant height (cm), branch number/plant, umbel number/plant, seed number/umbel, 1000 seed weight (g), seed yield (kg/da), the essential oil content (%) and the essential oil yield were highest from the lines K67, K28, K69 and K46. The seed yields of those lines were higher than currently planted cultivars.

2.8 Effect of plant density on growth and yield of coriander

Akhani *et al.* (2012) conducted a factorial experiment in the base of randomized complete blocks design with twelve treatments and three replications at research field of Agriculture Company of Ran in Firouzkuh of iran in 2011. The factors were biofertilizer (Nitrogen fixing bacteria), mixture of *Azotobacter chroococcum* and *Azospirillum lipoferum* in four levels (noninoculated, inoculated seeds, spray on the plant base at stem elongation stage and inoculated seeds + spray on the plant base at stem elongation stage) and plant density in three levels (12.5, 16.6 and 25 plants m^{-2}). Plant density, showed significant effects on plant height, number of umbels plant^{-1}, 1000 seed weight and seed yield. The maximum umbel number per plant, weight of 1000 seeds and dry weight of plant were obtained with 12.5 plants m^{-2} and the highest plant height and seed yield were obtained with 25 plants m^{-2}.

Masood *et al.* (2004) in an experiment on fennel showed that with increasing of plant density, plant height increased. According to the results of study of Amarjit *et al.*, (1992) on dill, plant density had no significant effect on essential oil percent, but increase in density significantly increased essential oil yield.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experimental plot, characteristics of soil, climate and materials used for the experiment. The details of the experiment were described below:

3.1 Location and site of the experiment field

The field experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh from September 2018 to March 2019 to evaluate the effect of vermicompost levels and plant density on growth and quality seed yield of coriander (*Coriandrum sativum* L.). It is located at $90^{0}22'$ E longitude and $23^{0}41'$ N latitude at an altitude of 8.2 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28 which is shown in Appendix I.

3.2 Climate

The climate of the experimental area is characterized by high temperature, high humidity and medium rainfall with occasional gusty winds during the kharif season (March- September) and a scanty rainfall associated with moderately low temperature in the Rabi season (October-March). The weather information regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season September 2018 to March 2019 has been presented in Appendix II.

3.3 Characteristics of the soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from

0-15 cm depths were collected from the experimental field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil are presented in Appendix III.

3.4 Planting Material

In this experiment Coriander variety of BARI Dhonia-1 was used as a planting material. BARI Dhonia1 was developed by Bangladesh Agricultural Research Institute (BARI). The seed was collected from the Regional Spice Research Centre, BARI, Joydebpur, Gazipur.

3.5 Land Preparation

The land was first opened by a tractor and prepared thoroughly by ploughing and cross ploughing with a power tiller followed by country plough. Laddering helped breaking the clods and leveling the land followed every ploughing. Before sowing each unit of plot was cleaned by removing the weeds, stubbles and crop residues. Finally each plot was prepared by puddling.

3.6 Experimental Design and Layout

The experiment was laid out in a randomized complete block design (RCBD) having twelve treatment combinations (3 different plant density × 4 different levels of vermicompost) with three replications. The unit plot size was 1m × 1m (1.0 m^2). The whole experimental area was first divided into three blocks which was considered as replication and each block was further divided into 12 plots which were considered as unit plots. The block to block distance was 1m and the plot to plot distance was 50 cm.

3.7 Treatments of the experiment

The experiment consists of two (2) factors i.e. different plant density and different levels vermicompost. Details of factors and their combinations are presented below:

Factor A: Different plant density

P_1: 20 plants/m^2 (25 × 20 cm)

P_2: 40 plants/m^2 (25 × 10 cm)

P_3: 80 plants/m^2 (25 × 5 cm)

Factor B: Different levels of vermicompost

V_0: 0 t/ha

V_1: 5 t/ha

V_2: 10 t/ha

V_3: 15 t/ha

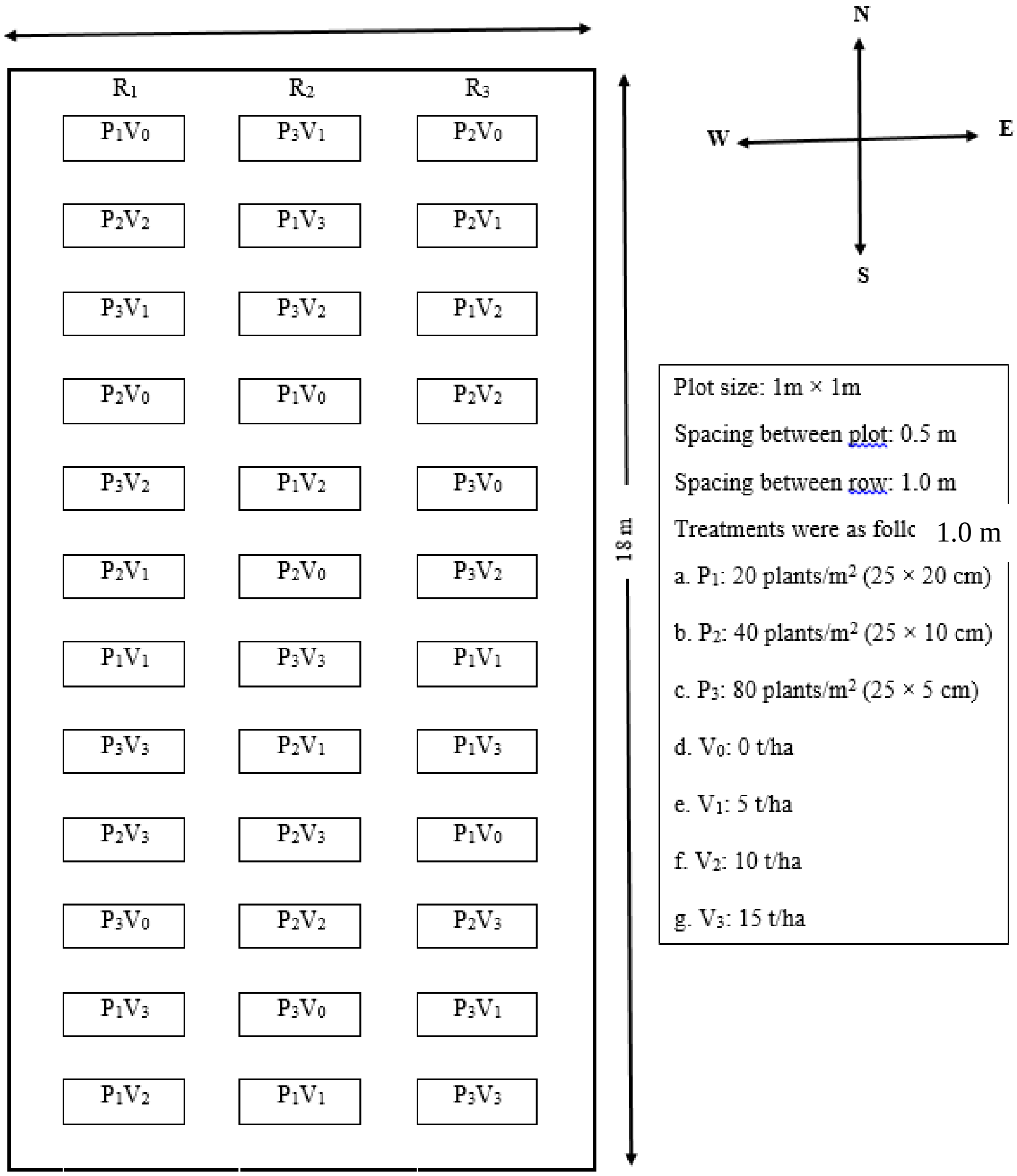


Figure 1. Layout of the experimental plot

3.8 Seed sowing

Before sowing time, the seeds (fruits) were rubbed for separating the two mericarps (seeds) and were soaked in water for 24 hours to enhance germination. Seeds were also treated with Bavistin at the rate of 2g per kg of seeds before sowing. Seeds were sown in rows continuously by hand based on the treatment. The seeds were covered with good pulverized soil just after sowing and gently pressed by hands. The sowing was done on October 15, 2018 with slight watering just to supply sufficient moisture needed for quick germination. Seedlings of the plots were thinned later to maintain of experiential spacing after 25 days after sowing (DAS).

3.9 Intercultural operations

The desired population density was maintained by thinning plants 20 days after emergence. Irrigation, mulching, weeding and plant protection measures etc. were performed as needed to uniform germination, better crop establishment and proper plant growth.

3.10 Irrigation

Four irrigations were given as plants required. First irrigation was given immediately after topdressing and other three irrigation were given 2-3 days before weeding. After irrigation when the plots were in zoe condition, spading was done uniformly and carefully to conserve the soil moisture. The four irrigation were given at 20, 30, 60 and 90 days after sowing.

3.11 Weeding

The field was kept free by hand weeding. First weeding was done after 25 days after sowing (DAS). Plant thinning was also done at the time of weeding. Second and third weeding was done after 50 and 60 DAS, respectively.

3.12 Crop protection

The field was investigated time to time to detect visual differences among the treatments and any kind of infestation by weeds, insects and diseases so that considerable losses by pest could be minimized. Diazinon 60 EC was spayed twice at 15 days interval @ 2 ml L^{-1} of water to control aphid. Some plots started to die after rotting in the basal portion of the plant. For controlling this disease, Dithane M-45 was sprayed thrice at 10 days interval @ 2 g L^{-1} water.

3.13 Harvesting and threshing

Randomly selected ten plants, those were considered for data recording was collected from each plot to analyze the yield and yield contributing characters. The rest of the crops were harvested when 80% of the fruit in terminal matures. After collecting sample plants, harvesting was started on March 15 and completed on March 30, 2019. The harvested crops were tied into bundles and carried to the threshing floor. The crop bundles were sun dried by spreading those on the threshing floor. The seeds were separated from the plants by beating the bundles with bamboo sticks.

3.14 Drying and weighing

The seeds thus collected were dried in the sun for couple of days. Dried seeds of each plot were weighed and subsequently converted into yield t ha^{-1}.

3.15 Data collection

Ten plants from each plot were selected as random and were tagged for the data collection. Data were collected at harvesting stage. The sample plants were uprooted prior to harvest and dried properly in the sun. The seed yield and stover yield per plot were recorded after cleaning and drying those properly in the sun. Data were collected on the following parameters:

- Plant height at bolting (cm)
- Number of primary branches per plant
- Number of umbels per plant
- Umbel circumference (cm)
- Number of umbellates per umbel
- Number of seeds per umbel
- Number of seeds per umbellate
- Number of seeds per plant

- Dry seed yield per plant (g)
- Dry seed yield per plot (g)
- Thousand seed weight (g)
- Dry seed yield (t/ha)
- Stover yield (straw yield) per plot (g)
- Stover yield (straw yield) t/ha
- Electric conductivity
- Germination percentage
- Seedling root length
- Seedling shoot length

3.15.1 Plant height (cm)

The height of the plant was determined by measuring scale considering the distance from the soil surface to the tip of the randomly ten selected plants and mean values were calculated for each treatment.

3.15.2 Number of primary branches per plant

The number of primary branches per plant was counted at harvest of coriander plants. Mean value of data were calculated and recorded.

3.15.3 Number of umbel per plant

The number of umbels from ten plants were counted and calculated as per plant basis.

3.15.4 Number of umbellates per umbel

The number of umbellates per umbel from ten umbels of each of selected plants were counted and calculated as per umbel basis.

3.15.5 Number of seeds per plant

The number of seed from ten plants were counted and calculated as per plant basis.

3.15.6 1000 seed weight (g)

A composite sample was taken from the yield of ten plants. One thousand seed of each plot were counted and weighed with a digital electric balance. The seed weight of 1000 was recorded in gram.

3.15.7 Seed weight per plot (g)

The separated seeds of plot were collected, cleaned, dried and weighed properly. The seed weight per plot was then recorded in gram.

3.15.8 Yield t ha^{-1}

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to tones per hectare.

3.15.9 Germination percentage

After harvesting germination test was done in the laboratory of the Department of Horticulture, SAU. Fifty seeds were placed in a Petridis and replicated thrice. Germinated seedling was counted. Finally, total number was converted as percentage. Germination percentage was calculated by using the following formula:

$$\text{Germination} = \frac{\text{Number of germinated seeds}}{\text{Number of seeds set for test}} \times 100$$

3.15.10. Shoot and root length of seedling

From the germinated seedling, shoot and root length was measured using measuring scale and recorded as centimeter (cm). Average values of 10 shoot and root were used for determining shoot and root length. Shoot and root length was taken at 14 days of seedling age.

