EFFECT OF NITROGEN LEVELS AND PLANT DENSITY ON SEED YIELD AND YIELD COMPONENTS OF CORIANDER (*Coriandrum sativum* L.)

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF NITROGEN LEVELS AND PLANT DENSITY ON SEED YIELD AND YIELD COMPONENTS OF CORIANDER (*Coriandrum sativum* L.)"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRICULTURAL BOTANY,** embodies the result of a piece of bona fide research work carried out by **SHYAMAL CHANDRA SARKER, Registration No. 08-03088** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated: June, 2015
Dhaka, Bangladesh

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DEDICATED TO
MY
BELOVED PARENTS

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The Author

FFECT OF NITROGEN LEVELS AND PLANT DENSITY ON YIELD AND YIELD COMPONENTS OF CORIANDER (*Coriandrum sativum* L.*)*

ABSTRACT

A field experiment was conducted at the farm of Sher- E- Bangla Agricultural University, Dhaka from November 2014 to February 2015 to find out the optimum nitrogen levels and suitable plant density for higher yield of coriander. The experiment consists of four levels of nitrogen viz. 0, 40, 80 and 120 kg N ha^{-1} and three plants densities viz. 500×10^3, 400×10^3 and 333×10^3 plants ha^{-1} as maintained by 20× 10, 25 ×10 and 30× 10 cm spacing. The experiment was laid out in a randomized complete block design. Nitrogen and plant density independently as well as in combination had significant effect on most of the characters studied. The tallest plant and maximum number of leaves $plant^{-1}$ were recorded at 120 kg N ha^{-1} followed by 80 kg N ha^{-1} at different growth stages. Application of 120 kg N ha^{-1} gave the maximum primary and secondary branches $plant^{-1}$, umbellates $umbel^{-1}$, seed $plant^{-1}$, 1000 seed weight, seed yield $plot^{-1}$ and seed yield (1.46 ton ha^{-1}). Application of 80 kg N ha^{-1} produced identical results in respect of primary and secondary branches $plant^{-1}$, umbellates umbel-$^{-1}$, seed $plant^{-1}$, and 1000 seed weight. The highest plant height, seed yield (1.27 ton ha^{-1}) was recorded from 333×10^3 plants ha^{-1}. Application of 120 kg N ha^{-1} coupled with 333×10^3 plants ha^{-1} gave the maximum seed yield of 1.5 ton ha^{-1} closely followed by 400×10^3 plants ha^{-1} at the same nitrogen dose.

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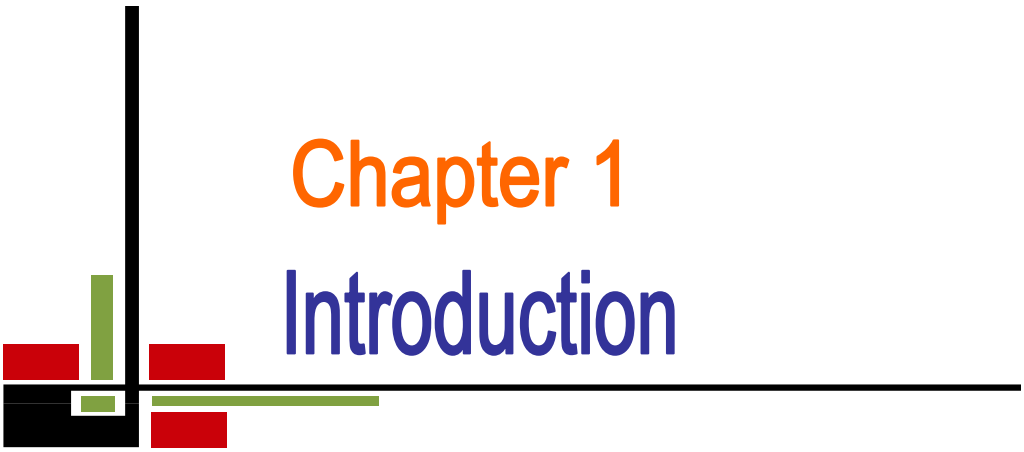
LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^0C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance



Chapter 1
Introduction

CHAPTER I

INTRODUCTION

Coriander (*Coriandrum sativum* L.) belonging to the family*Apiaceae*is an important spice cropgrown in *rabi* season throughout Bangladeshand it is known as ‘dhonia’. The young plant of corianderis used as appetizer in preparing fresh chutneys and sauces and leaves are usedto flavour food, curries, soups, fish sauce, etc. and seeds are used in cakes,soups, sausage, pickles, curries, etc. (Janardhanan and Thoppil, 2004; Tiwary andAgarwal, 2004).

Coriander is a herbal plant used in many industries, including the manufacture of pharmaceuticals, food and cosmetics. The plant material used for processing by the herbal industry is the fruit (*Fructus Coriandri*) and essential oil (*Oleum Coriandri*) extracted from coriander fruit (Bourdock and Carabin, 2009). Coriander fruits are useful for processing because of their rich chemical composition as well as the rich taste and aroma. Coriander fruits owe their flavour mainly to essential oil, which contains many volatile compounds, such as linalool, geraniol, α-pinene and others [Diederichsen, 1996, Weiss, 2002]. Coriander oil also possesses medicinal properties, as: antibacterial, anti-fungal or anti-oxidant properties [Singh *et al.*, 2006; Matasyoh *et al*., 2009; Asgarpanah and Kazemivash, 2012].

Of all mineral nutrients, nitrogen has the most profound influence on agricultural and biological traits of plants (Rumińska, 1983). This element is the basic

component of protoplasm. It plays an important role in the synthesis of many chemical compounds (including proteins and enzymes), which translates into the processes involved in the growth and development of plants (Podsiadło, 2005; Carrubba, 2009; Khan *et al*., 2012; Khalid, 2013). Nitrogen deficit in soil leads to retarded growth and loss of weight of plant aerial organs as well as premature ripeness of plants (Oliveira *et al*., 2003). Excess nitrogen causes abundant growth of vegetative organs to the detriment of generative ones (Oliveira *et al*., 2003; Carrubba, 2009) makes plants more vulnerable to lodging and diseases, prolongs the period of vegetation and delays maturity and harvest (Ebert, 1982). In short, a proper course of onthogenesis depends on nitrogen, which functions as a limiting factor of agricultural yields (Okut and Yidirim, 2005, Rzekanowski *et al*., 2007;Khalid, 2013).

Coriander does not have a high demand for nitrogen (Rumińska, 1983) although it responds to nitrogen fertilization with higher fruit yields (Oliveira *et al*; 2006; Rzekanowski *et al*., 2007; Kumar *et al.*, 2008; Carrubba, 2009). To produce 1 t of fruit, coriander takes up about 33 kg N from soil (Carrubba 2009). Experimental research has proven that optimal doses of nitrogen, ensuring the best coriander yields, are within 20 to 90 kg N ha^{-1} (Luayza *et al*., 1996; Okut and Yidirim 2005, Oliveira *et al*., 2006; Rzekanowski *et al*., 2007; Tehlan and Thakral, 2008 and Kumar italic., 2008). Differences in nitrogen fertilization and coriander yields may stem from the geographical origin of this plant and its adaptation to warm and dry climates. In moderate climatic conditions, the uptake

of nitrogen from soil and its effective use to produce yields can be modified by different thermal and moisture conditions.

Plant density per unit are important in terms of the number of fruits 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).

The applied nitrogen rate and plant density are two important parameters influencing the yield of medicinal plants. Das *et al.,* 1991 studied the effect of nitrogen fertilization on coriander and concluded that increased plant height and branch number per main stem with 40 kg N ha^{-1} application. Rahimi *et al*., 2009; stated that nitrogen application had significant and positive effect on plant height and branch number per main stem. Also, in another study Oliver *et al*., 2003 found that the highest of plant height observed in 80 kg N ha^{-1} application treatment which was 17.4% greater as compared with no nitrogen application treatment. In studies of some researchers reported that with increasing of nitrogen application increased essential oil percent of coriander (Gulen, 1995; Yalcintas, 1995; Bhati, 1988).

