EFFECT OF NITROGEN AND PHOSPHOROUS ON MORPHOLOGICAL PARAMETERS AND YIELD OF BLACK CUMIN (*Nigella sativa* L.)

MD. ASHIKUR RAHMAN

DEPARTMENT OF AGRICULTURAL BOTANY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA -1207

December, 2014

EFFECT OF NITROGEN AND PHOSPHOROUS ON MORPHOLOGICAL PARAMETERS AND YIELD OF BLACK CUMIN (*Nigella sativa* L.)

BY

MD. ASHIKUR RAHMAN

Registration No. : 08-2836

A Thesis

Submitted to the Department of Agricultural Botany
Sher-e-Bangla Agricultural University, Dhaka, in partial
fulfillment of the requirements
for the degree
of

MASTER OF SCIENCE
IN
AGRICULTURAL BOTANY

SEMESTER: JULY-DECEMBER, 2014

Approved by:

Prof. Asim Kumar Bhadra
Department of Agricultural Botany
Supervisor

Dr. Mohd. Moniruzzaman
Principal Scientific Officer
Horticulture Research Centre, BARI
Co-Supervisor

Dr. Md. Ashabul Hoque
Associate Professor
Department of Agricultural Botany
Chairman
Examination Committee

Asim Kumar Bhadra
Professor
Department of Agricultural Botany
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh
Mobile: +8801710487750
E-mail:asimbhadra@yahoo.com

CERTIFICATE

*This is to certify that thesis entitled, "**EFFECT OF NITROGEN AND PHOSPHOROUS ON MORPHOLOGICAL PARAMETERS AND YIELD OF BLACK CUMIN (Nigella sativa 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 (M.S.) IN Agricultural Botany**, embodies the result of a piece of bona fide research work carried out by Md. Ashikur Rahman, Registration No.: **08-02836** 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 been duly been acknowledged by him.

Dated: December, 2014
Place: Dhaka, Bangladesh

(Asim Kumar Bhadra)
Professor
Supervisor

Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

*All praises are due to the **Almighty "Allah"** Who kindly enabled the author to complete the research work and the thesis leading to Master of Science.*

*The author feels proud to express his profound respect, deepest sense of gratitude, heartful appreciation to **Prof. Asim Kumar Bhadra**, Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, for his constant inspiration, scholastic guidance and invaluable suggestions during the conduct of the research and for his constructive criticism and whole hearted co-operation during preparation of this thesis.*

*The author expresses his heartfelt gratitude and indebtness to **Dr. Mohd. Moniruzzaman,** principal Scientific Officer, Horticulture Research Centre, Bangladesh Agricultural Research Institute for his assistance in planning and execution of the study and for his constructive instruction, critical reviews and heartiest co-operation during preparation of the manuscript.*

*The author also expresses his heartfelt thanks to **Prof. Dr. Md. Ashabul Hoque**, Chairman, Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka.*

The author also expresses his heartfelt thanks to all the teachers of the Dept. of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka for their help, valuable suggestions and encouragement during the period of study.

The Author also wishes to acknowledge his indebtedness to the Farm Division of Sher-e-Bangla Agricultural University, Dhaka for their co-operation in the implementation of research works. The Author is also thankful to Arif Bhai for their constant encouragement.

At last but not the least, the Author feels indebtedness to his beloved parents and relatives, whose sacrifice, inspiration, encouragement and continuous blessing paved the way to his higher education.

The Author

EFFECT OF NITROGEN AND PHOSPHOROUS ON MORPHOLOGICAL PARAMETERS AND YIELD OF BLACK CUMIN (*Nigella sativa* L.)