3.16 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of variance resulting from the experimental treatments. All mean data were analyzed two way ANOVA via SPSS software version 20. Comparisons of the mean data and standard error (S.E.) were determined by DMRT (Duncan's Multiple Range Test) at $p \leq 0.5$ level significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the potentiality of producing coriander as influenced by different vermicompost levels and plant densities. Data of the different parameters were analyzed statistically and the results were presented in the Tables and Figures. The results of the present study were presented and discussed in this chapter under the following headings.

4.1 Plant height

4.1.1 Effect of plant density

Significant variation was observed on plant height due to variation in plant density at bolting stage (Table 1). The result of the experiment showed that at bolting stage, the tallest plant (81.81 cm) was obtained from the P_2 (40 plants/m^2) treatment, which was statistically similar with P_3 (80 plants/m^2) treatment whereas, the shortest plant (71.25 cm) was obtained from the P_1 (20 plants/m^2) treatment. The results showed that maximum plant density gave higher plant height while minimum plant density gave lower plant height. This might be due to the highest plant population per unit area which compete for light which helps to elongate plant. Moniruzzaman (2011) reported similar findings from the closest spacing i.e. higher plant population.

4.1.2. Effect of vermicompost

Marked variation was observed on plant height due to application of different level of vermicompost at bolting stage (Table 1). The data presented in the table showed an increasing trend with the increases of vermicompost rate. This might be due to higher availability of nutrients that progressively increase the height of the plant. From the results of the experiment showed that at bolting stage, the tallest plant (83.22 cm) was recorded from the V_3 (15 t ha^{-1}) treatment which was statistically at par with V_2 (10 t ha^{-1}) treatment. On the other hand, the shortest plant (72.16 cm) was obtained from the V_0 (vermicompost controlled condition). It is clear that all vermicompost levels maintained a lead over control with regard to plant height. It is also observed that plant height increased with the increase of vermicompost doses. This corroborates the results of Ravimycin (2016) and Sanwal *et al.* (2017) obtained the maximum plant height at 80 t ha^{-1}.

4.1.3 Combined effect of plant density and vermicompost

Significant influence was observed on plant height due to combined effect of plant density and vermicompost application (Table 2). From the result of the experiment showed that at bolting stage, the tallest plant (87.21 cm) was observed on the treatment combination P_2V_3 (40 plant/m^2 with 15 t/ha vermicompost) which was statistically similar with P_3V_3 (80 plant/m^2 with 15 t/ha vermicompost) where the shortest plant (65.01 cm) was observed from the treatment combination P_1V_0 (20 plant/m^2 with no vermicompost).

4.2 Number of primary branches per plant

4.2.1 Effect of plant density

Significant variation was marked on number of primary branches per plant due to the influence of plant density (Table 1). From the results of the study showed that the maximum number of primary branches (6.95) per plant was achieved from P_2 (40 plants/m^2) treatment which was statistically different from all other treatments. On the other hand, the minimum number of primary branches (3.72) was recorded in P_3 (80 plants/m^2) treatment. Akhani *et al.* (2012) reported similar findings from the closest spacing i.e. lowest number of primary branches per plant.

4.2.2 Effect of vermicompost

Significant variation was marked on number of primary branches per plant due to the application of different level of vermicompost (Table 1). The data presented in the table showed an increasing trend with the increases of vermicompost rate. This might be due to higher availability of nutrients that progressively increase the number of primary branches of the plant. Results showed that maximum number of primary branches (6.93) per plant was obtained from V_3 treatment which was statistically similar with V_2 (6.31) treatment. On the other hand, the control treatment V_0 gave minimum (3.21) number of primary branches per plant. Dadiga *et al.* (2015) reported similar findings from the closest spacing i.e. highest number of primary branches per plant.

4.2.3 Combined effect of plant density and vermicompost

Interaction of vermicompost and plant density put a significant effect on number of primary branches per plant of coriander (Table 1). From the result of the experiment showed that the maximum number of primary branches per plant (8.31) was obtained from P_2V_3 (40 plants/m^2 with 15 t/ha vermicompost) treatment which was statistically similar with P_3V_3 and P_2V_2. While the minimum number of primary branches per plant (1.60) from P_1V_0 (20 plants/m^2 with no vermicompost) treatment.

Table 1. Effect of plant density and vemicompost on plant height at bolting stage and number of primary branches of coriander

Treatments	Plant height at bolting (cm)	Number of primary branches per plant
Plant density		
P_1	71.25±1.38 [b]	5.45±0.55 [b]
P_2	81.81±1.21 [a]	6.95±0.40 [a]
P_3	80.07±1.16 [a]	3.72±0.42 [c]
Level of significance	*	*
Vermicompost		
V_0	72.16±1.83 [c]	3.21±0.52 [c]
V_1	76.50±1.68 [bc]	5.06±0.46 [b]
V_2	78.96±1.69 [ab]	6.31±0.47 [ab]
V_3	83.22±1.49 [a]	6.93±0.58 [a]
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

P_1: 20 plants/m^2

P_2: 40 plants/m^2

P_3: 80 plants/m^2

V_0: 0 t/ha

V_1: 5 t/ha

V_2: 10 t/ha

V_3: 15 t/ha

Table 2. Combined effect of plant density and vermicompost on plant height at bolting stage and number of primary branches of coriander

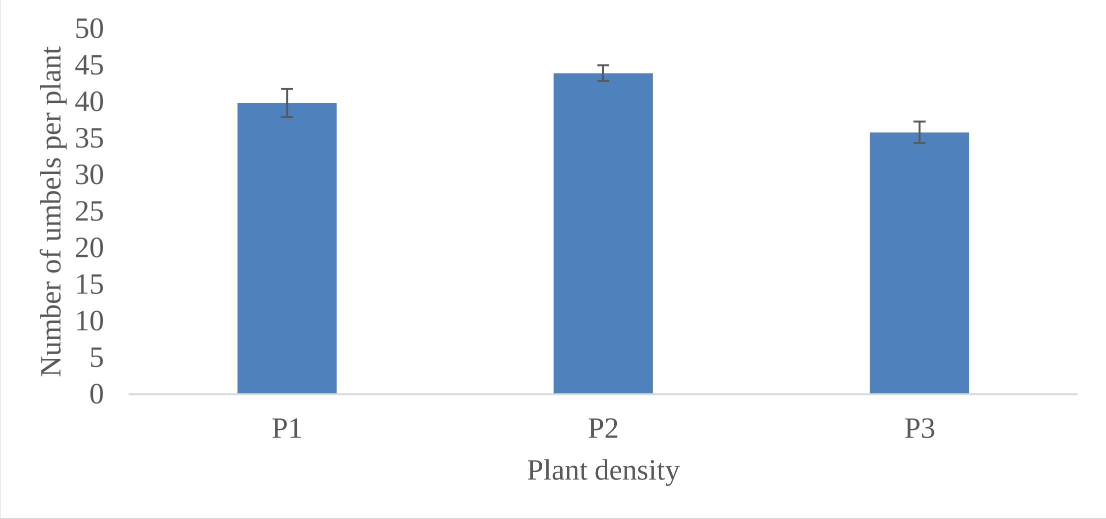
Treatments	Plant height at bolting (cm)	Number of primary branches per plant
P_1V_0	65.01±0.57 ^{j}	1.60±0.47 ^{f}
P_1V_1	70.51±0.58 ^{i}	3.81±0.24 ^{de}
P_1V_2	72.23±0.59 ^{h}	4.82±0.28 ^{cd}
P_1V_3	77.43±0.51 ^{ef}	4.71±0.47 ^{cd}
P_2V_0	76.51±0.86 ^{fg}	5.10±0.24 ^{c}
P_2V_1	80.38±0.53 ^{d}	6.72±0.27 b
P_2V_2	83.25±1.18 ^{bc}	7.82±0.48 ^{a}
P_2V_3	87.21±0.57 ^{a}	8.31±0.23 ^{a}
P_3V_0	75.01±0.41 ^{g}	3.00±0.29 ^{e}
P_3V_1	79.42±1.15 ^{de}	4.73±0.47 ^{cd}
P_3V_2	81.15 ±o.48 ^{cd}	6.33±0.25 ^{b}
P_3V_3	85.16±0.88 ^{ab}	7.82±0.28 ^{a}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.3 Number of umbels per plant

4.3.1 Effect of plant density

There was a marked variation was observed on number of umbels per plant influenced by different plant density (Figure 1). Results showed that maximum number of umbels (43.91) per plant was obtained from P_2 treatment (40 plants/m^2) which was statistically different from all other treatments and the minimum (35.81) number of umbels per plant was recorded in P_3 treatment. Similar result was found in the experiment done by Sarker (2015).

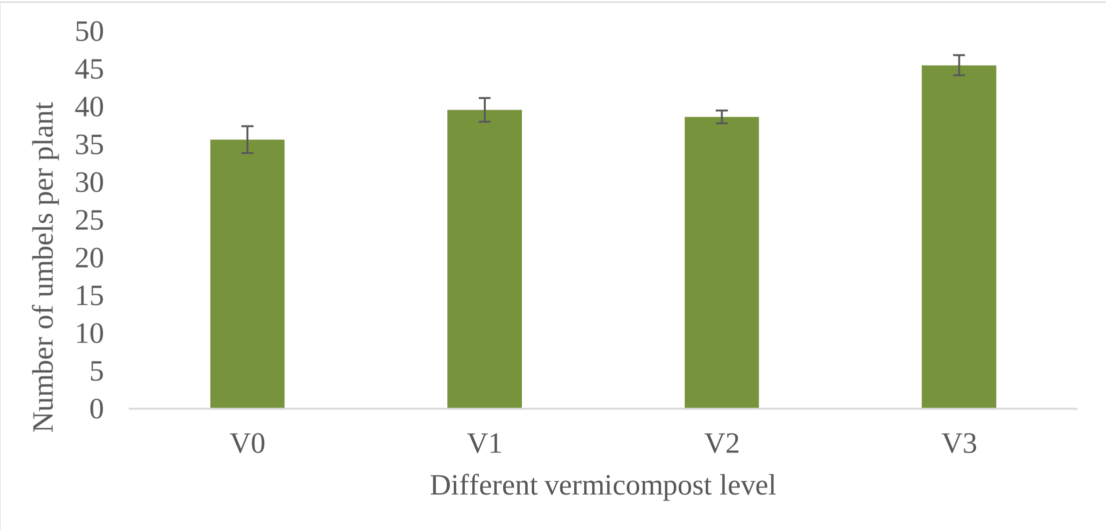


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 1. Effect of plant density on number of umbels per plant of coriander

4.3.2 Effect of vermicompost

Significant influence was observed on number of umbels per plant due to the variation of vermicompost application (Figure 2). From the figure it was found that maximum number of umbels per plant (45.49) was observed in V_3 treatment which was statistically different from all other treatments. On the other hand, minimum number of umbels per plant (35.66) was observed in V_0 treatment which was statistically at par with V_2 and V_3. This corroborates the result of Sanwal *et al.* (2015).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 2. Effect of different vermicompost level on number of umbels per plant of coriander

4.3.3 Combined effect of plant density and vermicompost

Marked variation was observed on number of umbels per plant due to combined effect of plant density and vermicompost application (Table 3). From the result it was observed that the maximum number of umbels per plant (50.19) was recorded from P_2V_3 (40 plants/m^2 with 15 t/ha vermicompost) combination which was statistically different from all other treatments combination. On the other hand, minimum number of umbel per plant (29.50) was recorded from P_3V_0 combination.