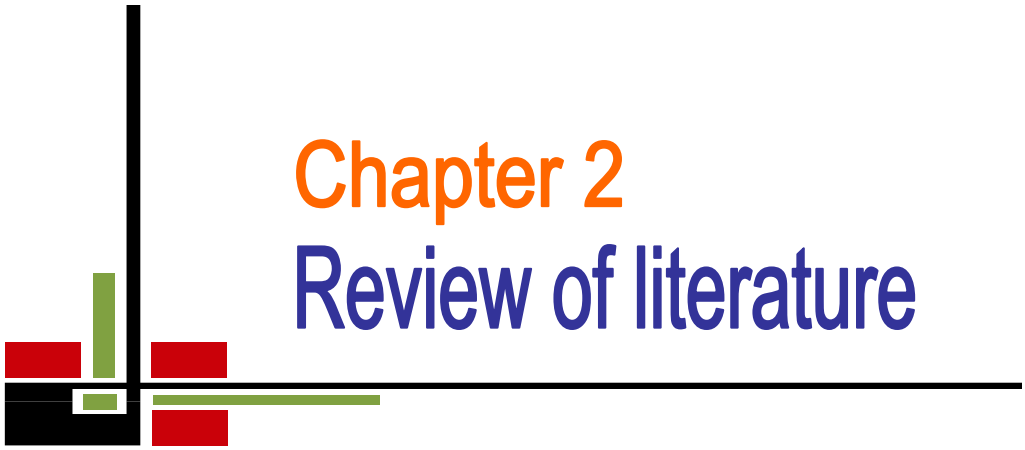
Akbarinia *et al.* (2006) in a study the effect of nitrogen rates and plant densities on fruit yield, essential oil percent and yield of coriander fruits concluded that the highest fruit yield was obtained by using 60 kg Nha^{-1} while the highest

essential oil percent and yield were obtained with 90 kg Nha^{-1} application. Moreover, they stated that fruit and essential oil yield were higher in 30 $plantsm^{-2}$ densities, while essential oil percent was higher in 30 and 40 $plantsm^{-2}$ densities. Nevertheless, Ghobadi and Ghobadi (2010) and Dierchesen (1996) reported the highest fruit yield of coriander at density 50 $plantsm^{-2}$.

Keeping the above facts in view,the present study was undertaken to investigate the effect of different levels of nitrogen and plant density on coriander with the following objectives:

1. To determine the suitable nitrogen dose for higher seed yield of coriander.

2. To find out the optimum plant density for higher coriander seed yield.



Chapter 2
Review of literature

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 chemical fertilizers play an important role on its growth, yield and quality. Nitrogen is one of the major important macronutrients which are responsible for controlling growth and yield of coriander. A number of research works have been done on different levels of nitrogen and plant density on the yield of coriander in various parts of the world, which had been made in this regard in Bangladesh. The present study has been taken to investigate effect of nitrogen levels and plant density on yield and yield components of coriander (*Coriandrum sativum L.*). In this chapter an attempt had been made to collect related research findings of the present study.

2.1 Effect of nitrogen level on growth and yield of coriander

Szempliński and Nowak (2015) conducted an experiment during 2006–2008, in a random block design with four replications. The experimental factor was nitrogen fertilization in doses of 20, 40, 60, 80 and 100 kg N ha^{-1} and a control treatment (no nitrogen fertilization). The objective was to determine the effect of

nitrogen fertilization on the yield and quality of coriander herbal material (fruit). The experimental results showed that the weather conditions during the research determined the morphological traits and yield components as well as the volume of unprocessed herbal material obtained from coriander plants. The yield of coriander fruit was significantly higher in the season with high precipitations than in the other two years with lower precipitations. The respective differences were 44 and 32%. Nitrogen fertilization did not differentiate the number of plants per plot surface area, weight of fruits per plant or 1000 fruit weight, meaning that the fruit yields were not differentiated. However, a significant relationship has been shown between coriander yields and nitrogen fertilization in the years of the experiment. The experiment evidenced that the chemical composition of coriander fruits was more strongly determined by the weather conditions during the growing season than by nitrogen fertilization. A higher content of essential oil in fruit (1.50%) was obtained by coriander growing under drier weather; when the growing season was much wetter, the content of essential oil was much lower (1.07%). The major component of coriander oil was linalool, which made up 67.4% of the chemical profile. Nitrogen fertilization did not differentiate the chemical profile of coriander essential oil.

Lokhande *et al*. (2015)conducted during *rabi* season at Panjabrao Krishi Vidyapeeth, Akola (Maharashtra), India. The experiment comprising sixteen treatments of different nitrogen and phosphorus levels was laid in factorial randomized block design with three replications. The maximum plant height,

number of branches per plant, days for first flowering, days for 50% flowering, flesh and dry biomass weight, days required for harvesting, number of umbels per plant, seed yield, germination percent of primary and secondary umbels were recorded with 60 kg nitrogen and 30 kg phosphorus followed by 30 kg nitrogen and 45 kg phosphorus as compared to control without application of fertilizers. Higher dose 30 kg nitrogen and 45 kg P_2O_5 per hectare of both the fertilizers had no effect in increasing the seed yield.

Moniruzzaman and Rahman, (2015) conducted an experiment at BSMRAU farm, Gazipur to evaluate the effects of four nitrogen levels (0, 40, 80 and 120 $kgha^{-1}$) and four levels of leaf cutting (no cutting, one cutting at 30 DAS), two cuttings at 30 & 45 DAS and three cuttings at 30, 45 & 60 DAS) on three genotypes of coriander (*Coriandrum sativum* L.) (CS001, CS002 and CS003). The genotype CS003 produced the highest foliage yield (8.92 t ha^{-1}) and the genotype CS001 gave the highest seed yield (0.93 t ha^{-1}). The maximum seed yields was obtained from the N application at 80 kg Nha^{-1}. The 80 kg N ha^{-1}coupled with three cuttings gave the top most foliage yield while the same rate accompanied with one cutting gave the top most seed yield for all genotypes.

Yousuf *et al.* (2014) conducted an experiment at the Spices Research Centre, Shibgonj, Bogra, Bangladesh during the rabi seasons of 2008-2009 and 2009-2010 to determine the requirement of N, P, K, and S of coriander (BARI Corinader 1) for achieving satisfactory seed yield of this crop. Different levels of

nitrogen (0, 40, 70, and 100 kg ha^{-1}), phosphorus (0, 25, 50, and 70 $kgha^{-1}$), potassium (0, 30, 60, and 90 $kgha^{-1}$), and sulphur (0, 10, 20, and 30 $kgha^{-1}$) were distributed in the plot. The experiment was tested in randomized complete block design with three replications. There was positive impact of application of those nutrients on the yield and yield contributing characters of coriander up to a moderate level of $N_{70}P_{50}k_{30}S_{20}$ $kgha^{-1}$. The highest seed yield (2.06 tha^{-1} in 2008-2009 and 2.09 t ha^{-1} in 2009-2010) was obtained with this moderate application of N, P, K, and S (70, 50, 30, and 20$kgha^{-1}$, respectively) and yield was declined with higher doses of these elements. The fertilizer treatment$N_{70}P_{50}k_{30}S_{20}$ $kgha^{-1}$was observed to bethe best suitable dose for coriander cultivation on Grey Terrace Soil of Amnura Soil Series under AEZ-25(Level Barind Tract) of Bangladesh.

Patel *et al*. (2013)conducted on loamy sand soil of Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *rabi* season of 2009-10 to investigate effect of varying levels of nitrogen and sulphur on growth and yield of coriander (*Coriandrum sativum* L.). Sixteen treatment combinations consisting of four levels each of nitrogen (20, 40, 60 and 80 kg Nha^{-1}) and sulphur (0, 10, 20 and 30 kg S ha^{-1}) replicated four times. Among the levels of nitrogen @ 80 kg ha^{-1} showed its producing highest seed yield (1203 kg ha^{-1}) and straw yield (1596 kg ha^{-1}). The highest performance is attributed to significant improvement in growth and yields parameters *viz.*, plant height, number of branches $plant^{-1}$, number of umbels $plant^{-1}$, number of

umbellate umbel^{-1}, number of seeds umbellate^{-1}, test weight (g) and seed weight plant^{-1} (g). Similarly application of nitrogen @ 80 kg ha^{-1} recorded highest quality parameters (protein content, volatile oil content and total oil yield) and uptake of nitrogen and sulphur . Among the levels of sulphur @ 30 kg ha^{-1} recorded significantly higher seed yield (1184 kg ha^{-1}) and straw yield (1577 kg ha^{-1}). Sulphur application @ 30 kg ha^{-1} significant improvement in growth and yield parameters *viz.*, number of branches plant^{-1}, number of umbels plant^{-1}, test weight (g) and seed weight plant^{-1} (g). Application of sulphur @ 30 kg ha^{-1} also showed positive effect on protein, volatile oil content and total oil yield as well as uptake of nitrogen and sulphur.

Nowak and Szempliński (2011) conducted an experiment during in 2006-2008 to evaluate the effect of nitrogen and boron fertilization on the morphometric features and yield of coriander. The research showed significant positive effect of increasing nitrogen fertilization on stem length, number of side branchings, inflorescences and fruit number per plant and negative effect on side branching height. With increasing nitrogen fertilization fruit number and fruit yield per coriander plant were higher, and the maximum yield was obtained at the highest nitrogen rate. Coriander reacted to increasing nitrogen rates with an increase of fruit yield per plant, however at the same time decrease of the weight of 1000 fruits was observed, mainly as a result of formation of a greater number of them. In the research, boron fertilization did not differentiate morphometric features or the fruit yield of coriander.

Rahimi *et al*. (2009) stated that nitrogen application had significant and positive effect on plant height and branch number per main stem. Also, in another study Oliveira*et al*. (2003) found that the highest of plant height observed in 80 kg Nha^{-1} application treatment which was 17.4% greater as compared with no nitrogen application treatment. In studies of some researchers reported that with increasing of nitrogen application increased essential oil percent of coriander (Gulen, 1995; Yalcintas, 1995; Bhati, 1988).

Das *et al.* (1991) studied the effect of nitrogen fertilization on coriander and concluded that increased plant height and branch number per main stem with 40 kg N ha^{-1} application.