ABSTRACT

An experiment was conducted to evaluate the effect of nitrogen and phosphorous on growth and yield of black cumin (*Nigella sativa* L.) using var.BARI Kalozira at the Farm of Sher-e-Bangla Agricultural University, Dhaka during November to March (R*abi* season), 2013-14. The treatments consist of four levels of nitrogen application viz., 0, 30, 60 and 90 kg ha^{-1} and phosphorous viz. 0, 10, 20 and 30 kg ha^{-1}. The experiment was laid out in a randomized complete block design (factorial) with three replications. Nitrogen and phosphorous levels singly as well as in combination had significant effect on most of the characters studied. The tallest plant and maximum leaves plant^{-1} were recorded at 90 kg N ha^{-1} followed by 60 kg N ha^{-1} at different growth stages. Application of 90 kg N ha^{-1} gave the maximum primary and secondary branches plant^{-1}, capsules plant^{-1}, seeds capsules^{-1}, 1000 seed weight and seed yield. Application of 60 kg N ha^{-1} produced identical results in respect of primary and secondary branches plant^{-1}, capsules plant^{-1} and 1000 seed weight. 30 kg P ha^{-1} gave the highest plant height, leaves plant^{-1}, secondary branches plant^{-1}, capsules plant^{-1}, seeds capsules^{-1}, 1000 seed weight and seed yield which was closely followed by 20 kg P ha^{-1}. Application of 90 kg N ha^{-1} coupled with 30 kg P ha^{-1} gave the maximum capsules plant^{-1} and seed yield which was statistically similar to those parameters obtained from 90 kg N ha^{-1} × 20 kg P ha^{-1}, 60 kg N ha^{-1} × 30 kg P ha^{-1}.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

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
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorous and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER–I

INTRODUCTION

Black cumin (*Nigella sativa* L.) commonly known as 'Kalozira' belongs to family Ranunculaceae. It is cultivated for seed yield and oil production. The seed contain 30-35 % of oil which has several uses for pharmaceutical and food industries (Ustun *et al.,* 1990). It is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey (Riaz *et al.,* 1996). In India, it is commercially cultivated in Punjab, Himachal Pradesh, Madhya Pradesh, Jharkhand, Assam, West Bengal and Andhra Pradesh (Vijay and Malhotra, 2006). The black cumin seed cake is a by-product obtained from the black cumin seeds which it is used in the production of bio-oil (Sen and Kar, 2012). Black cumin is an annual flowering plant, native to Southwest Asia. It grows to 20 to 30 cm tall, with finely divided, linear (but not thread-like) leaves. The flowers are delicate, and usually coloured pale blue and white, with 5 to 10 petals. The fruit is a large and inflated capsule composed of 3 to 7 united follicles, each containing numerous seeds. The seed is used as a spice (Abadi *et al.,* 2015).

Black cumin's capsule (fruit) has five parts and its seeds are usually small (1-5 mg) in dark gray or black color. The ripe seed contains 7 % moisture, 4.34 % ash, 23 % protein, 0.39 % fat, 4.99 % starch and 5.44 % raw fiber (Zargari, 1990).

Medicinal plants are used to cure many ailments that are either non-curable or seldom cured through modern systems of medicine. Approximately 80% of the world population depends on medicinal plants for their health and healing (Aliyu, 2003). Societal motivations to use herbs are increasing due to concern about the side effects of synthetic drugs. Many botanicals and some dietary supplements are good sources of antioxidants and anti-inflammatory compounds (Balasubramanian and Palaniappan, 2001). Quality in medicinal plants is more important than other plant products. Environmental factors have an important role on plant growth. Some of these factors such as irrigation and manure can be controlled by human. Both of them are essential to increase yield and quality of plants (Singh and Goswami, 2000). Because the need of increasing the medicinal plant production all over the world, its production became an ultimate goal to meet the great increase of population to avoid chemical therapy side effects on human health through utilization of the medical herbs. However, the use of the most suitable and recommended agricultural practices in growing such crops could provide the producers with higher income, in comparison with many other traditional crops (Hassan *et al*. 2012).

Nitrogen is essential for plant growth which ultimately increases yield of the crop. It is reported that application of 30 -60 kg nitrogen per hectare is essential to achieve maximum performance of cumin (Champawat and Pathak, 1982; Ehteramian, 2002;Tuncturk *et al*., 2012).