Table 3. Combined effect of plant density and vermicompost on number of umbels per plant of coriander

Treatments	Number of umbels per plant
P_1V_0	36.36 ± 0.87^{ef}
P_1V_1	34.55 ± 1.44^{f}
P_1V_2	$37.1 \pm 0.86^{d\text{-}f}$
P_1V_3	42.11 ± 1.16^{bc}
P_2V_0	$41.12 \pm 1.45^{b\text{-}d}$
P_2V_1	44.14 ± 0.87^{b}
P_2V_2	$40.20 \pm 1.14^{b\text{-}e}$
P_2V_3	50.19 ± 1.43^{a}
P_3V_0	29.50 ± 1.15^{g}
P_3V_1	$40.12 \pm 1.85^{b\text{-}e}$
P_3V_2	$43.68 \pm 2.04^{c\text{-}f}$
P_3V_3	44.17 ± 0.82^{b}
Level of significance	*

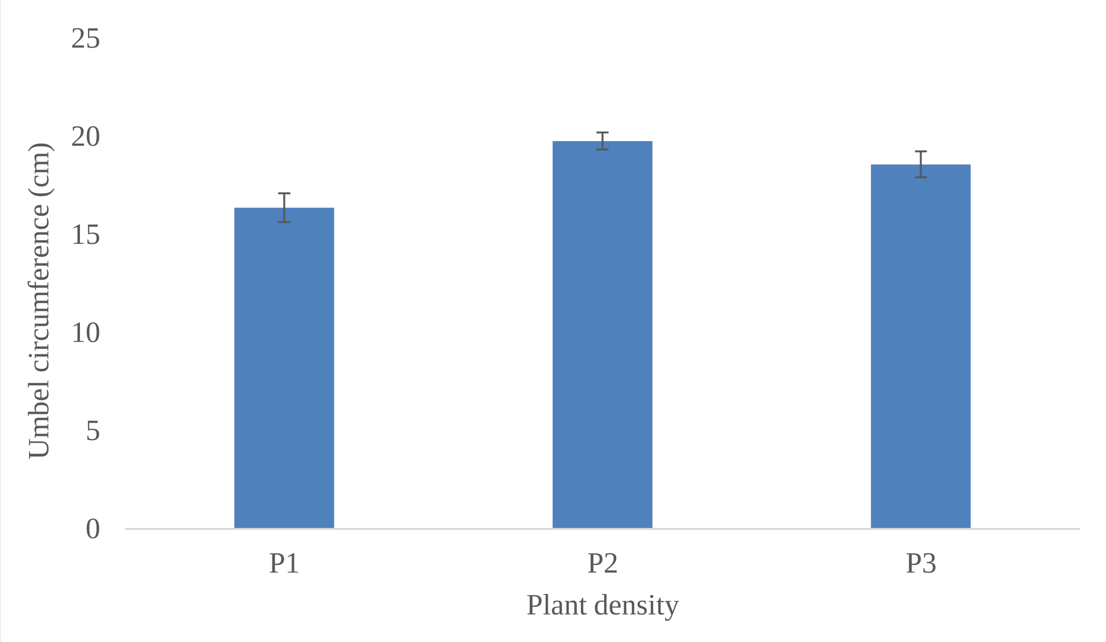
The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.4. Umbel circumference

4.4.1 Effect of plant density

There was marked variation was observed on umbel circumference due to variation of plant density (Figure 3). From the results of the experiment, it was observed that P_2

treatment (40 plants/m^2) produced highest umbel circumference of coriander (19.77 cm) which was statistically at par with P_3 (18.58 cm) treatment and the minimum (16.37 cm) umbel circumference was recorded in P_1 (20 plants/m^2) treatment. This corroborates the result of Kaium *et al.* (2015).

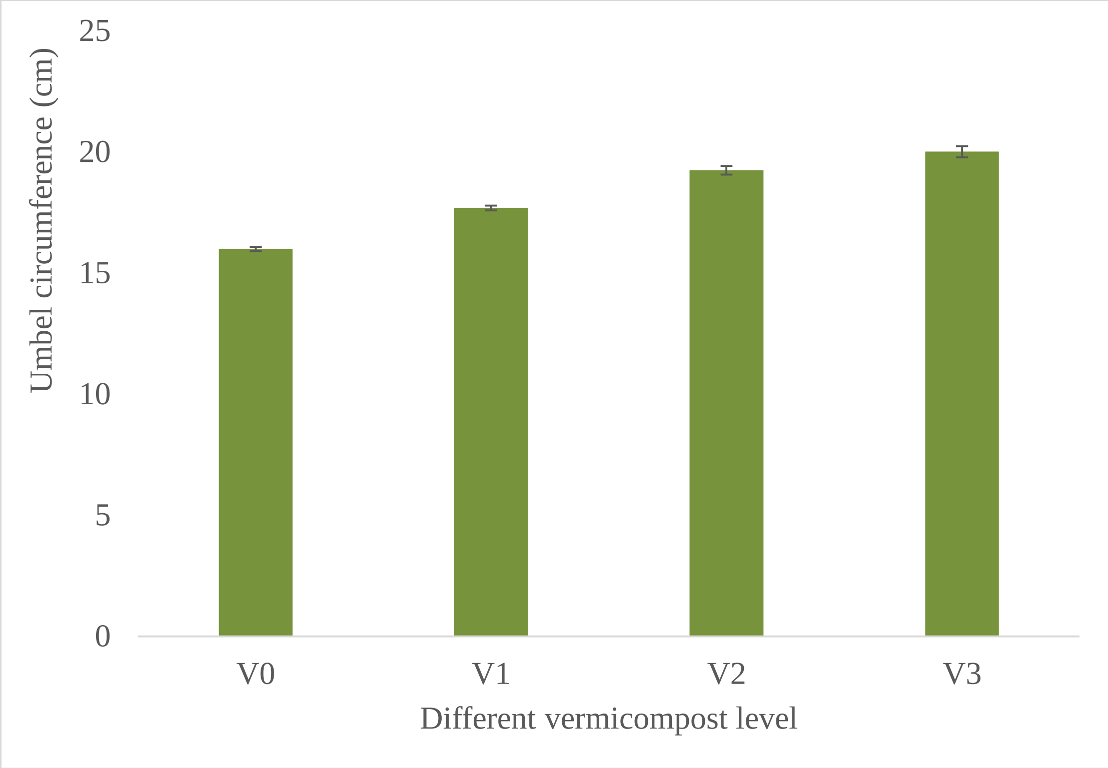


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 3. Effect of plant density on umbel circumference of coriander

4.4.2 Effect of vermicompost

Significant influence was observed on umbel circumference of coriander due to the variation of vermicompost application (Figure 4). From the figure it was found that highest umbel circumference of coriander (20.02 cm) was observed in V_3 treatment which was statistically at par with V_2 (19.25 cm) treatment. On the other hand, lowest umbel circumference of coriander (16.00 cm) was observed in V_0 treatment which was statistically similar with V_1 (17.69 cm) treatment. This corroborates the result of Gowda *et al.* (2015).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 4. Effect of different vermicompost level on umbel circumference of coriander

4.4.3. Combined effect of plant density and vermicompost

There was marked variation was observed on umbel circumference of coriander due to combined effect of plant density and vermicompost application (Table 4). From the result it was observed that the highest umbel circumference of coriander (21.80 cm) was recorded from P_2V_3 (40 plants/m^2 with 15 t/ha vermicompost) combination which was statistically similar with P_2V_2 and P_3V_3 treatment combination. On the other hand, lowest umbel circumference of coriander (13.22 cm) was recorded from P_1V_0 combination.

Table 4. Combined effect of plant density and vermicompost on umbel circumference of coriander

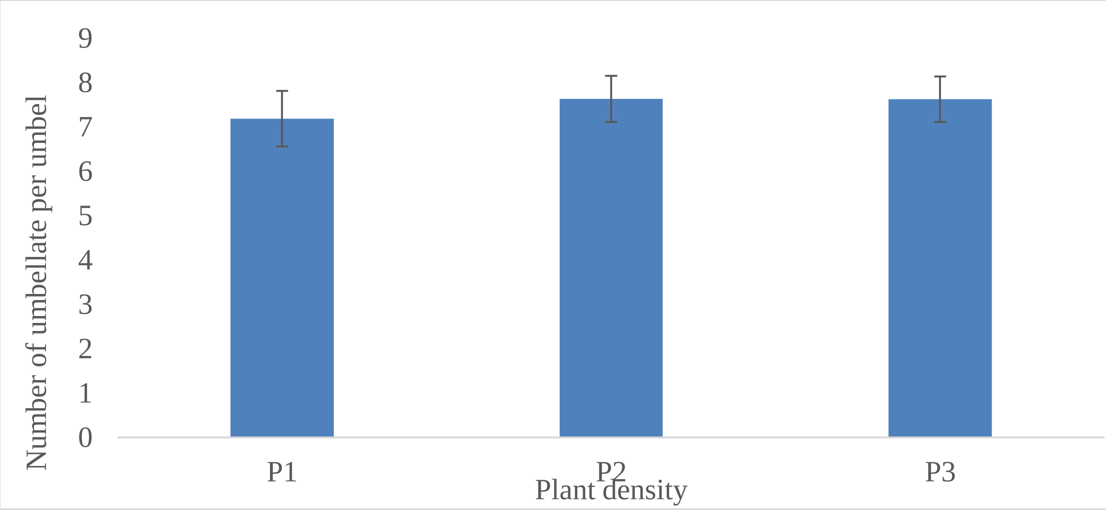
Treatments	Umbel circumference (cm)
P_1V_0	13.22±0.92 ^{d}
P_1V_1	16.12±0.63 ^{bc}
P_1V_2	17.50±1.21 ^{bc}
P_1V_3	18.65±1.15 ^{bc}
P_2V_0	17.71±.28 ^{bc}
P_2V_1	17.96±0.57 ^{bc}
P_2V_2	21.71±0.69 ^{a}
P_2V_3	21.80±1.15 ^{a}
P_3V_0	19.00±0.57 ^{bc}
P_3V_1	18.54±1.02 ^{bc}
P_3V_2	19.70±0.87 ^{bc}
P_3V_3	18.24±0.34 ^{ab}
Level of significance	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.5 Number of umbellate per umbel

4.5.1 Effect of plant density

Non-significant effect was observed on number of umbellate per umbel due to different plant density under the study (Figure 5). From the results of the experiment, it was observed that P_2 treatment (40 plants/m^2) produced maximum number of umbellate per umbel (7.64), whereas, the minimum number of umbellate per umbel (7.19) was recorded from P_1 treatment. This corroborates the result of Kaium *et al.* (2015).

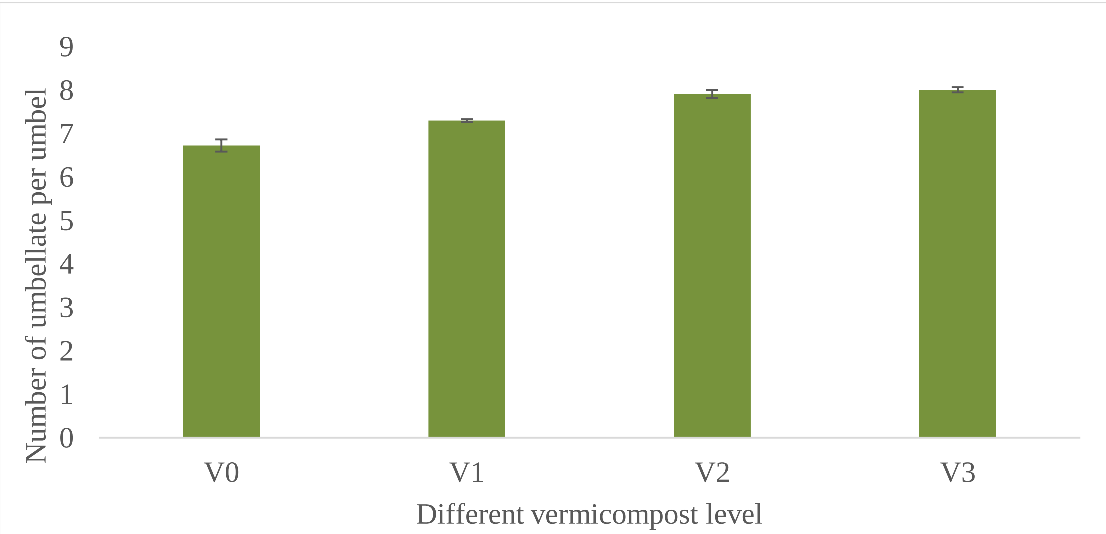


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 5. Effect of plant density on number of umbellate per umbel of coriander

4.5.2 Effect of vermicompost

Significant influence was observed on number of umbellate per umbel due to the variation of vermicompost application (Figure 6). From the figure it was observed that maximum number of umbellates per umbel (8.01) was observed in V_3 treatment which was statistically similar with the V_2 treatment. On the other hand, the minimum number of umbellate per umbel (6.73) was observed in V_0 treatment. This corroborates the result of Gowda *et al.* (2008).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 6. Effect of different vermicompost level on number of umbellate per umbel of coriander