2.2 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 withtwelve 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 hadno significant effect on essential oil percent, but increase in density significantly increased essential oil yield. Also, in study on the impact densities of 20, 25, 40 and 50 $plantm^{-2}$ on chamomile.

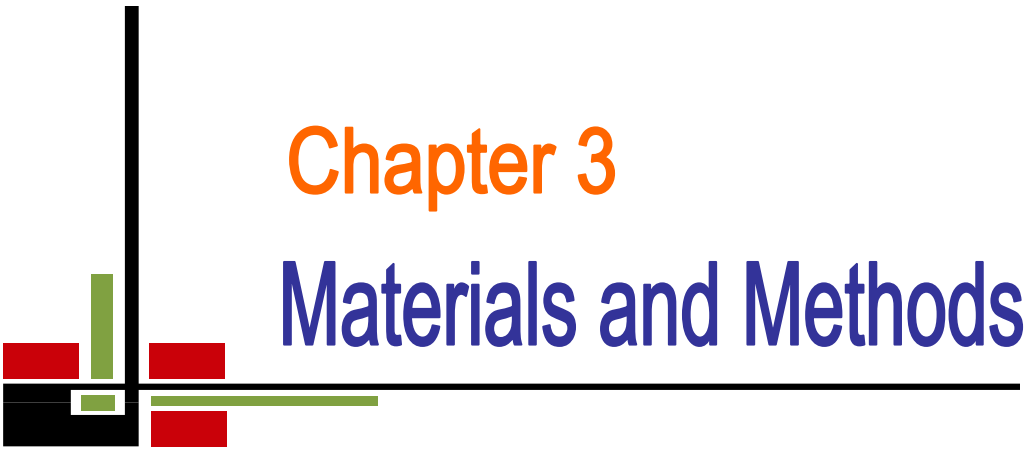
2.3 Combined effect of nitrogen level and plant density on growth and yield of coriander

Pawar *et al*. (2007) conducted an experiment during the *rabi* season of 2003-2004 to study effect of nitrogen rates (50, 75 and 100 $kgha^{-1}$) and spacing on coriander. Application of nitrogen at a rate of 100 $kgha^{-1}$ resulted in the maximum plant height, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant, east-west spread of the plant, fresh weight of plant and yield per hectare.

Moosavi *et al*. (2013) carried out in research field of Islamic Azad University, Birjand Branch, Birjand, Iran in 2010 based on a randomized complete block design with three replications. The main plots were nitrogen rates at four levels (0, 40, 80 and 120 kg N ha^{-1}) and the sub-plots were plant densities at three levels (30, 40 and 50 plants m^{-2}). The results showed that nitrogen rate had

significant effect on fruit yield, essential oil percent and yield traits and interaction between nitrogen rate and plant density only affected fruit yield but change in plant density significantly affected all traits except essential oil percent. Means comparison showed that as N fertilization rate was increased from 0 to 80 kg N ha^{-1}, plant height and fruit yield were increased by 19.8 and 74.1 %, respectively. Moreover, means comparison showed that the increase in plant density from 30 to 50 plants m^{-2}, increased plant height, first fruit distance from ground and fruit respectively. Given the results of the study, the treatment of 80 kg N ha^{-1}application with the density of 50 plants m^{-2}recommended for the cultivation of coriander in Birjand, Iran.

Akbarinia *et al.* (2006), In a study of the effect of nitrogen rates and plant densities on fruit yield, essential oil percent and yield of coriander fruits concluded that the highest fruit yield was obtained by using 60 kg N ha^{-1} while the highest essential oil percent and yield were obtained with 90 kg Nha^{-1} application stated that fruit yield was higher in 30 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}.



Chapter 3

Materials and Methods

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 November 2014 to February 2015 to evaluate the effect of nitrogen levels and plant density on yield and yield components of coriander (*Coriandrum sativum L.*). It is located at $90^{0}22^{'}$ E longitude and 23°4l′ N latitude at an altitude of 8.6 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 Climatic condition

The experimental area is under the sub-tropical climate that is characterized by less rainfall associated with moderately low temperature during rabi season, October-March.

3.3 Soil condition

The soil of experimental area is situated to the Modhupur Tract under the AEZ - 28 and Tejgoan soil series. The soil was sandy loam in texture having pH 5.47 - 5.63. The physical and chemical characteristics of the soil have been presented in Appendix II.

3.4 Crop

Coriander (*Coriandrum sativum* L.) is an annual herb and according to the climatic conditions, is cultivated as a summer or winter annual crop. At flowering, the glabrous plant can reach up to 1.40 m. in height. The germination is epigeal and the plant has a tap root. The stem is more or less erect and sympodial, monochasial-branched, sometimes with several side branches at the basal node. Each branch finishes with an inflorescence. The colour of stem is green and sometimes turns to red or violet during the flowering period. The stem of the adult plant is hollow, and its basal parts can reach a diameter of up to 2 cm. The leaves are alternate, and the first ones are often gathered in a rosette. The inflorescence is a compound umbel. Sometimes there are one or two linear bracts. The umbel has two to eight primary rays, which are of different length, in such a way that the umbellets are located at the same level. Coriander has an inferior ovary and five calyx teeth are of different length, as are the petals in peripherally situated flowers.

3.5 Seed

In this experiment Coriander variety of BARI Dhonia1 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.

3.6 Fertilizers

Manures and fertilizers were applied at the following doses as per Moniruzzman (2011). Fertilizers doses were as follows

Fertilizers	Doses
Cowdung	5 t ha^{-1}
Nitrogen (N)	As per treatment
Phosphorus (P)	11 kg ha^{-1}
Potassium (K)	25 kg ha^{-1}

The entire amount of cowdung, phosphorus from TSP and potassium from MOP with the half of nitrogen was applied during final land preparation. The rest of the nitrogen was applied at 25 days after sowing of seeds as top dress.

3.7 Treatments of the experiment

The experiment consisted of two factors which were as follows

Factor A: 4 Nitrogen doses (N)

N_0 = 0 kg N ha^{-1}

N_1 = 40 kg N ha^{-1}

N_2 = 80 kg N ha^{-1}

N_3= 120 kg N ha^{-1}

Factor B: 3 Plant Spacing

$D_1 = 500\times10^3$ plants ha^{-1}

$D_2 = 400\times10^3$ plants ha^{-1}

$D_3 = 333\times10^3$ plants ha^{-1}

500×10^3 plants ha^{-1}, 400×10^3 plants ha^{-1} and 333×10^3 plants ha^{-1} were maintained following spacing 20cm×10cm, 25cm×10cm and 30cm×10cm respectively.

3.8 Treatment combination

There were 12 treatment combinations of different N doses and plant densities used in the experiment which were as follows:

1. N_0D_1
2. N_0D_2
3. N_0D_3
4. N_1D_1
5. N_1D_2
6. N_1D_3
7. N_2D_1
8. N_2D_2
9. N_2D_3
10. N_3D_1
11. N_3D_2
12. N_3D_3

3.9. Design and layout of the experiment

The experiment consisted of 12 treatment combinations and was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 3 m x 1 m (3.00 m^2). The distance between block to block was 1 m and distance between plots to plot was 0.5m.

3.10. Land preparation

The land was ploughed well with power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were cleaned properly. The final ploughing and land preparation were done on 15 November, 2014. According to the lay out of the experiment the entire experimental area was divided into blocks and subdivided into plot for the sowing of coriander seed. In addition, irrigation and drainage channels were prepared around the plot.

3.11. Sowing of Seed

The seeds (fruits) were for separating the two mericarps and soaked in water for 24 hours to enhance germination. Seeds were also treated Bavistin at the rate of 2g per kg of seeds before sowing. Sowing was done on 20 November, 2014 in rows as per treatments. Seeds were sown continuously in rows at the rate of 40 kg ha^{-1}. After sowing the seeds were covered with soil and slightly pressed by hand.

3.12 Thinning and weeding

The optimum plant population was maintained by thinning excess number of plants from the rows at 15 days after sowing (DAS) maintaining 10 cm distance between plants. Proper plants densities 500×10^3 plants ha^{-1}, 400×10^3 plants ha^{-1} and 333×10^3 plants ha^{-1} were maintained following spacing 20cm×10cm, 25cm×10cm and 30cm×10cm, respectively.

3.13 Irrigation

Two irrigations were given as plants required. First irrigation was given immediately after topdressing and second irrigation were applied 60 DAS. After irrigation when the plots were in zoe condition, spading was done uniformly and carefully to conserve the soil moisture.

3.14 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.

3.15 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 February 15 and completed on February 28, 2015. 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.

3.16 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 kg ha^{-1}.

3.17 Data collection

Ten plants from each plot were selected as random and were tagged for the data collection. Some data were collected from sowing to harvesting with 20 days interval and some 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:

1. Plant height (cm) at different growth stages (from 30 DAS to 70 DAS)
2. No. of leaves per plant at different growth stages (from 30 DAS to 70 DAS)
3. Number of primary branches per plant
4. Number of secondary branches per plant
5. Number of umbels per plant
6. Number of seed per umbel
7. Number of seed per plant
8. 1000 seed weight (g)
9. Seed yield per plot (g)
10. Seed yield (kg ha^{-1})

3.16.1 Plant height (cm)

Plant height was measured three times at 30, 50 and 70 after sowing(DAS). 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.