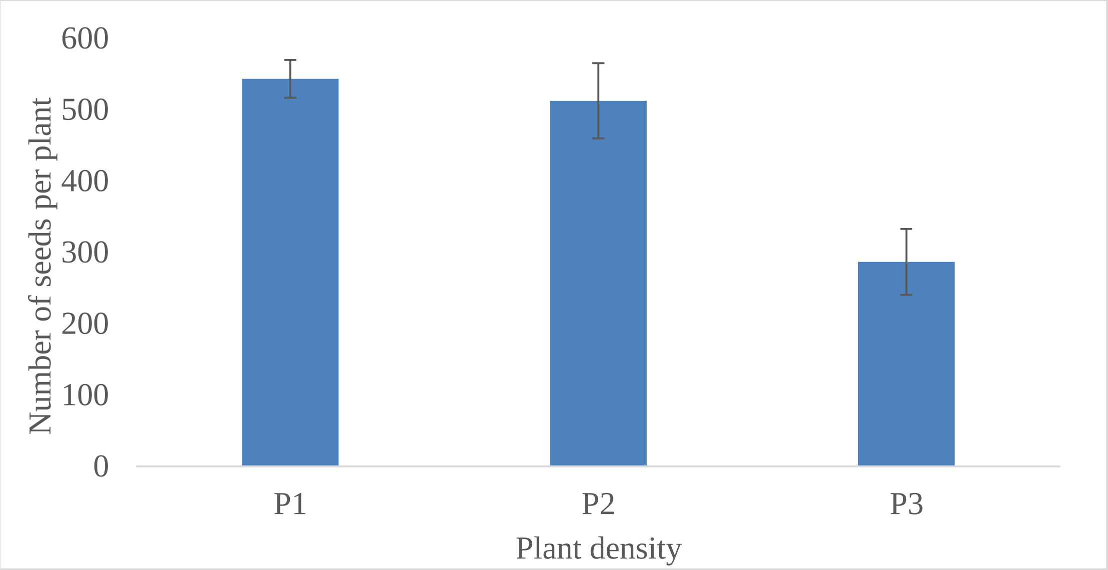
4.5.3 Combined effect of plant density and vermicompost

There was marked variation was observed on number of umbellate per umbel due to combined effect of plant density and vermicompost application (Table 5). From the result it was observed that the combination of P_2V_3 (40 plants/m^2 with 15 t/ha vermicompost) treatment gave the maximum number of umbellates per umbel (8.16) which was statistically similar with P_3V_2, P_3V_3 and P_2V_2 treatment (8.13, 8.10 and 8.03, respectively) combination. On the other hand, the minimum number of umbellate per umbel (6.26) was recorded from P_1V_0 combination.

4.6 Number of seeds per plant

4.6.1 Effect of plant density

There was marked variation was observed on number of seeds per plant due to variation of plant density (Figure 7). From the results it was found that, the maximum number of seeds per plant (543.42) was found from P_1 (20 plants/m^2) treatment which was statistically at par with P_2 (512.50). On the other hand, the minimum number of seeds per plant (286.66) was recorded from P_3 treatment. This corroborates the result of Kaium *et al.* (2015).

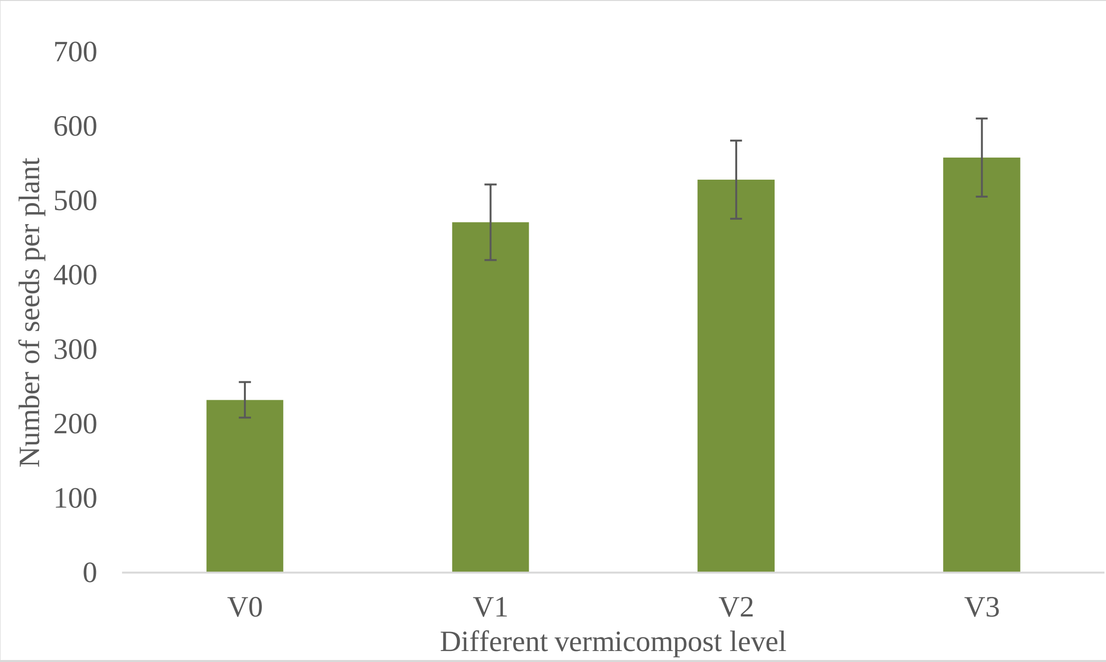


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 7. Effect of plant density on number of seeds per plant of coriander

4.6.2 Effect of vermicompost

Significant influence was observed on number of seeds per plant due to the variation of vermicompost application (Figure 8). The data presented in the figure showed an increasing trend with the increases of vermicompost rate. This might be due to higher availability of nutrients that progressively increase the number of seed per plant of coriander. From the figure it was observed that maximum number of seeds per plant (557.90) was found from V_3 treatment which was statistically similar with V_2 and V_1 treatment (528.32 and 471.00, respectively). On the other hand, the minimum number of seeds per plant (232.22) was observed in V_0 treatment. This corroborates the result of Gowda *et al.* (2008).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 8. Effect of different vermicompost level on number of seeds per plant of coriander

4.6.3 Combined effect of plant density and vermicompost

Marked variation was observed on number of seeds per plant due to combined effect of plant density and vermicompost application (Table 5). From the result it was observed that the combination of P_2V_3 (60 plants/m^2 with 15 t/ha vermicompost) treatment gave the maximum number of seeds per plant (665.02) which was statistically at par with P_2V_2, P_1V_3, P_1V_2 and P_1V_1. On the other hand, the minimum number of seeds per plant (136.65) was recorded from P_3V_0 treatment combination.

Table 5. Combined effect of plant density and vermicompost on number of umbellate per umbel and number of seeds per plant of coriander

Treatments	Number of umbellate per umbel	Number of seeds per plant
P_1V_0	6.26 ± 0.26^{f}	281.67 ± 1.15^{c}
P_1V_1	7.16 ± 0.03^{de}	625.01 ± 0.57^{a}
P_1V_2	7.56 ± 0.03^{bc}	596.67 ± 1.16^{a}
P_1V_3	7.76 ± 0.03^{b}	670.34 ± 1.15^{a}
P_2V_0	6.96 ± 0.03^{e}	278.34 ± 1.17^{c}
P_2V_1	7.36 ± 0.03^{cd}	451.67 ± 10.00^{b}
P_2V_2	8.03 ± 0.08^{a}	665.01 ± 15.19^{a}
P_2V_3	8.16 ± 0.03^{a}	665.02 ± 1.73^{a}
P_3V_0	6.96 ± 0.03^{e}	136.65 ± 1.73^{d}
P_3V_1	7.36 ± 0.03^{cd}	337.76 ± 13.91^{c}
P_3V_2	8.13 ± 0.03^{a}	323.88 ± 13.91^{c}
P_3V_3	8.10 ± 0.05^{a}	348.35 ± 1.15^{c}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.7 Dry seed yield per plant

4.7.1 Effect of plant density

There observed a marked variation on the weight of dry seed yield per plant of coriander due to variation of plant density (Table 6). From the results it was found that, the highest weight of dry seed per plant (6.51 g) was found from P_1 (20 plants/m^2) treatment which was statistically at par with P_2 (5.58 g) treatment. On the other hand, the lowest dry seed weight per plant (4.08 g) was recorded from P_3 treatment. This corroborates the result of Kaium *et al.* (2015).

4.7.2 Effect of vermicompost

Significant influence was observed on the weight of dry seed yield per plant of coriander due to the variation of vermicompost application (Table 6). From the results it was found that, the highest weight of dry seed per plant of coriander (6.90 g) was found from V_3 treatment which was statistically similar with V_2 treatment. On the other hand, the lowest dry seed weight per plant (3.95 g) was recorded from V_0 treatment, which was also statistically similar with V_1 treatment. This findings is more or less similar with the result of Dadiga *et al.* (2015).

4.7.3 Combined effect of plant density and vermicompost

Marked variation was observed on the weight of dry seed yield per plant of coriander due to combined effect of plant density and vermicompost application (Table 7). From the result it was observed that the combination of P_1V_3 (20 plants/m^2 with 15 t/ha vermicompost) treatment gave the highest dry seed weight per plant (8.36 g) which was statistically similar with P_1V_2 and P_2V_3. On the other hand, the lowest dry seed weight per plant (3.07 g) was recorded from P_3V_0 combination which was statistically similar with P_3V_1, P_3V_2, P_3V_0, P_2V_0, P_1V_1 and P_1V_0.

4.8 Dry seed yield per plot

4.8.1 Effect of plant density

Significant influence was observed on dry seed weight of coriander per plot due to different plant density under the study (Table 6). From the results it was found that, the highest dry seed weight per plot (266.65 g) of coriander was found from P_3 (80 plants/m^2) treatment which was statistically similar with P_2 treatment. On the other hand, the lowest dry seed weight per plot (137.72 g) of coriander was recorded from P_1 treatment. This result is more or less similar with the result of Kaium *et al.* (2015).

4.8.2 Effect of vermicompost

Significant influence was observed on the weight of dry seed yield per plot of coriander due to the variation of vermicompost application (Table 6). From the results it was found that, the highest dry seed weight of coriander per plot (271.39 g) was found from V_3 treatment which was statistically similar with V_2 treatment. On the other hand, the lowest dry seed weight per plot (128.84 g) was recorded from V_0 treatment. This result is more or less similar with the result of Dadiga *et al.* (2015).

4.8.3 Combined effect of plant density and vermicompost

There observed a marked variation on the weight of dry seed yield per plot of coriander due to combined effect of plant density and vermicompost application (Table 7). From the result it was observed that the combination of P_3V_3 (80 plants/m^2 with 15 t/ha vermicompost) treatment gave the highest dry seed weight per plot (333.80 g) of coriander. On the other hand, the lowest dry seed weight per plot (50.91 g) was recorded from P_1V_0 combination.

Table 6. Effect of plant density and vemicompost on dry seed yield per plant and dry seed yield per plot of coriander

Treatments	Dry seed yield per plant (g)	Dry seed yield per plot (g)
Plant density		
P_1	6.51±0.56 [a]	137.72±17.09 [b]
P_2	5.58±0.43 [a]	223.33±15.81 [a]
P_3	4.08±0.39 [b]	266.65±16.51 [a]
Level of significance	*	*
Vermicompost		
V_0	3.95±0.38 [c]	128.84±20.12 [b]
V_1	4.69±0.46 [bc]	199.65±21.21 [b]
V_2	6.02±0.68 [ab]	237.06±13.38 [ab]
V_3	6.90±0.48 [a]	271.39±22.27 [a]
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

P_1: 20 plants/m^2 | V_0: 0 t/ha
P_2: 40 plants/m^2 | V_1: 5 t/ha
P_3: 80 plants/m^2 | V_2: 10 t/ha
V_3: 15 t/ha

Table 7. Combined effect of plant density and vermicompost on dry seed yield per plant and dry seed yield per plot of coriander

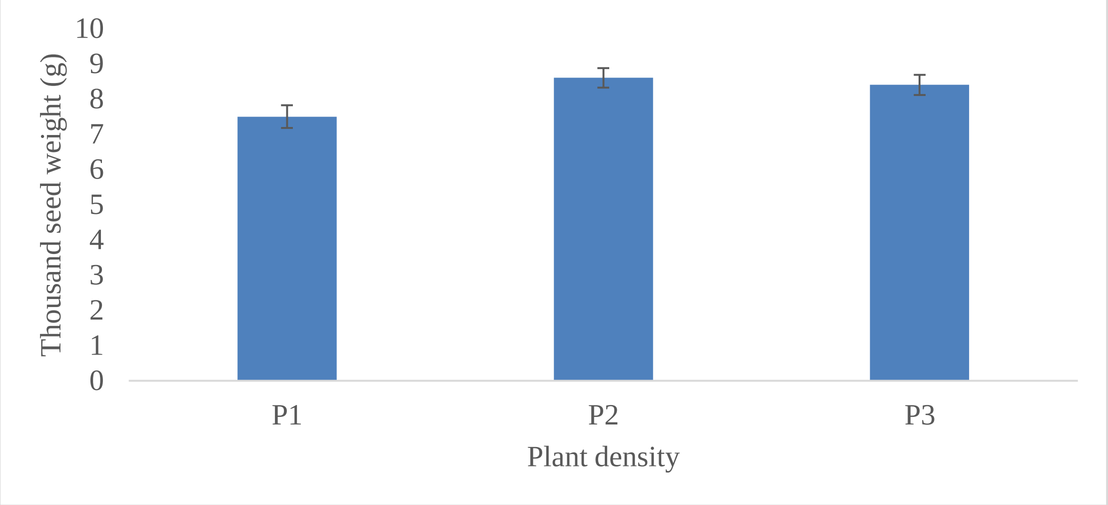
Treatments	Dry seed yield per plant (g)	Dry seed yield per plot (g)
P_1V_0	4.71±0.57 $^{c-f}$	50.91±1.15 ^{i}
P_1V_1	4.96±0.86 $^{c-f}$	123.81±2.88 ^{h}
P_1V_2	8.03±0.44 ^{ab}	190.92±1.73 ^{f}
P_1V_3	8.36±0.33 ^{a}	185.25±2.30 ^{f}
P_2V_0	4.08±0.86 $^{d-f}$	150.80±2.88 ^{g}
P_2V_1	5.55±0.53 $^{c-e}$	207.22±2.30 ^{e}
P_2V_2	6.01±0.73 $^{b-d}$	240.20±1.70 ^{d}
P_2V_3	6.70±0.87 $^{a-c}$	295.13±2.30 ^{b}
P_3V_0	3.07±0.19 ^{f}	184.81±2.02 ^{f}
P_3V_1	3.57±0.75 ^{ef}	267.94±12.35 ^{c}
P_3V_2	4.03±0.99 $^{d-f}$	280.08±12.19 ^{bc}
P_3V_3	5.65±0.29 $^{c-e}$	333.80±1.73 ^{a}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.9 Thousand seed weight (g)

4.9.1 Effect of plant density

Significant influence was observed on thousand seeds weight of coriander due to different plant density under the study (Figure 9). From the results it was found that, the maximum thousand seeds weight (8.60 g) was obtained from P_2 (60 plants/m^2) treatment which was statistically at par with P_3 treatment. On the other hand, the minimum thousand seeds weight of coriander (7.50 g) was obtained from the P_1 treatment. This corroborates the result of Kaium *et al.* (2015).

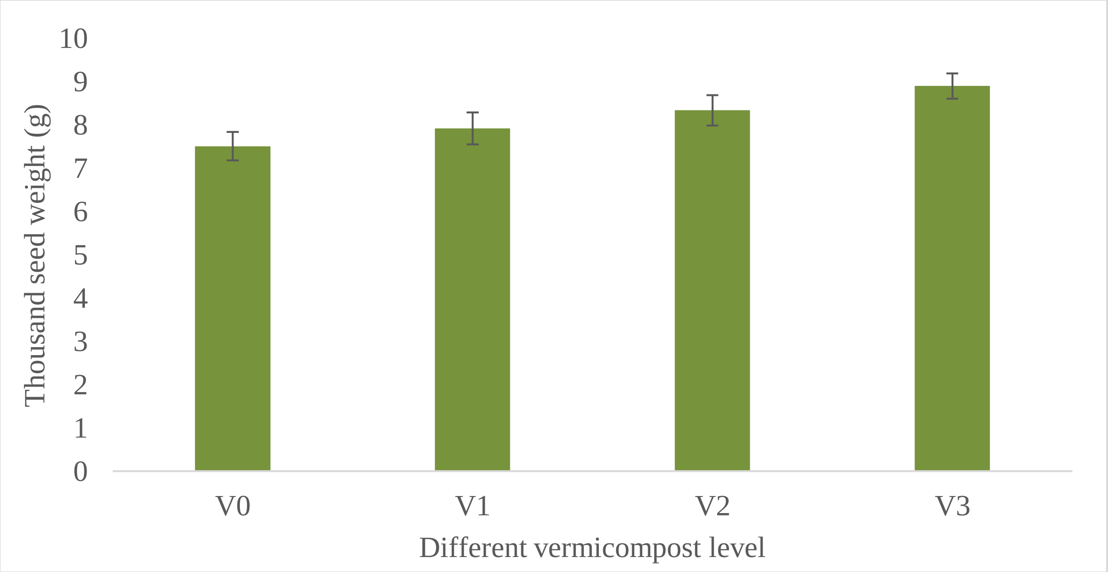


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 9. Effect of plant density on thousand seed weight of coriander

4.9.2 Effect of vermicompost

Significant variation was observed on the thousand seeds weight of coriander influenced by the variation of vermicompost application (Figure 10). From the results it was found that, the maximum thousand seeds weight (8.90 g) was found from V_3 treatment which was statistically similar with V_2 and V_1 treatment. On the other hand, the minimum 1000 seeds weight (7.51 g) was recorded from V_0 treatment. This corroborates the result of Darzi *et al.* (2015).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 10. Effect of different vermicompost level on thousand seed weight of coriander

4.9.3 Combined effect of plant density and vermicompost

Marked variation was observed on thousand seeds weight due to combined effect of plant density and vermicompost application (Table 8). From the result it was observed that the combination of P_2V_3 (40 plants/m^2 with 15 t/ha vermicompost) treatment gave the maximum weight of thousand seeds (9.19 g), which was statistically similar with P_2V_2 and P_2V_3 treatment combination. On the other hand, the minimum thousand seeds weight of coriander (6.80 g) was recorded from P_1V_0 treatment combination.

Table 8. Combined effect of plant density and vermicompost on thousand seeds weight of coriander

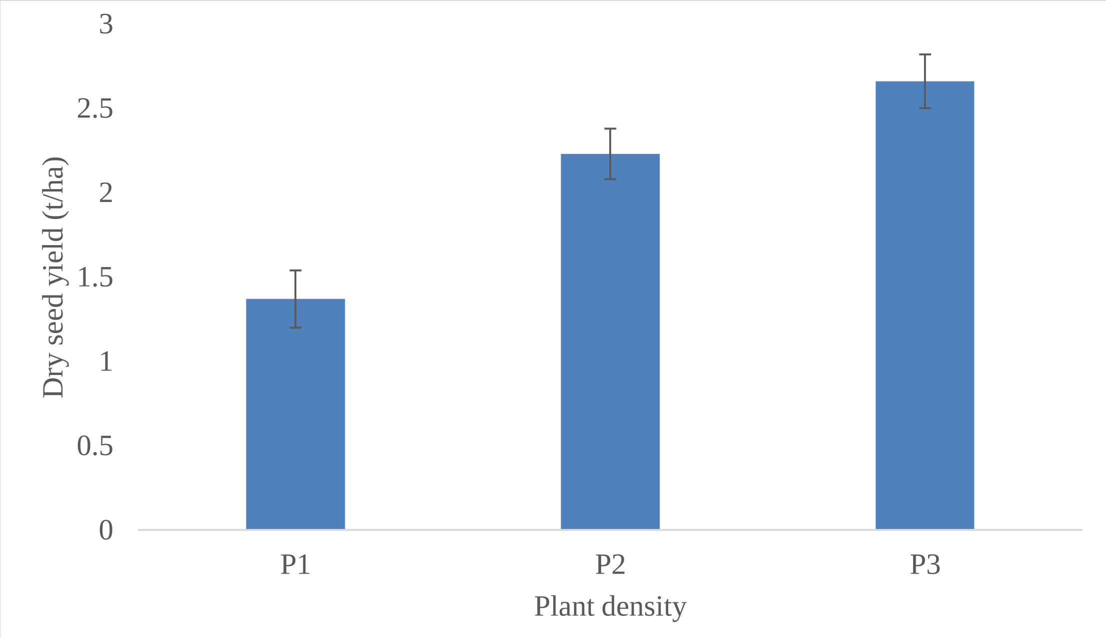
Treatments	Thousand seed yield (g)
P_1V_0	6.80±0.57 ^{c}
P_1V_1	7.00±0.58 ^{bc}
P_1V_2	7.60±0.56 $^{a-c}$
P_1V_3	8.63±0.57 $^{a-c}$
P_2V_0	7.90±0.58 $^{a-c}$
P_2V_1	8.45±0.56 $^{a-c}$
P_2V_2	8.86±0.59 ^{ab}
P_2V_3	9.19±0.57 ^{a}
P_3V_0	7.82±0.58 $^{a-c}$
P_3V_1	8.33±0.57 $^{a-c}$
P_3V_2	8.56±0.56 $^{a-c}$
P_3V_3	8.90±0.59 ^{ab}
Level of significance	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.10 Dry seed yield per hectare

4.10.1 Effect of plant density

Significant influence was observed on the weight of dry seed yield of coriander per hectare due to different plant density under the study (Figure 11). From the results it was found that, the highest dry seed yield per hectare (2.66 t) was found from P_3 (60 plants/m^2) treatment which was statistically at par with P_2 (2.23 t/ha) treatment. On the other hand, the lowest dry seed yield per hectare (1.37 t) was recorded from P_1 treatment. This finding is more or less similar with the result of Sharangi and Roychowdhury (2014).

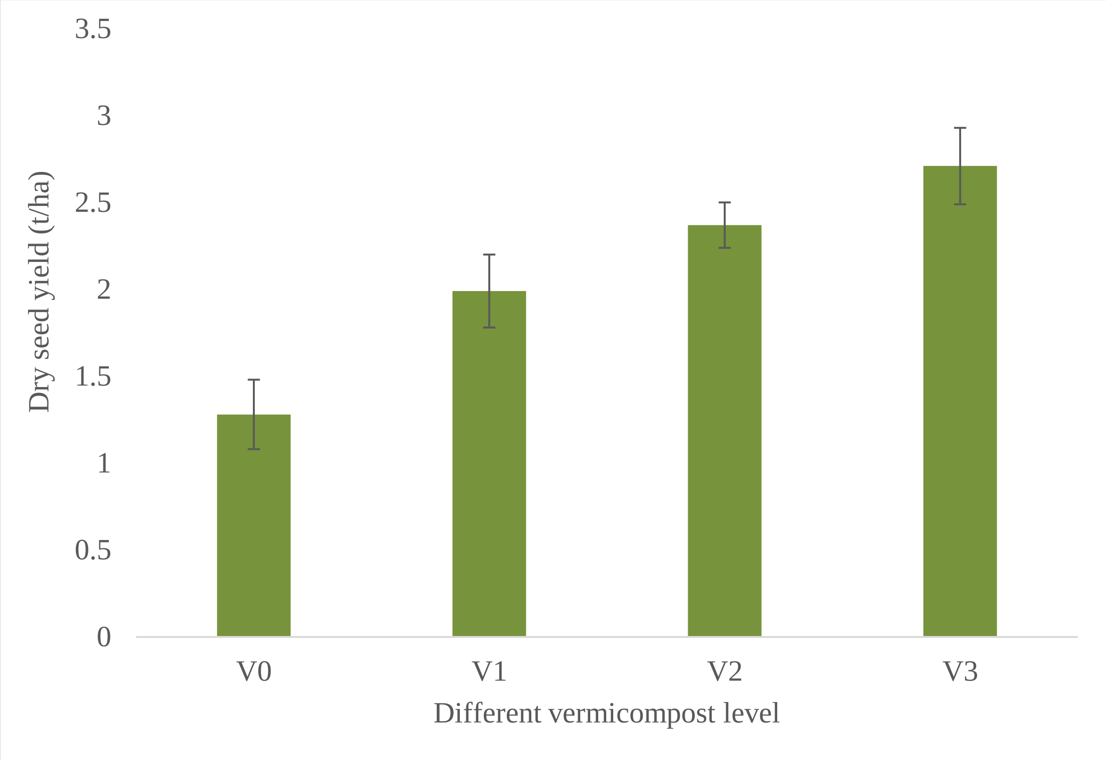


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 11. Effect of plant density on dry seed yield (t/ha) of coriander

4.9.2 Effect of vermicompost

Significant influence was observed on the yield of dry seed per hectare of coriander due to the variation of vermicompost application (Figure 12). From the results it was found that, the highest dry seed yield per hectare of coriander (2.71 t) was found from V_3 treatment which was statistically similar with V_2 treatment. On the other hand, the lowest dry seed yield per hectare (1.28 t) was recorded from V_0 treatment. This corroborates the result of Darzi *et al.* (2015).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 12. Effect of different vermicompost level on dry seed yield of coriander

4.10.3. Combined effect of plant density and vermicompost

There observed a marked variation on the yield of dry seed of coriander per hectare due to combined effect of plant density and vermicompost application (Table 9). From the result it was observed that the combination of P_3V_3 (80 plants/m^2 with 15 t/ha vermicompost) treatment gave the maximum dry seed weight per hectare (3.33 t). On the other hand, the minimum dry seed yield of coriander per hectare (0.50 t) was recorded from P_1V_0 treatment combination.