3.16.2 Number of leaves per plant

Number of leaves per plant was counted three times at 20 days interval such as 30, 50 and 70 DAS of coriander plants. Mean values of data were calculated and recorded.

3.16.3 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.

3.16.4 Number of secondary branches per plant

The number of secondary branches per plant was counted at harvest of coriander plants.

3.16.5 Number of umbel per plant

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

3.16.6 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.

3.16.7 Number of seeds per plant

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

3.16.8 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.

3.16.9 Seed weight per plot (g)

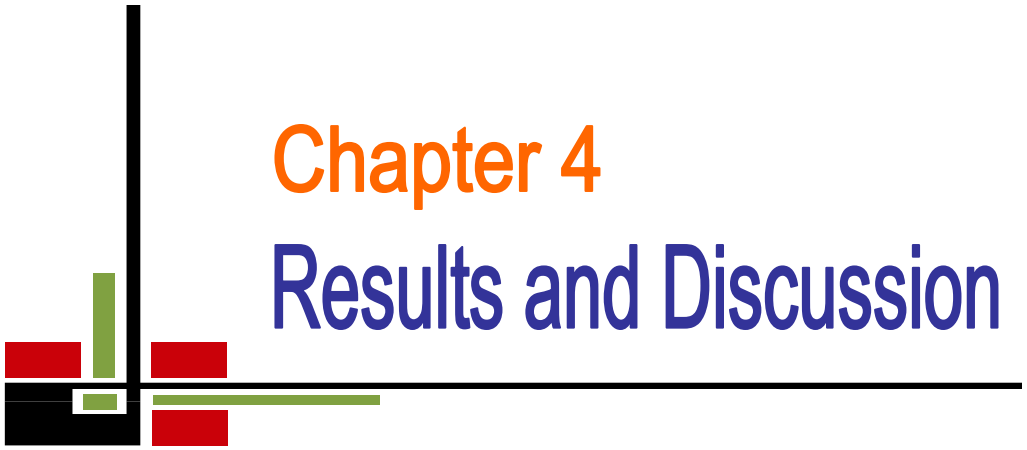
The separated seeds of plot were collected, cleaned, dried and weighed properly. The seed weight per plot was then recorded in gram.

3.16.10 Yield t ha^{-1}

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

3.17 Data analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and mean separation were done by Least Significance Difference (LSD) test.



Chapter 4

Results and Discussion

Chapter IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the potentiality of producing coriander as influenced by different nitrogen levels and plant densities. Data of the different parameters were analyzed statistically and the results was 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

The plant height recorded at 30, 50 and 70 days after sowing (DAS) varied significantly due to application of nitrogen application (Fig.1. During the period of plant growth the maximum plant height (13.62, 30.56, and 76.78 cm at 30, 50 and 70 DAS, respectively) was observed in N_3 (120 kg Nha^{-1}) treatment. On the other hand the shortest plant height (9.98, 24.00 and 50.33 cm at 30, 50 and 70 DAS, respectively) was observed in N_0 (control) treatment. It is clear that all N levels maintained a lead over control with regard to plant height. It is also observed that plant height increased with the increase of nitrogen doses. This corroborates the results of Moniruzzaman and Rahaman (2015), Szemplinski and Nawak(2015) obtained the maximum plant height at 100 kg N ha^{-1}.

The plant height of coriander was not significantly influenced by different plant spacing at 30, 50 and 70 DAS (Fig.2). During the period of plant growth the tallest plant (11.82, 27.5 and 65.75 cm at 30, 50 and 70 DAS, respectively) was observed in D_1 treatment and minimum (11.53, 25, and 57.42 cm at 30, 50 and 70 DAS, respectively) in D_3 treatment (Fig.2). The results showed that maximum plant density (D_1) gave higher plant height while minimum plant density (D_3)gave lower plant height. This might be due to the highest plant population per unit area which compete for light which helps to elongate plan. Moniruzzaman (2011) reported similar findings from the closest spacing i.e. higher plant population.

The plant height was significantly influenced by the interaction effect of nitrogen plant density (Table 1). The tallest plant (14.03, 36.00 and 87.00 cm at 30, 50 and 70 DAS, respectively) was found from the application120 kg N ha^{-1} with the maximum plant density (N_3D_1)and the lowest (9.30, 22.00 and 46.00 cm at 30, 50 and 70 DAS, respectively) from no nitrogen application with lower plant population (N_0D_3). At 30 DAS and 50 DAS there was no significant difference observed between N_3D_1 and N_3D_3 in respect of plant height. At 70 DAS indicate plant height was recorded in N_2D_3, N_3D_1 and N_3D_2.

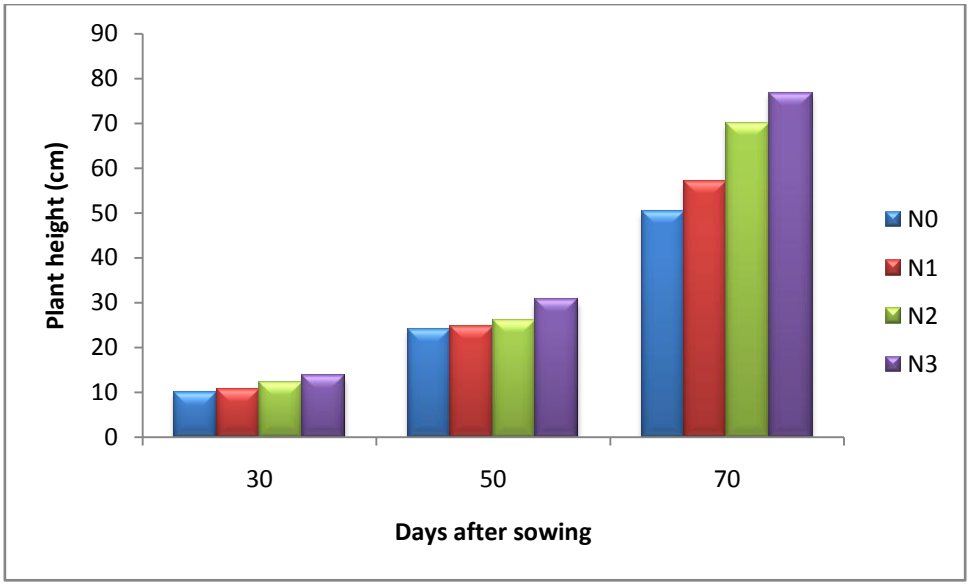


Fig. 1. Effect of nitrogen on plant height of coriander at different days after sowing. N_0= 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1})

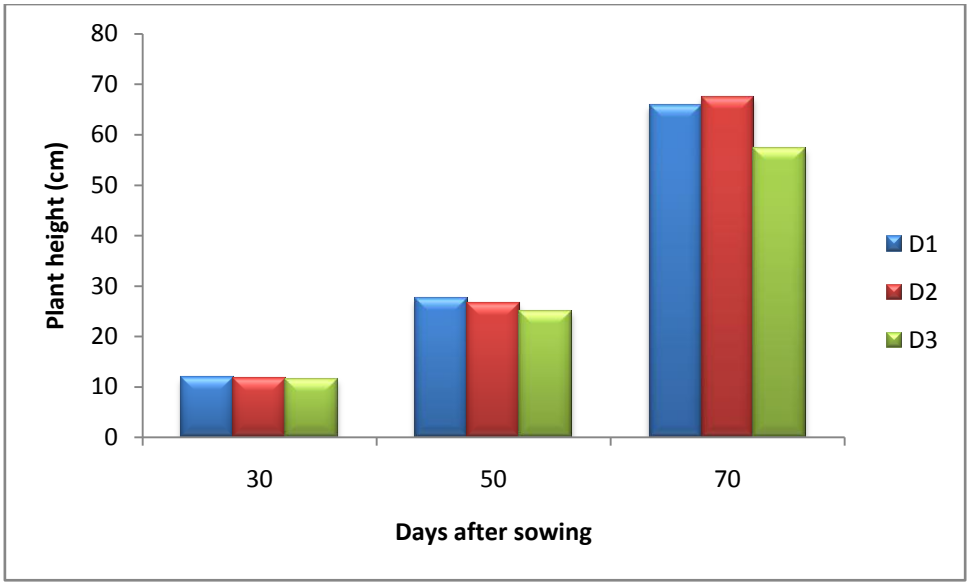


Fig. 2. Effect of plant densities on plant height of Coriander at different days after sowing. D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

Table 1. Combined effect of nitrogen and plant density on plant height of Coriander at different growth stages

Treatment	Plant height (cm)		
	30 DAS	50 DAS	70 DAS
N_0D_1	10.63 cdefg	26.67 bcd	46.33 d
N_0D_2	10.00 fg	23.33 cd	51.33 d
N_0D_3	9.30 g	22.00 d	46.00 d
N_1D_1	10.50 defg	22.67 d	63.00 bcd
N_1D_2	11.40 bcdef	24.33 cd	61.67 cd
N_1D_3	10.43 efg	26.67 bcd	53.33 d
N_2D_1	12.30 bc	24.67 cd	59.67 cd
N_2D_2	12.00 bcde	23.00 cd	72.67 abc
N_2D_3	12.20 bcd	31.00 ab	78.00 ab
N_3D_1	14.03 a	36.00 a	87.00 a
N_3D_2	12.83 ab	29.33 bc	84.00 a
N_3D_3	14.00 a	26.33 bcd	59.33 cd
$LSD_{(0.05)}$	1.56	5.54	15.04
CV (%)	7.92	12.43	13.98

N_0= 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1}

D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

DAS =Days after Sowing

4.2 Number of leaves per plant

Applications of nitrogen significantly increase the number of leaves per plant at 30, 50 and 70 DAS (Fig.3). The maximum number of leaves per plant (5.63, 30.28 and 35.28 at 30, 50 and 70 DAS, respectively) was produced by N_3 treatment and the minimum (18.44, 23.44 and 23.44 at 30, 50 and 70 DAS, respectively) was produced by the control (N_0) treatment. This indicated that number of leaves per plant increased with increasing N levels. This is in argument with the findings of Akhani *et al.* (2012), Patel *et al.* (2013) and Moniruzzaman and Rahman (2015). Plant density had no significant effect on number of leaves per plant (Fig.4). The maximum number of leaves (5.15, 26.00and 31.00 at 30, 50 and 70 DAS, respectively) was obtained from D_3. The D_1 treatment gave minimum number of leaves (3.75, 22.42 and 27.42 at 30, 50 and 70 DAS, respectively) per plant. It revealed that with the increases of plant population per unit area, number of leaves per plant also increased. It might be due to the fact that enough space for vertical and horizontal expansion in lower plant density the optimum spacing that leads for production of maximum number of leaves per plant than higher plant density. Moniruzzaman (2011), also reported similar results earlier.

The number of leaves per plant was also significantly influenced by the interaction effect of nitrogen and plant density (Table 2). The number of leaves per plant was found to be the highest (7.33, 33.33 and 38.33 at 30, 50 and 70 DAS, respectively) from the treatment combination of 120 kg N ha^{-1} with minimum plant density (N_3S_3) treatment. The lowest number of leaves (2.33,

17.00 and 22.00) was observed from the control nitrogenwith maximum plant density (N_0S_1) treatment.

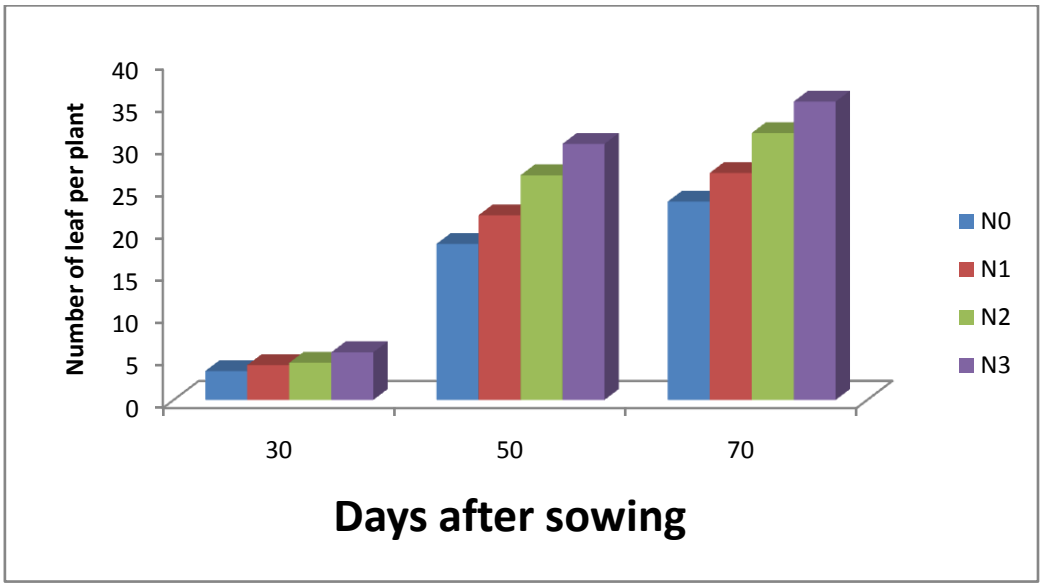


Fig. 3. Effect of nitrogen on number of leaves per plant of Coriander at different days after sowing. (N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1})

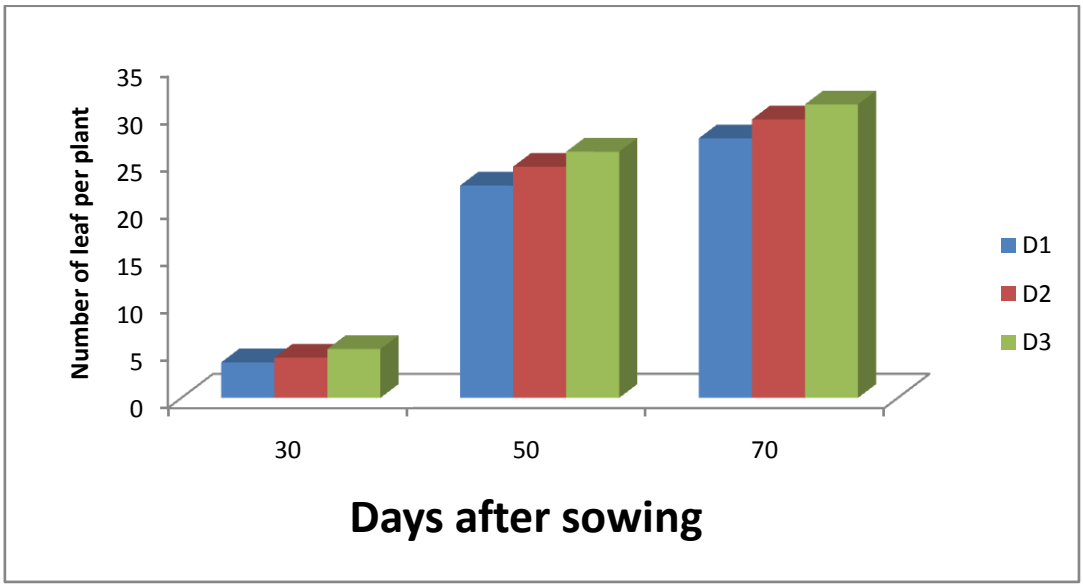


Fig. 4. Effect of plant density on number of leaves per plant of Coriander at different days after sowing.D_1= 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

Table 2. Combined effect of nitrogen and plant density on number of leaves per plant of coriander at different growth stages

Treatment	Number of leaves per plant		
	30 DAS	50 DAS	70 DAS
N_0D_1	2.33 e	17.00 g	22.00 g
N_0D_2	3.78 d	18.33 fg	23.33 fg
N_0D_3	4.11 cd	20.00 ef	25.00 ef
N_1D_1	4.00 cd	20.67 ef	25.67 ef
N_1D_2	4.00 cd	22.33 de	27.33 de
N_1D_3	4.33 bcd	22.50 de	27.50 de
N_2D_1	4.22 bcd	24.50 d	29.50 d
N_2D_2	4.11 cd	27.00 c	32.00 c
N_2D_3	4.83 bc	28.17 bc	33.17 bc
N_3D_1	4.44 bcd	27.50 bc	32.50 bc
N_3D_2	5.11 b	30.00 b	35.00 B
N_3D_3	7.33 a	33.33 a	38.33 A
$LSD_{(0.05)}$	0.86	2.43	2.39
CV (%)	11.52	5.89	5.83

N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1}

D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

DAS =Days after Sowing

4.3Number of primary branch per plant

Application of nitrogen had significant effect on number of primary branches per plant (Table 3). The N_3gave the maximum number of primary branches per plant (8.82) closely followed by N_2 and N_1. The control treatment gave minimum (5.80) number of primary branches per plant.

The number of primary branches per plant was not significantly influenced by plant density (Table 4). However, the treatment D_3 produced maximum number of primary branches per plant (7.85) and the minimum (6.51) number of primary branches per plant was recorded in D_1 treatment.

Interaction of nitrogenand plant density put a significant effect on number of primary branches per plant (Table 5). The maximum number of primary branches per plant (9.65) was obtained from N_3D_3 treatment while the minimum number of primary branches per plant (5.22) fromN_0D_1treatment. There was no significant difference observed between N_3D_2 and N_3D_3 combination in respect of number of secondary branches per plant.