Table 9. Combined effect of plant density and vermicompost on dry seed yield of coriander

Treatments	Dry seed yield (t/ha)
P_1V_0	0.50±0.02 [i]
P_1V_1	1.23±0.05 [h]
P_1V_2	1.90±0.03 [f]
P_1V_3	1.85±0.04 [f]
P_2V_0	1.50±0.05 [g]
P_2V_1	2.07±0.04 [e]
P_2V_2	2.40±0.03 [d]
P_2V_3	2.95±0.04 [b]
P_3V_0	1.84±0.032 [f]
P_3V_1	2.67±0.21 [c]
P_3V_2	2.79±0.22 [bc]
P_3V_3	3.33±0.03 [a]
Level of significance	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.11 Stover yield per plot

4.11.1 Effect of plant density

Significant influence was observed on the weight of stover yield per plot of coriander due to different plant density under the study (Table 10). From the results it was found that, the highest weight of stover yield per plot (318.11 g) was found from P_3 (80 plants/m^2) treatment. On the other hand, the lowest stover weight per plot (166.30 g) was recorded from P_1 treatment. This result is collaborate with the result of Sharangi and Roychowdhury (2014).

4.11.2 Effect of vermicompost

Significant influence was observed on the weight of stover yield per plot of coriander due to the variation of vermicompost application (Table 10). From the results it was found that, the highest weight of stover yield per plot (330.49 g) was found from V_3 treatment. On the other hand, the lowest weight of stover yield per plot (157.65 g) was recorded from V_0 treatment. This corroborates the result of Singh *et al.* (2009).

4.11.3 Combined effect of plant density and vermicompost

There was marked variation was observed on the weight of stover yield per plot of coriander due to combined effect of plant density and vermicompost application (Table 11). From the result it was observed that the combination of P_3V_3 (80 plants/m^2 with 15 t/ha vermicompost) treatment gave the highest stover yield per plot (410.69 g). On the other hand, the lowest stover weight per plot (95.65 g) was recorded from P_1V_0 treatment combination.

4.12 Stover yield per ha

4.12.1 Effect of plant density

Significant influence was observed on the weight of stover yield of coriander per hectare due to different plant density under the study (Table 10). From the results it was found that, the highest stover yield per hectare (3.17 t) was found from P_3 (80 plants/m^2) treatment. On the other hand, the lowest stover yield of coriander per hectare (1.66) was recorded from P_1 treatment. This result is collaborate with the result of Sharangi and Roychowdhury (2014).

4.12.2 Effect of vermicompost

Significant influence was observed on the yield of dry seed per hectare of coriander due to the variation of vermicompost application (Table 10). From the results it was found that, the highest stover yield of coriander per hectare (3.30 t) was found from V_3 treatment. On the other hand, the lowest stover yield per hectare (1.57 t) was recorded from V_0 treatment. This corroborates the result of Singh *et al.* (2009).

4.12.3 Combined effect of plant density and vermicompost

There was marked variation was observed on the stover yield of coriander per hectare due to combined effect of plant density and vermicompost application (Table 11). From the result it was observed that the combination of P_3V_3 (80 plants/m^2 with 15 t/ha vermicompost) treatment gave the maximum stover yield per hectare (4.10 t). On the other hand, the minimum stover yield of coriander per hectare (0.95 t) was recorded from P_1V_0 combination.

Table 10. Effect of plant density and vemicompost on stover yield per plot and stover yield per hacter of coriander

Treatments	Stover yield per plot (g)	Stover yield per ha (t)
Plant density		
P_1	166.30±14.68 ^{c}	1.66±0.14 ^{c}
P_2	251.96±21.71 ^{b}	2.51±0.21 ^{b}
P_3	318.11±19.98 ^{a}	3.17±0.19 ^{a}
Level of significance	*	*
Vermicompost		
V_0	157.65±19.03 ^{c}	1.57±0.19 ^{c}
V_1	246.02±21.30 ^{b}	2.45±0.21 ^{b}
V_2	257.58±23.02 ^{b}	2.56±0.22 ^{b}
V_3	330.49±26.61 ^{a}	3.30±0.26 ^{a}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

P_1: 20 plants/m^2
P_2: 40 plants/m^2
P_3: 80 plants/m^2

V_0: 0 t/ha
V_1: 5 t/ha
V_2: 10 t/ha
V_3: 15 t/ha

Table 11. Combined effect of plant density and vermicompost on stover yield per plot and stover yield per hectare of coriander

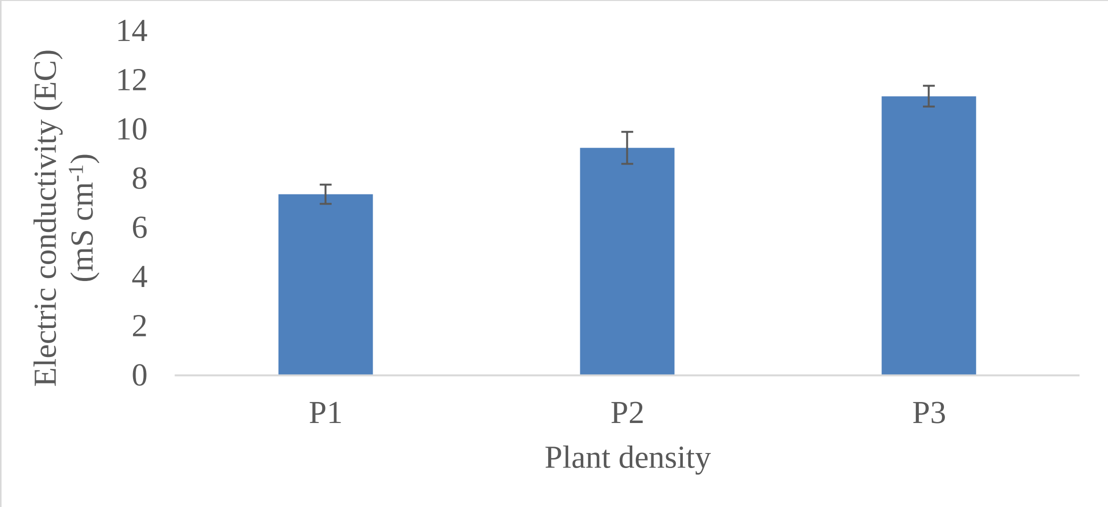
Treatments	Stover yield per plot (g)	Stover yield per ha (t)
P_1V_0	95.65±2.88 ^{h}	0.95±0.05 ^{h}
P_1V_1	179.00±5.19 ^{f}	1.79±0.09 ^{f}
P_1V_2	160.44±6.64 ^{g}	1.60±0.06 ^{g}
P_1V_3	230.12±5.77 ^{e}	2.30±0.05 ^{e}
P_2V_0	150.64±2.88 ^{g}	1.50±0.02 ^{g}
P_2V_1	235.95±4.61 ^{e}	2.35±0.04 ^{e}
P_2V_2	270.34±5.77 ^{d}	2.70±0.05 ^{d}
P_2V_3	350.67±2.30 ^{b}	3.50±0.02 ^{b}
P_3V_0	226.66±1.15 ^{e}	2.26±0.01 ^{e}
P_3V_1	323.13±11.30 ^{c}	3.22±0.11 ^{c}
P_3V_2	311.96±12.57 ^{c}	3.11±0.12 ^{c}
P_3V_3	410.69±1.73 ^{a}	4.10±0.01 ^{a}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.13 Electric conductivity

4.13.1 Effect of plant density

A significant difference was found in EC test value due to variation of plant density of coriander (Figure 13). Lowest value of the EC test indicate highest vigority of seed. The data presented in the figure showed an increasing trend with the decreasing of spacing. The maximum electric conductivity (EC) test value (11.35 mS cm^{-1}) of coriander was recorded from P_3 treatment. Whereas, the lowest EC test value (7.37 mS cm^{-1}) was recorded with P_1 treatment. This corroborates the result of Katiyar *et al.* (2014).

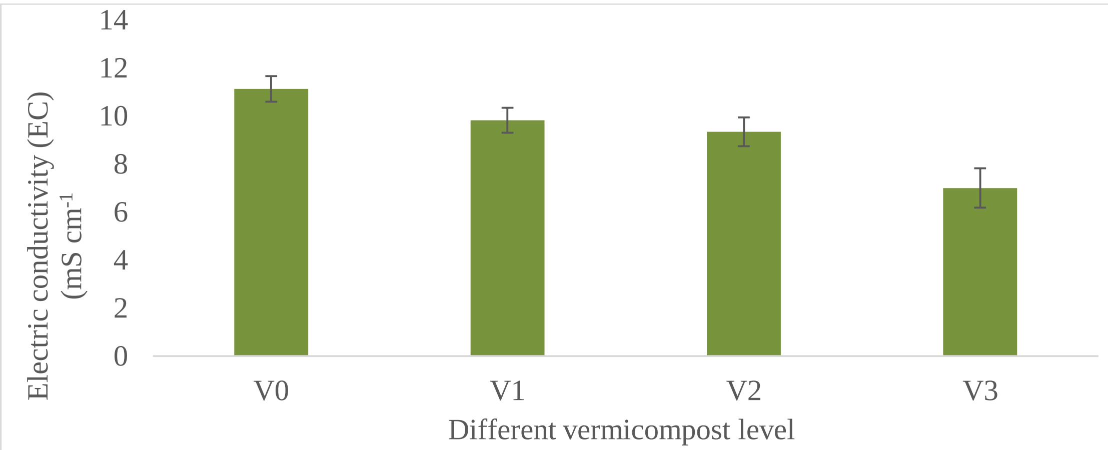


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 13. Effect of plant density on electric conductivity of coriander

4.13.2 Effect of vermicompost

A significant variation was found in electric conductivity test value due to applicaiton of different doses of vermicompost (Figure 14). Lowest value of the EC test indicate highest vigority of seed. The data presented in the figure showed a decreasing trend with the increases of vermicompost rate. The maximum electric conductivity (EC) test value (11.13 mS cm^{-1}) was recorded from V_0 treatment which was statistically similar with V_1 and V_2 treatment. On the other hand, the minimum electric conductivity (EC) test value (7.00 mS cm^{-1}) was recorded from the control (V_3) treatment. This corroborates the result of Srikanth *et al.* (2000).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 14. Effect of different vermicompost level on electric conductivity of coriander

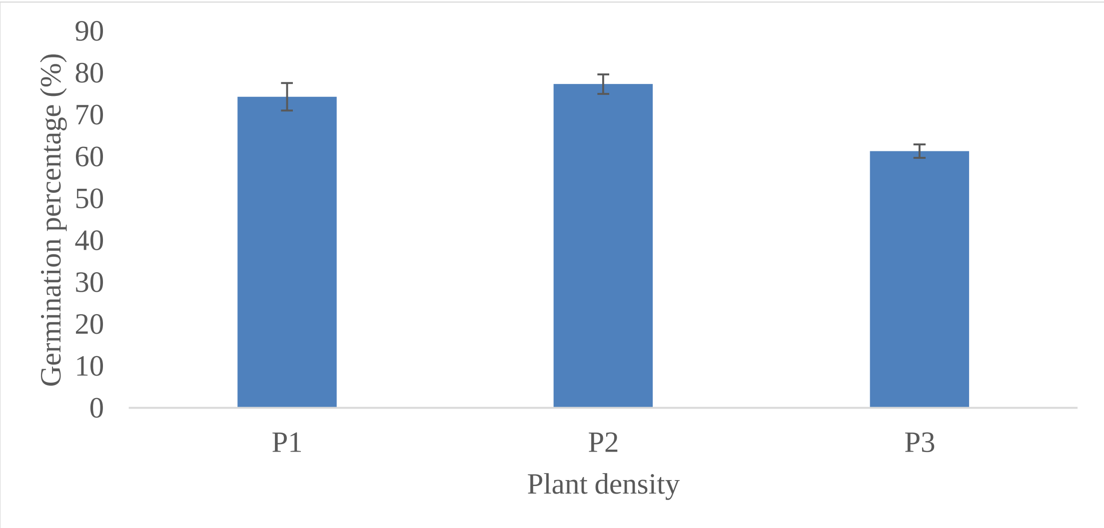
4.13.3 Combined effect of plant density and vermicompost

The interaction effect of plant density and vermicompost put significant effect on electric conductivity (EC) test value of coriander (Table-14). Higher value of EC test indicates low vigor of seed. The highest EC test value (13.00 mS cm^{-1}) was recorded form the combination P_3V_0 treatment. Whereas, the minimum electric conductivity (EC) test value (4.02 mS cm^{-1}) was obtained from P_2V_3 treatment combination.