Table 3. Effect of nitrogen on no. of primary and secondary branches, umbels per plant and umbellate per umbel

Treatment	Number of primary branches		Number of secondary branches	Number of umbels plant^{-1}		Number of umbellates Umbel^{-1}
N_0	5.80	b	14.83	12.59	B	3.26
N_1	6.57	ab	15.11	16.63	ab	3.40
N_2	7.50	ab	16.28	17.15	ab	4.00
N_3	8.82	a	17.38	22.78	a	5.23
LSD $_{(0.05)}$	NS		NS	9.89		3.48
CV (%)	10.00		11.56	6.80		6.08

N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1})

Table 4. Effect of plant density on no.of primary and secondary branches, umbels per plant and umbellate per umbel

Treatment	Number of primary branches	Number of secondary branches	Number of umbels plant^{-1}	Number of umbellate Umbel^{-1}
D_1	6.51	15.36	16.16	3.63
D_2	7.16	15.93	17.08	3.92
D_3	7.85	16.42	18.61	4.37
$LSD_{(0.05)}$	NS	NS	NS	NS
CV (%)	10.00	11.56	6.80	6.08

$D_1 = 500\times10^3$ plants ha^{-1}, $D_2 = 400\times10^3$ plants ha^{-1}, $D_3 = 333\times10^3$ plants ha^{-1}.

Table 5. Combined effect of nitrogen and plant density onno.of primary and secondary branches, umbels per plant and umbellate per umbel

Treatment	Number of primary branches		Number of secondary branches		Number of umbels plant^{-1}		Number of umbellate umbel^{-1}	
N_0D_1	5.22	g	14.04	b	8.89	h	3.04	e
N_0D_2	5.77	fg	15.10	ab	14.22	f	3.43	cde
N_0D_3	6.40	efg	15.36	ab	16.44	de	3.27	de
N_1D_1	6.07	fg	14.61	b	11.67	g	3.07	e
N_1D_2	6.53	efg	15.21	ab	14.67	ef	3.37	cde
N_1D_3	7.10	cdef	15.51	ab	15.00	ef	3.77	cde
N_2D_1	6.77	def	15.90	ab	17.22	d	3.47	cde
N_2D_2	7.50	cde	16.40	ab	19.22	c	4.17	bcde
N_2D_3	8.23	bc	16.53	ab	21.78	b	4.37	bcd
N_3D_1	8.00	bcd	16.87	ab	21.22	b	4.57	bc
N_3D_2	8.82	ab	17.01	ab	22.78	ab	5.07	ab
N_3D_3	9.65	a	18.26	a	24.33	a	6.07	a
$LSD_{(0.05)}$	1.22		3.11		1.99		1.09	
CV (%)	10.00		11.56		6.80		6.08	

N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1}

D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

DAS =Days after Sowing

4.4Number of secondary branch per plant

Application of nitrogen had no significant effect on numbers of secondary branches per plant (Table 3). However,the N_3treatment produced the maximum number of secondary branches per plant (14.83) and thecontrol treatment produced minimum number of secondary branch per plant (14.83).

The number of secondary branches per plantwas not significantly influenced by density (Table 4). However, the treatment D_3 produced maximum number of secondary branches per plant (16.42) and the minimum (15.36) Number of secondary branches per plantwas recorded in D_1 treatment.

The interaction of nitrogen and plant density had significant effect onnumber of secondary branches per plant (Table 5). The highest number of secondary branches per plant (18.26) was obtained from the treatment combination of N_3D_3 closely followed by all combinations except N_0D_1 and $N_1D_1$and the minimum number of secondary branches per plant (14.04) was found in the treatment combination of N_0D_1treatment.

4.5Number of umbels per plant

Application of nitrogen significantly influenced the number of umbels per plant (Table 3). The maximum number of umbels per plant (22.78) was observed in N_3 closely followed by N_1 and N_2 and the minimum (12.59) was found in

theN_0(Table 3). This corroborates the result of Moniruzzaman and Rahman (2015).

The number of umbels per plant was not significantly influenced by plant density (Table 4). Treatment D_3 produced maximum number of umbels per plant (18.61) and the minimum (16.16) number of umbels per plantwas recorded in D_1 treatment (Table 4). It revealed that the increase of plant population showed decreasing trend of numbers of umbels per plant.

The interaction effect of nitrogen and plant density was significant in respect of number of umbels per plant (Table 5). The maximum number of umbels per plant (24.33) was recorded from N_3D_3 combination closely followed by N_3D_2 combination and its minimum number was obtained from N_0D_1 treatment combination.

4.6Number of umbellate per umbel

Different nitrogen levels did not significantly influence the number of umbellates per umbel (Table 3). However, the maximum number of umbellates per umbel (5.23) was observed in N_3 and the minimum number of umbellates per umbel (3.26) was found in the N_0.

The number of umbellates per umbel was not also significantly influenced by plant density (Table 4).Treatment D_3 produced maximum number of umbellates

per umbel (4.37) and the minimum (3.63)number of umbellates per umbel was recorded in D_1 treatment.

The interaction of nitrogen and plant density showed significant effect in respect of number of umbellates per umbel(Table 5). The combination of N_3D_3 gave the maximum number of umbellates per umbel which was statistically similar with N_3D_2 and the minimum umbellates per umbel recorded from N_0D_1 combination.

4.7Number of seeds per plant

Application of nitrogen had significant effect on numbers of seeds per plant (Table 6). The treatmentN_3 produced the highest number of seeds per plant (918.30) and the control treatment produced thelowest number of seeds per plant (786.70).

The number of seeds per plant was significantly influenced by plant density (Table 7). Treatment D_3 produced maximum number of seeds per plant(861.3) which was identical with D_2 (832.90/plant) and the minimum (828.8)number of seeds per plant was recorded in D_1 treatment (Table 7).

The interaction of nitrogen and plant density was found significant in respect of number of seeds per plant(Table 8). The highest number of seeds per plant (940.00) was obtained from the treatment combination of N_3D_3 closely followed by $N_3D_2$and the minimum number of seeds per plant (756.7) was found in the treatment combination of N_0D_1 treatment.

Table 6. Effect of nitrogen on yield and yield contributing character of coriander

Treatment	Number of seeds plant^{-1}		1000-seed weight(g)	Seed yield plot^{-1}(g)		Seed yield (t ha^{-1})	
N_0	786.70	c	14.70	266.70	d	0.89	b
N_1	818.30	bc	14.74	364.30	c	1.21	ab
N_2	840.70	b	14.82	410.60	b	1.37	a
N_3	918.30	a	14.88	439.00	a	1.46	a
LSD $_{(0.05)}$	47.87		NS	17.76		0.35	
CV (%)	5.63		8.53	10.32		10.30	

N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1})

Plot area: 3.00 m^2

Table 7. Effect of plant density on yield and yield contributing characters of coriander

Treatment	Number seeds per plant		1000-seed weight(g)	Seed yield per plot(g)		Seed yield (t ha^{-1})	
D_1	828.80	b	14.72	358.00	b	1.19	c
D_2	832.90	ab	14.81	370.70	ab	1.24	b
D_3	861.30	a	14.83	381.80	a	1.27	a
LSD $_{(0.05)}$	31.54		NS	22.16		0.04	
CV (%)	5.63		8.53	10.32		10.30	

D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}

Plot area:3.00 m^2.

Table 8. Combined effect of nitrogen and plant density on yield and yield contributing characters of coriander

Treatment	Number of seeds plant^{-1}		1000-seed weight(g)		Seed yield (g plot^{-1})		seed yield (t ha^{-1})	
N_0D_1	756.70	f	14.27	c	245.00	d	0.82	d
N_0D_2	793.30	ef	14.34	bc	271.70	d	0.90	d
N_0D_3	810.00	de	14.71	ab	283.30	d	0.94	d
N_1D_1	800.00	de	14.83	a	355.00	c	1.18	c
N_1D_2	820.00	cde	14.84	a	363.30	bc	1.21	bc
N_1D_3	835.00	cde	14.69	ab	374.70	bc	1.25	bc
N_2D_1	822.00	cde	14.81	a	400.30	abc	1.34	abc
N_2D_2	840.00	cd	14.88	a	412.00	abc	1.38	abc
N_2D_3	860.00	bc	14.97	a	419.30	abc	1.40	abc
N_3D_1	900.00	ab	14.95	a	431.70	ab	1.44	ab
N_3D_2	915.00	a	15.04	a	435.70	ab	1.45	ab
N_3D_3	940.00	a	15.07	a	449.7	a	1.50	a
LSD $_{(0.05)}$	40.62		0.39		64.70		0.21	
CV (%)	5.63		8.53		10.32		10.30	

N_0 = 0 kg ha^{-1}, N_1=40 kg ha^{-1}, N_2 = 80 kg ha^{-1} N_3 =120 kg ha^{-1}

D_1 = 500×10^3 plants ha^{-1}, D_2 =400×10^3 plants ha^{-1}, D_3 =333×10^3 plants ha^{-1}.

DAS =Days after Sowing

Plot area: 3.00 m^2

4.8 Thousand seedweight

Different nitrogen levels did not significantly influence thousand seed weight (Table 6).However,the N_3 treatment produced the highest thousand seed weight (14.88) and the control treatment produced thelowest thousand seed weight (14.7).

Thousand seed weightwas not alsosignificantly influenced by plant density (Table 7).Treatment D_3 produced maximum thousand seed weight(14.83) and the minimum (14.72)thousand seed weightwas recorded in D_1 treatment.

The interaction of nitrogen and plant density was found significant in respect of thousand seed weight(Table 8). The highest thousand seed weight (15.07) was obtained from the treatment combination of N_3D_3 closely followed by all others treatments except N_0D_1 and $N_0D_3$and the minimum thousand seed weight (14.27) was found in the treatment combination of N_0D_1 treatment.

4.9Seed yield per plot (g)

A significant variation was observed on seed yield per plot (3.00 m^2)due to the use of nitrogen (Table 6). The maximum seed yield per plot (439.00 g) was recorded from N_3 (120 kg N^{-1}ha) treatment, while the minimum (266.7 g) was from the control (N_0) treatment.

The seed yield per plot was also found to differ significantly by plant density (Table 7). The maximum seed yield per plot (381.8 g) was obtained from D_3

treatment closely followed by D_2 treatment. The D_1treatment gave the minimum seed yield per plot (358.00g).

The interaction of nitrogen and plant density put significant effect on seed yield per plot(Table-8). The combination N_3D_3 gave the maximum seed yield per plot (449.7) which was identical with N_2D_1, N_2D_2,N_2D_3 N_3D_1 andN_3D_2 combinations. Minimum seed yield was produced when nitrogen was not applied.

4.10seed yield (t ha^{-1})

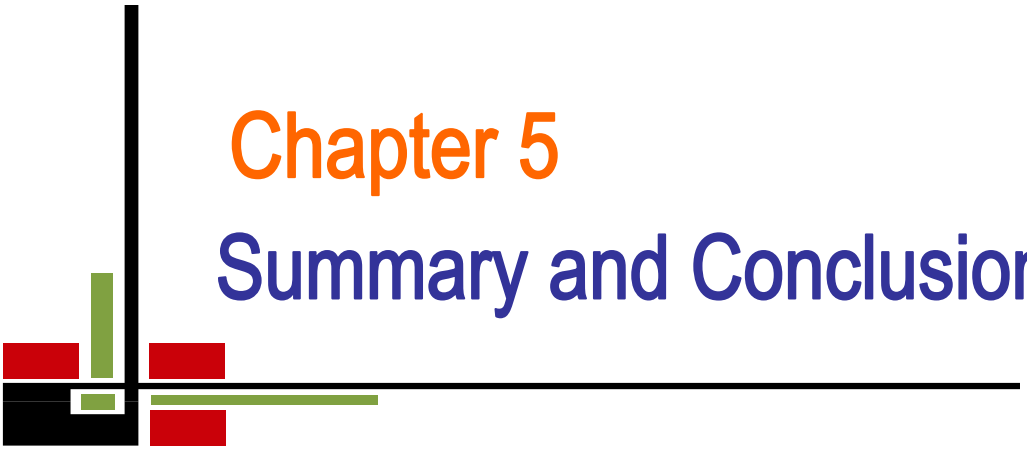
Yieldof coriander varied significantly due to different nitrogen levels (Table 6). The maximum yield (1.46 t ha^{-1}) was recorded from 120 kg N ha^{-1}(N_2) treatment closely followed by N_1 and N_2 treatments. This is in partial agreement with Moniruzzaman and Rahman (2015), Szemplinski and Nowak (2015) who got the maximum seed yield of coriander from the application of 80 kg Nha$^{-1.}$ Application of 120 kg Nha^{-1} gave the highest number of primary branches plant^{1}, number of umbels plant^{-1}, number of seeds plant^{-1} and thus gave the maximum seed yield ha^{-1}.The minimum yield (0.89 t ha^{-1})was obtained found from control (N_0) treatment.

The yield of coriander perhectare was found to be statistically significant due to plant density (Table 7). The highest yield (1.27 t ha^{-1}) was obtained from D_1 treatment and the lowest (1.19 t ha^{-1}) was obtained from D_3 treatment.

This corroborate the result of Akhani *et al.,* (2015), who got the highest yield of coriander 25 plants m^{-2} (250×10^3 plants ha^{-1}). Amrajit *et al.*, (1992) obtained the highest seed yield of till from the maximum density of plants per unit area.

A significant combined effect of nitrogen and plant density was also observed on yield of coriander per hectare (Table 8). The highest yield of coriander ($1.5tha^{-1}$) was obtained from 120 kg Nha^{-1} with maximum plant density (N_3D_1) closely followed by N_2D_1, N_2D_2, N_2D_3,N_3D_1 andN_3D_2 combinations. The result is in partial agreement with Mossavi *et al.*, (2013), who got the maximum seed yield of coriander from the combination of 80 kg Nha^{-1} with 50 plants m^{-2} (500×10^3plants ha^{-1}) in gram.

Akbarinia *et al.,* (2006) got the highest seed yield of coriander from the combination of 90 kg Nha^{-1} and 30 plants m^{-2} (300×10^3 plants ha^{-1}).



Chapter 5

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka to examine the effect of nitrogen levels and plant density on yield and yield components of coriander (*Coriandrum sativum L.*). The experiment consisted of four levels of nitrogen viz. 0, 40, 80 and 120 kg ha^{-1} and three different plant densities viz. 500×10^3, 400×10^3 and 333×10^3 plant ha^{-1}. 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 leaves per plant, number of primary branches per plant, number of secondary 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 and seed yield per hectare were recorded and analyzed statistically.

The different nitrogen levels independently had significant effect on plant height at 30, 50, 70 days after sowing (DAS). Application of 120 kg N ha^{-1} produced the tallest plant (13.62, 30.56, and 76.78 cm at 30, 50 and 70 DAS, respectively) and the control treatment gave the lowest plant height at 9.98, 24.00 and 50.33 cm at 30, 50 and 70 DAS, respectively. The plant height of coriander was not significantly influenced by different plant density at 30, 50 and 70 DAS.

During the period of plant growth the tallest plant (11.82, 27.5 and 65.75 cm at 30, 50 and 70 DAS, respectively) was observed in D_1 treatment.

Number of leaves plant^{-1} was significantly influenced by different levels of nitrogen application at different days after sowing (DAS). Application of 120 kg N ha^{-1} produced the maximum number of leaves plant^{-1} (5.63, 30.28 and 35.28 at 30, 50 and 70 DAS, respectively) and the control treatment gave the lowest result. Different did not plant densities was not significantly increase number of leaves plant^{-1} at 30, 50 and 70 DAS. The maximum number of leaves plant^{-1} (5.15, 26.00 and 31.00 at 30, 50 and 70 DAS, respectively) obtained from D_3 treatment. The N_3 treatment gave the maximum number of primary branches per plant (8.82). The control treatment gave minimum (5.80) number of primary branch per plant. Treatment D_3 produced maximum number of primary branch per plant (7.85) and the minimum (6.51) number of primary branch per plant was recorded in D_1 treatment. The highest number of secondary branches plant^{-1} was recorded from 120 kg N ha^{-1} (N_3) (17.38). The lowest number of secondary branches plant^{-1} was observed from control treatment (N_0) (14.83). The Number of secondary branches per plant was significantly influenced by plant density. Treatment D_3 produced maximum number of secondary branch per plant (16.42) and the minimum (15.36) number of secondary branches per plant was recorded in D_1 treatment.

Nitrogen did not significantly influence the number of umbellates per umbel. The maximum number of umbellates per umbel (5.23) was observed in N_3 treatment. Treatment D_3 produced maximum number of umbellate per umbel

(4.37). The effect of nitrogen was significant in this regard the treatment. N_3 produced the highest number of seeds per plant (918.30) and control treatment produced the lowest number of seeds per plant (786.70). Treatment D_3 produced maximum number of seeds per plant (861.3) and the control treatment gave the lowest one (828.8). Application of nitrogen at different levels did not significantly increased the 1000-seed weight up to 120 kg ha^{-1} which produced maximum seed weight (14.88 g). Treatment D_3 gave the highest 1000-seed weight (14.83) where as control treatment gave the lowest (14.72) 1000-seed weight.

Different nitrogen levels had significant effect on seed yield per plot. The maximum seed yield per plot (439.00 g) was recorded from N_3 (120 kg N ha^{-1}) treatment, while the minimum (266.7 g) was from the control (N_0) treatment. The maximum seed yield per plot (381.8 g) was obtained from D_3 treatment. The D_1 treatment showed the minimum seed yield per plot (358.00). Yield of coriander varied significantly due to different levels of nitrogen. The maximum yield (1.46 t ha^{-1}) was obtained from 120 kg N ha^{-1} (N_3) treatment. The minimum yield (0.89 t ha^{-1}) in this respect was found from control (N_0) treatment.

The yield of coriander per hectare was significantly influenced by plan density. The highest yield (1.27 t ha^{-1}) was obtained from D_1 treatment and the lowest (1.19 t ha^{-1}) in this regard was obtained from D_3 treatment.

All the parameter were significantly influenced by the interaction of nitrogen and plant density. The tallest plant (14.03, 36.00 and 87.00 cm at 30, 50 and 70 DAS, respectively) was found from the 120 kg N ha^{-1} maximum plant density treatment. The number of leaves per plant was recorded to be the highest (7.33, 33.33 and 38.33 at 30, 50 and 70 DAS, respectively) from the treatment combination of 120 kg N ha^{-1} with minimum plant density (N_3D_3) treatment. The maximum number of primary branches per plant (9.65) was obtained from N_3D_3 treatment. The highest number of secondary branches per plant (18.26) was obtained from the treatment combination of N_3D_3 and the minimum number of secondary branches per plant (14.04) was found in the treatment combination of N_0D_1 treatment.