4.14 Germination percentage

4.14.1 Effect of plant density

A significant difference was found in germination percentage of coriander seed due to different plant density (Figure 15). The maximum germination percentage (77.33 %) was recorded from P_2 treatment which was statistically similar with P_1 (74.33 %). On the other hand, the minimum (61.33 %) was recorded from P_3 treatment. This corroborates the result of Kumar *et al.* (2014).

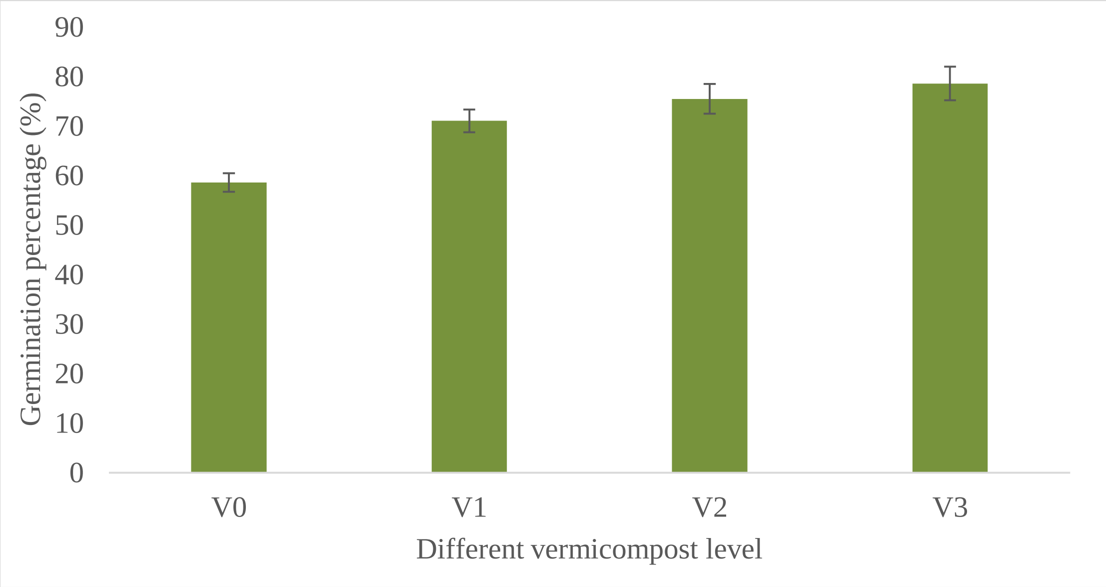


[P_1 = 20 plants/m^2; P_2 = 40 plants/m^2; P_3 = 80 plants/m^2]

Figure 15. Effect of plant density on germination percentage of coriander

4.14.2 Effect of vermicompost

A significant variation was observed on germination percentage of seed due to the application of different doses vermicompost (Figure 16). The data presented in the table showed an increasing trend with the increase of vermicompost rate. This might be higher availability of nutrients that progressively increase the germination percentage of the plant. The maximum germination percentage of seed (78.66 %) was recorded from V_3 treatment which was statistically at par with V_2 (75.55 %) and V_1 (71.11 %). Whereas, the minimum germination percentage (58.66 %) was from the control (V_0) treatment. This corroborates the result of Shirkhodaei and Darzi (2014).



[V_0: 0 t/ha; V_1: 5 t/ha; V_2: 10 t/ha and V_3: 15 t/ha]

Figure 16. Effect of different vermicompost level on germination percentage of coriander

4.14.3 Combined effect of plant density and vermicompost

The interaction effect of plant density and vermicompost put significant effect on germination percentage of coriander seed (Table-14). The combination P_2V_3 gave the maximum germination percentage (85.33 %) which was statistically similar with P_2V_2 (81.33 %) and P_1V_2 (81.33 %). On the other hand, minimum seed germination percentage (57.33%) was obtained from P_1V_0 treatment.

Table 12. Combined effect of plant density and vermicompost on electric conductivity and germination percentage of coriander

Treatments	Electric Conductivity (EC) (mS cm^{-1})	Germination percentage (%)
P_1V_0	11.00±0.29 ^{b}	57.33±1.33 ^{e}
P_1V_1	9.50±0.30 ^{c}	73.33±1.33 ^{c}
P_1V_2	9.1±0.23 ^{cd}	81.33±1.33 ^{ab}
P_1V_3	7.5±0.34 ^{e}	85.33±1.33 ^{a}
P_2V_0	9.38±0.20 ^{c}	65.33±1.33 ^{d}
P_2V_1	8.40±0.51 $^{c-e}$	77.33±1.33 ^{bc}
P_2V_2	7.70±0.69 ^{de}	81.33±1.33 ^{ab}
P_2V_3	4.02±0.46 ^{f}	85.33±1.33 ^{a}
P_3V_0	13.00±0.28 ^{a}	53.33±1.33 ^{e}
P_3V_1	11.56±0.56 ^{b}	62.66±1.33 ^{d}
P_3V_2	11.36±0.68 ^{b}	64.00±2.30 ^{d}
P_3V_3	9.51±0.28 ^{c}	65.33±1.33 ^{d}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

4.15 Root length

4.15.1 Effect of plant density

A significant difference was found in root length due to different plant density (Table 13). The highest root length (6.01 cm) was recorded from P_2 treatment, which was statistically similar with P_1 (5.87 cm). On the other hand, the minimum root length (5.38 cm) was found from P_3 treatment. This corroborates the result of Akhani *et al.* (2012).

4.15.2 Effect of vermicompost

A significant difference was found in root length due to application of different vermicompost level (Table 13). It was observed from the table that root length increased gradually with the increase of level of vermicompost. The highest root length (6.04 cm) was recorded from the highest vermicompost treatment V_3 which was statistically at par with V_2 (5.87 cm) and V_1 (5.86 cm), respectively. Whereas, the lowest root length (5.25 cm) was found from the vermicompost controlled condition (V_0) treatment. This corroborates the result of Ayanoglu *et al.* (2002).

4.15.3 Combined effect of plant density and vermicompost

The interaction effect of plant density and vermicompost was significant on root length of coriander (Table 14). The data presented in the table showed an increasing trend with the increases of vermicompost rate and plant spacing. The highest root length (6.50 cm) was recorded from the combination P_2V_3 treatment. On the other hand, lowest root length (5.00 cm) was recorded with treatment P_3V_0.

4.16 Shoot length

4.16.1 Effect of plant density

Non-significant difference was found in shoot length due to the variation of plant density (Table 13). The maximum shoot length (8.32 cm) was recorded from P_2 treatment and the minimum shoot length (7.68 cm) was recorded in P_3 treatment.

4.16.2 Effect of vermicompost

A significant difference was found in shoot length due to application of different level of vermicompost (Table 13). The data presented in the table showed an increasing trend with the increases of vermicompost rate. This might be due to higher availability of nutrients that progressively increase the shoot length of the plant. The maximum shoot length (8.34 cm) was recorded from V_3 treatment, which was statistically similar with V_2 and V_1 treatment. On the other hand, the minimum shoot length (7.56 cm) was found in V_0 (vermicompost controlled condition) treatment.

4.16.3 Combined effect of plant density and vermicompost

The interaction effect of plant density and vermicompost was significant on shoot length of coriander (Table 14). The highest shoot length (8.80 cm) was recorded from the combination (P_2V_3) treatment whereas, the lowest shoot length (7.30 cm) was recorded from P_3V_0 treatment.

Table 13. Effect of plant density and vemicompost on shoot and root length of coriander

Treatments	Root length (cm)	Shoot length (cm)
Plant density		
P_1	5.87±0.71 ^{ab}	8.18±0.77
P_2	6.01±72 ^{a}	8.32±0.71
P_3	5.38±0.71 ^{b}	7.68±0.56
Level of significance	*	**NS**
Vermicompost		
V_0	5.25±0.89 ^{b}	7.56±0.78 ^{b}
V_1	5.86±0.67 ^{ab}	8.17± 0.79 ^{ab}
V_2	5.87±0.68 ^{ab}	8.18±0.44 ^{ab}
V_3	6.04±0.55 ^{a}	8.34±0.68 ^{a}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

P_1: 20 plants/m^2

P_2: 40 plants/m^2

P_3: 80 plants/m^2

V_0: 0 t/ha

V_1: 5 t/ha

V_2: 10 t/ha

V_3: 15 t/ha

Table 14. Combined effect of plant density and vermicompost on shoot and root length of coriander

Treatments	Root length (cm)	Shoot length (cm)
P_1V_0	5.50±0.58 ^{ab}	7.80±0.57 ^{ab}
P_1V_1	5.96±0.57 ^{ab}	8.27±0.56 ^{ab}
P_1V_2	6.00±0.28 ^{ab}	8.30±0.14 ^{ab}
P_1V_3	6.05±0.29 ^{ab}	8.35±0.57 ^{ab}
P_2V_0	5.25±0.57 ^{ab}	7.58±0.28 ^{ab}
P_2V_1	6.14±0.28 ^{ab}	8.46±0.58 ^{ab}
P_2V_2	6.15±0.29 ^{ab}	8.45±0.17 ^{ab}
P_2V_3	6.50±0.14 ^{a}	8.80±0.29 ^{a}
P_3V_0	5.00±0.56 ^{b}	7.30±0.57 ^{b}
P_3V_1	5.48±0.29 ^{ab}	7.78±0.23 ^{ab}
P_3V_2	5.47±0.57 ^{ab}	7.77±0.29 ^{ab}
P_3V_3	5.57±0.27 ^{ab}	7.88±0.06 ^{ab}
Level of significance	*	*

The data represent the mean value ± standard error. Different letter(s) corresponds to significant difference at $P \leq 0.05$ by Duncan's Multiple Range tests.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka to examine the effect of vermicompost levels and plant density on yield and yield components of coriander (*Coriandrum sativum* L.). The experiment consisted of four levels of vermicompost viz. 0, 5, 10 and 15 t ha^{-1} and three different plant densities viz. 20, 40 and 80 plant m^2. The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. There were 12 treatment combinations in all. The variety BARI Dhonia 1 was used for the experiment.

Data on different growth and yield parameters such as plant height, number of primary branches per plant, number of umbel per plant, number of umbellate per umbel, number of seed per plant, 1000 seed weight, seed yield per plot, electric conductivity, germination percentage, shoot and root length of seedling were recorded and analyzed statistically.

Different growth, yield parameters and seed quality were significantly influenced by different plant density. The tallest plant (81.81 cm) was obtained from P_2 (40 plants/m^2) treatment, while the shortest plant (71.25 cm) was obtained from P_1 (20 plants/m^2) treatment. The maximum and minimum number of primary branches per plant (6.95) and (3.72) was obtained from P_2 and P_3 treatment, respectively. The maximum and minimum number of umbels per plant (43.91) and (35.81) was obtained from P_2 and P_3 treatment, respectively. The highest and lowest umbel circumference (19.77 cm and 16.37 cm) was recorded in P_2 and P_3 treatment, respectively. The maximum and minimum number of umbellate per umbel (7.64 and 7.19) and maximum and minimum thousand seeds weight (8.60 g and 7.50 g) was recorded in P_2 and P_1, respectively. The maximum and minimum number of seeds per plant (543.42 and 286.66), highest and lowest dry seed yield per plant (6.51 g and 4.08 g) was obtained from P_1 and P_3 treatment, respectively. The highest and lowest dry seed weight per plot (266.65 g and 137.72 g), highest and lowest dry seed yield per hectare (2.66 t and 1.37 t), highest and lowest stover yield per plot (318.11 g and 166.30 g) and highest and lowest EC test value (11.35 mS cm^{-1} and 7.37 mS cm^{-1}) was found in P_3 and P_1 treatment, respectively. The maximum and minimum germination percentage (77.33 % and 61.33 %), highest and lowest root length (6.01 cm and 5.38 cm) and shoot length (8.32 cm and 7.68 cm) was found from P_2 and P_3 treatment, respectively.