The highest (24.33) and the lowest (8.89) number of umbels per plant were observed in the treatment combination N_3D_3 and N_0S_1. The highest (6.07) and the lowest (3.04) number of umbellates per umbel were observed in the treatment combination N_3D_3 and N_0D_1. The highest number of seed per plant (940.00) was obtained from the treatment combination of N_3D_3. Maximum thousand seed weight (15.07) was obtained from the treatment combination of N_3D_3. The interaction of nitrogen and plant density were significant in respect of seed yield per plot (3.00 m^2). The highest (449.7) and lowest (245.00) seed yield per plot was observed in the treatment combination N_3D_3 and N_0D_1. The significant combined effect of nitrogen and density was also observed on yield of coriander per hectare. The highest yield of coriander (1.5 t ha^{-1}) was obtained from 120 kg N ha^{-1} with maximum plant density (N_3D_1) treatment and the lowest

(0.82 t ha^{-1}) was found in no nitrogen with maximum plant density treatment (N_0D_1).

The result of the present study generated some information which may help increase the higher seed yield of coriander. Hence, the present study may be concluded as follows:

I. Application of 120 kg N ha^{-1} produced the tallest plant, maximum number of leaves $plant^{-1}$, primary and secondary branches $plant^{-1}$, umbels and seeds $plant^{-1}$ and gave the maximum seed yield of coriander.
II. Plant density of 333×10^3 plants ha^{-1} gave the highest yield of coriander.
III. Application of 120 kg N ha^{-1} coupled with 333×10^3 plants ha^{-1} gave the maximum seed yield which was identical with the combination of 400×10^3 plants ha^{-1} and similar nitrogen dose.

RECCOMENDATION

i. Application of 120 kg N ha^{-1} in combination with 333×10^3 plants ha^{-1} was suitable for coriander cultivation.

ii. The study might be conducted at the same Agro Ecological Condition for the conformation of the result.

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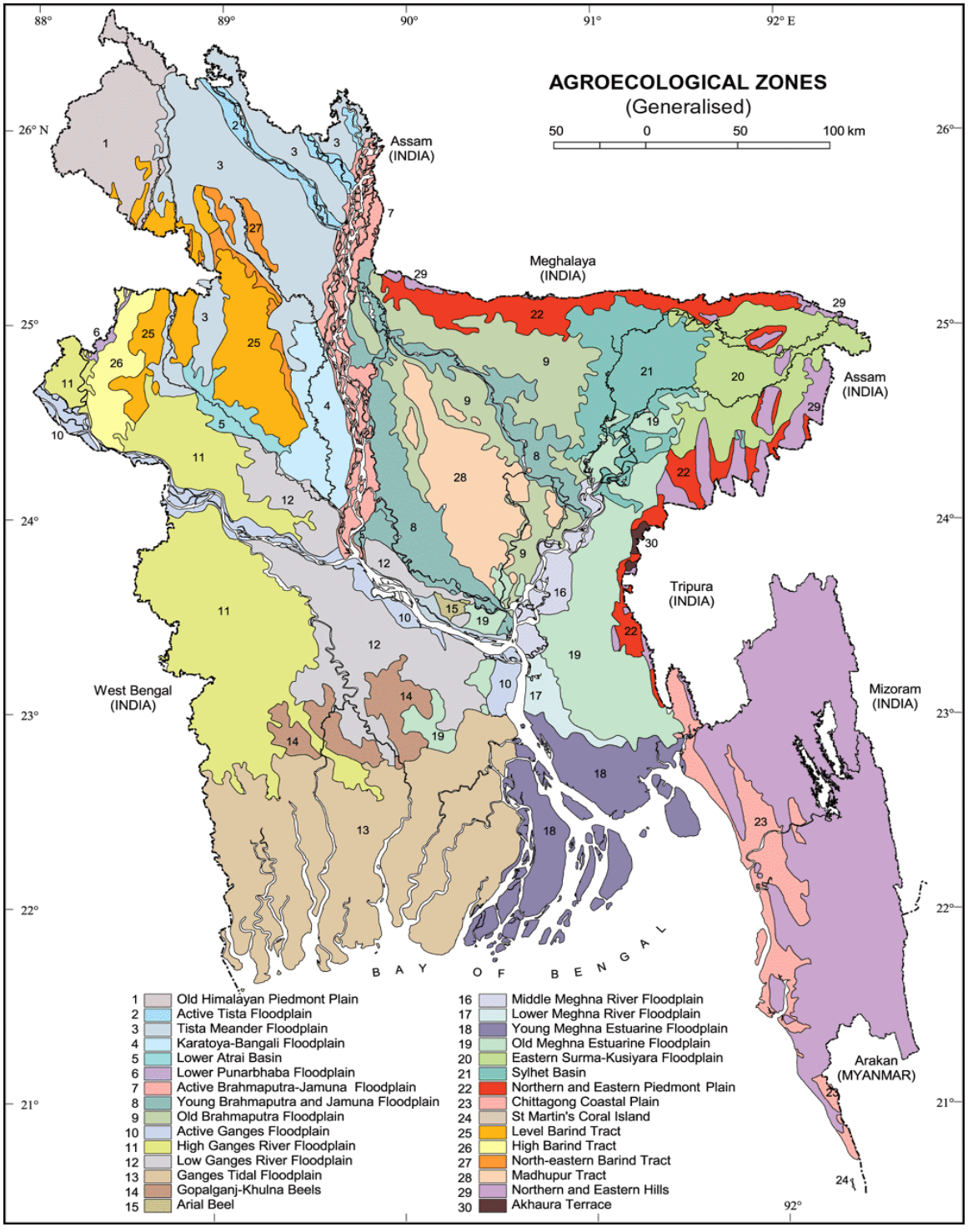
Appendices

APPENDICES

Appendix I: Experimental location on the map of agro-ecological zones of Bangladesh



Appendix II: **Soil characteristics of Sher-e-Bangla Agricultural University Farm, Dhaka analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka**

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Farm, SAU, Dhaka
AEZ	Modhupur tract (28)
General soil type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	**N/A**

Source: Soil Resources Development Institute(SRDI)

B. Physical and Chemical properties of the Initial soil

Characteristics	Value
Practical size analysis	
Sand (%)	16
Silt (%)	56
Clay (%)	28
Silt + Clay (%)	84
Textural class	Silty clay loam
Ph	5.56
Organic matter (%)	0.25
Total N (%)	0.02
Available P (µgm/gm soil)	53.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40
Available B (µgm/gm soil)	0.13
Available Zn (µgm/gm soil)	0.94
Available Cu (µgm/gm soil)	1.93
Available Fe (µgm/gm soil)	240.9
Available Mn (µgm/gm soil)	50.6

Source: Soil Resources Development Institute (SRDI)

Appendix III: Analysis of variance of the data onplant height of corianderas influenced at nitrogen and plant density

Sources of Variation	Degrees of freedom	Mean Square		
		plant height		
		30DAS	50DAS	70DAS
Replication	2	0.521	0.960	0.521
Factor A (Nitrogen)	3	131.23*	23.14*	140.44*
Factor B (plant density)	2	0.295 ^{NS}	344.44 ^{NS}	205.60 ^{NS}
AB	6	306.96*	430.12*	504.30*
Error	22	0.850	10.720	78.891

*significant at 5% level of probability,
NS- Non significant

Appendix V: Analysis of variance of the data on Number of leaves per plant ofcorianderas influenced at nitrogen and plant density

Sources of Variation	Degrees of freedom	Mean Square		
		Number of leaves per plant		
		30DAS	50DAS	70DAS
Replication	2	0.73	0.19	0.69
Factor A (Nitrogen)	3	7.75*	243.57*	243.57*
Factor B (plant density)	2	1.06*	8.69*	5.70*
AB	6	1.35*	44.46*	246.40*
Error	22	0.258	2.04	1.99

*significant at 5% level of probability,

Appendix V: Analysis of variance of the data on growth, yield and yield contributing character of coriander as influenced at nitrogen and plant density

Sources of Variation	Degrees of freedom	Mean Square							
		Primary branches/plant (no.)	Secondary branches/plant (no.)	umbels/ plant (no.)	Number of umbellate/ Umbel (no.)	Seeds/plant (no.)	1000 seed weight (g)	Seed yield plot^{-1} (g)	Seed yield (kgha^{-1})
Replication	2	0.066	0.877	1.55	0.970	1200.0	0.471	5.861	0.020
Factor A (Nitrogen)	3	15.29 *	4.27^{NS}	7.30*	157.93*	283339.33*	0.060^{NS}	51346.70*	0.574*
Factor B (Phosphorus)	2	5.32^{NS}	3.40^{NS}	1.64^{NS}	8.33^{NS}	3740.58*	0.042^{NS}	1694.69*	0.640*
AB	6	13.059*	10.27*	0.42*	36.69*	575.58*	0.304*	1499.81*	1.91*
Error	22	0.515	3.38	1.07	1.38	1515.15	1.59	1460.01	0.016

*significant at 5% level of probability,
NS- Non significant