Different growth, yield parameters and seed quality were significantly influenced by different levels of vermicompost. The tallest plant (83.22 cm) was obtained from V_3 (15 t ha^{-1}) treatment, while the shortest plant (72.16 cm) was obtained from V_0 (vermicompost controlled condition) treatment. The maximum and minimum number of primary branches per plant (6.93) and (3.21) was obtained from V_3 and V_0 treatment, respectively. The maximum and minimum number of umbels per plant (45.49) and (35.66) was obtained from V_3 and V_0 treatment, respectively. The highest and lowest umbel circumference (20.02 cm and 16.00 cm), maximum and minimum number of umbellate per umbel (8.01 and 6.73), maximum and minimum number of seeds per plant (557.90 and 232.22), highest and lowest dry seed yield per plant (6.90 g and 3.95 g), highest and lowest dry seed weight per plot (271.39 g and 128.84 g), highest and lowest dry seed yield per hectare (2.71 t and 1.28 t), maximum and minimum thousand seeds weight (8.90 g and 7.51 g), highest and lowest stover yield per plot (330.49 g and 157.65 g), maximum and minimum germination percentage (78.66 % and 58.66 %), highest and lowest root length (6.04 cm and 5.86 cm) and shoot length (8.34 cm and 7.56 cm) was recorded in V_3 and V_0 treatment, respectively. The highest and lowest EC test value (11.13 mS cm^{-1} and 7.00 mS cm^{-1}) was found in V_0 and V_3 treatment, respectively.

Different growth, yield parameters and seed quality were significantly influenced by combined effect of plant density and vermicompost application. The tallest plant (87.21 cm) was obtained from the treatment combination P_2V_3 (40 plant/m^2 with 15 t/ha vermicompost), while the shortest plant (65.01 cm) was obtained from the treatment combination P_1V_0 (20 plant/m^2 with no vermicompost). The maximum and minimum number of primary branches per plant (8.31) and (1.60) was obtained from P_2V_3 and P_1V_0 treatment, respectively. The maximum and minimum number of primary branches per plant (50.19) and (29.50) was obtained from P_2V_3 and P_1V_0 treatment, respectively. The highest and lowest umbel circumference (21.80 cm and 13.22 cm), maximum and minimum number of umbellate per umbel (8.16 and 6.26), maximum and minimum thousand seeds weight (9.19 g and 6.80 g) and maximum and minimum germination percentage (85.33 % and 57.33 %) was recorded in P_2V_3 and P_1V_0 treatment, respectively. The maximum and minimum number of seeds per plant (665.02 and 136.65), highest and lowest root length (6.50 cm and 5.00 cm) and shoot length (8.80 cm and 7.30 cm) was obtained from P_2V_3 and P_3V_0 treatment, respectively. The highest and lowest dry seed weight per plant (8.36 g and 3.07 g) obtained from P_1V_3 and P_3V_0 treatment combination, respectively. The highest and lowest dry seed weight per plot (333.80 g and 50.91 g), highest and lowest dry seed yield per hectare (3.33 t and 0.50 t), highest and lowest stover yield per plot (410.69 g and 95.65 g) was obtained from P_3V_3 and P_1V_0 treatment, respectively. The highest and lowest EC test value (13.00 mS cm^{-1} and 4.02 mS cm^{-1}) was found in P_3V_0 and P_2V_3 treatment, respectively.

Based on the experimental results, it may be concluded that-

i. Plant density had a positive effect on morphological characters, yield contributing characters, yield and seed quality of coriander. 80 plant m^2 (25 × 5 cm) plant density seemed to be more promising for getting higher yield, but 40 plant m^2 (25 × 10 cm) plant density seemed to be more promising for getting quality seed production.

ii. Vermicompost had a positive effect on morphological characters, yield contributing characters, yield and seed quality in coriander. Application of 15 t ha^{-1} of vermicompost seemed to be suitable for higher yield and seed production, and

iii. The combined effect of plant density and vermicompost application had positive effect on morphological characters, yield contributing characters, yield and seed quality in coriander. Application of 15 t ha^{-1} of vermicompost with 80 plants m^{-2} combination seemed to be more suitable for getting higher yield, but application of 15 t ha^{-1} of vermicompost with 40 plants m^{-2} combination seemed to be more suitable for getting quality seed production of coriander.

iv. Application of 15 t/ha vermicompost in combination with 80 plant/m^2 was suitable for getting higher yield and application of 15 t/ha vermicompost in combination with 40 plant/m^2 was suitable for getting quality seed production of coriander.

RECCOMENDATION

- The study might be conducted at the same Agro Ecological Condition for the conformation of the result.
- Further study should be needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

CHAPTER VI

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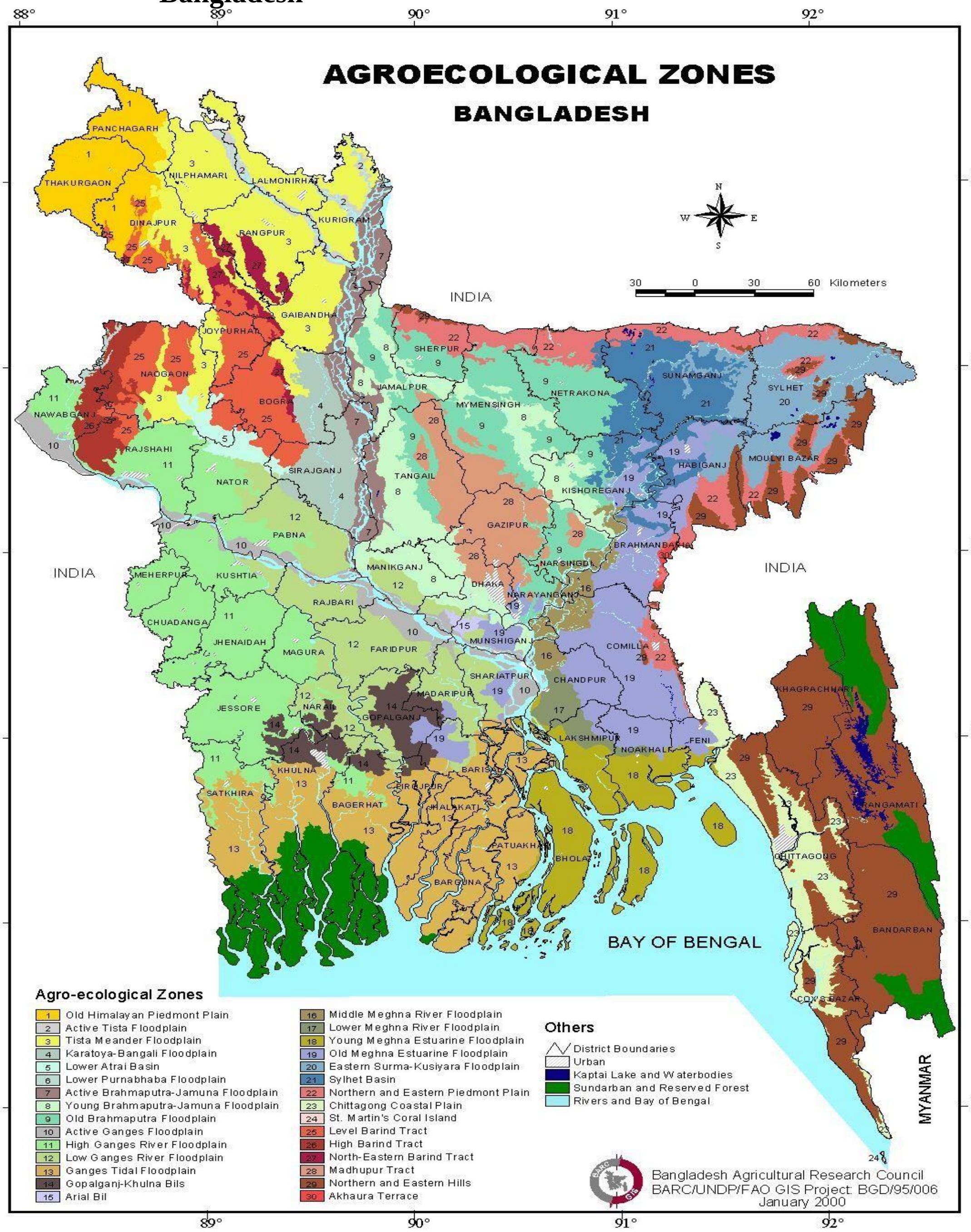
CHAPTER VII

APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Monthly recorded the average air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from October 2018 to March 2019

Month	Air temperature (^{0}C)		Relative humidity (%)	Total rainfall(mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2018	27.3	16.2	71	17.2	5.7
November, 2018	26.9	15.3	69	14.3	5.8
December, 2018	26.4	14.1	69	12.8	5.5
January, 2019	25.4	12.7	68	7.7	5.6
February, 2019	28.1	15.5	68	28.9	5.5
March, 2019	28.2	15.9	69	30.3	5.6

Source: Sher-e-Bangla Agricultural University Weather Station and Bangladesh Meteorological Department.

Appendix III. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Constituents	Percent
Sand	26
Silt	45
Clay	29
Textural class	Silty clay

Chemical composition:

Soil characters	Value
Organic carbon (%)	0.45
Organic matter (%)	0.54
Total nitrogen (%)	0.027
Phosphorus	6.3 μg/g soil
Sulphur	8.42 μg/g soil
Magnesium	1.17 meq/100 g soil
Boron	0.88 μg/g soil
Copper	1.64 μg/g soil
Zinc	1.54 μg/g soil
Potassium	0.10 meg/100g soil

Appendix IV. Analysis of variance (mean square) of plant height at bolting, number of primary branches per plant, number of umbels per plant of coriander

Source of Variation	df	Mean Square of		
		Plant height at bolting	Number of primary branches per plant	Number of umbels per plant
Vermicompost	3	192.469***	24.329***	152.510***
Plant density	2	385.050***	31.253***	196.712***
Combination	11	1352.591***	12.732***	83.784***
Replication	2	1.898	.000	.000
Error	17	1.731	.366	5.199
Total	35			

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix V. Analysis of variance (mean square) of umble circumference, number of umbellates per umble, number of seed per plant of coriander

Source of Variation	df	Mean Square of		
		Umble circumference	Number of umbellates per umble	Number of seed per plant
Vermicompost	3	28.490**	3.173***	197020.562***
Plant density	2	35.608**	.795NS	235779.624***
Combination	11	16.066**	1.037**	104647.515***
Replication	2	.030	.004	2953.229
Error	17	2.137	.023	2658.038
Total	35			

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix VI. Analysis of variance (mean square) of dry seed yield per plant, dry seed yield per plot, dry seed yield per hectare of coriander

Source of Variation	df	Mean Square of		
		Dry seed yield per plant	Dry seed yield per plot	Dry seed yield per hectare
Vermicompost	3	15.737***	33579.424***	3.368***
Plant density	2	18.107**	51663.292***	5.189***
Combination	11	8.429***	18984.344***	1.904***
Replication	2	.220	2.111	.000
Error	17	1.335	87.137	.009
Total	35			

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix VII. Analysis of variance (mean square) of 1000 seed weight, stover yield per plot, stover yield per hectare of coriander

Source of Variation	df	Mean Square of		
		1000 seed weight	Stover yield per plot	Stover yield per hectare
Vermicompost	3	3.200*	13240.632***	4.492***
Plant density	2	4.081*	14863.221***	6.914***
Combination	11	1.713*	7088.673***	2.538***
Replication	2	3.000	321.028	.001
Error	17	1.027	299.436	0.012
Total	35			

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix VIII. Analysis of variance (mean square) of electric condructrivity, germination percentage, root length of coriander

Source of Variation	df	Mean Square of		
		Electric condructrivity	Germination percentage	Root length
Vermicompost	3	26.735***	694.963***	1.086*
Plant density	2	47.733***	868.000***	1.313*
Combination	11	16.601***	368.606***	.579*
Replication	2	.110	64.000	4.380
Error	17	.577	6.222	.547
Total	35			

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix IX. Analysis of variance (mean square) of Shoot length of coriander

Source of Variation	Df	Mean Square of
		Shoot length
Vermicompost	3	1.068385.050*
Plant density	2	1.343NS
Combination	11	.576*
Replication	2	3.559
Error	17	.504
Total	35	

NS Indicates non-significant
*indicates significant at <5% level of probability
**indicates significant at 1% level of probability
***indicates significant at <1% level of probability

Appendix X: Experimental activities and photographs