Phosphorus is essential for the general health of the plant and root development and more stem strength. It improves flower formation and makes seed production more uniform. It also improves seed quality and resistant to plant disease. The early supply of phosphorous to the crop is influenced by soil phosphorous and phosphorous application as well as by soil and environmental conditions that affect phosphorous phytoavailability and root growth. Roots absorb phosphorous ions from the soil solution. The ability of the plant to absorb phosphorous will depend on the concentration of phosphorous ions in the soil solution at the root surface and the area of absorbing surface in contact with the solution (Barber, 1984). Therefore, the rate of phosphorous uptake is related to the rate of water uptake and phosphorous concentration in soil solution. The phosphorous ions near the root hairs are absorbed quickly, resulting in a depletion zone with a decreasing phosphorous concentration gradient near the root surface (Bagshaw *et al*., 1972). In highly P fertilized soils, the P concentration in soil solution is high (>1 ppm) and the depletion zone is readily replenished, but the replenishment is slow when soil solution phosphorous is low especially for soil solid phase with a low buffer capacity. Therefore it is important that phosphorous management balances the goal of providing sufficient phosphorous to the crop to optimize crop yield with the goal of avoiding excess phosphorous and environmental risk. Where plant-available phosphorous in the soil is low, efficient applications of fertilizer phosphorous or manure and/or improved mycorrhizal association may improve crop phosphorous levels.

Availability of nitrogen is of prime importance for growing plants as it is a major and indispensable constituent of protein and nucleic acid molecules (Troug, 1973). An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally lead to higher productivity. Application of phosphorus was found to increase plant height, number of branches, fresh and dry weight and essential oil content of black cumin (Sushama and Jose, 1994). Therefore, the present investigation was undertaken to study the effect of nitrogen and phosphorous on growth and yield of black cumin with the following objectives:

1. To characterize the different doses of N and P on morphological characteristics of black cumin.

2. To find out the suitable doses of nitrogen and phosphorous for higher seed yield of black cumin.

3. To evaluate the combination effect of nitrogen and phosphorous on seed yield of black cumin.

CHAPTER - II

REVIEW OF LITERATURE

Black cumin is one of the most important medicinal plants all over the world including Bangladesh. The yield of black cumin depends on many factors such as are 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 and phosphorus are the two major important macronutrients which are responsible for controlling growth and yield of black cumin. A number of research works have been done on different levels of nitrogen and Phosphorus on the yield of black cumin in various parts of the world, which have been made in this regard in Bangladesh. The present study has been taken to investigate the effect of nitrogen and phosphorous on growth and yield of black cumin (*Nigella sativa* L.). In the chapter an attempt has been made to research findings related to the present study have been reviewed here.

2.1 Effect of nitrogen on growth and yield of black cumin

Kaheni *et al.* (2013) conducted in a randomized complete block design with two factors and three levels of nitrogen (0, 30 and 60 kg N ha^{-1}) and four planting dates (11 November, 1 December, 23 December and 2 January) with three replications in Agricultural and Natural Resources Research Center of South Khorasan, located in 20 km Kerman-Birjand road. Different levels of nitrogen fertilizer had a significant effect on the number of umbels per plant, 1000 seed weight and dry matter yield, but were not significantly affected on the number of seeds per umbel, plant height, and number of branches, forage and grain yield. In final results, due to reduce the risk of untimely cold winter in this region, we were recommend to achieve maximum performance in cumin, application of 60 kg nitrogen and late planting dates (as 23 December and 2 January).

Tuncturk *et al*. (2012) carried out to determine the effects of different nitrogen doses (0, 20, 40, 60 and 80 kg ha^{-1}) on the yield and some yield components of black cumin (*Nigella sativa* L.) in Van ecological conditions in 2006 and 2007. Field trials were designed by Completely Randomized Block Design with three replications at the experimental fields of Agricultural Faculty of Yuzuncu Yil University. In the study, plant height (cm), number of branch plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1}, thousand-seed weight (g) and seed yield (kg ha^{-1}) were determined. In conclusion, the effects of nitrogen doses on the yield and some yield components were statistically significant except for 1000 seed weight and number of seeds capsule^{-1}. Plant height, number of branch plant^{-1}, number of capsule plant^{-1} and seed yield were increased by increasing nitrogen doses. According to the results, the highest values were obtained in seed yield (575 kg ha^{-1}), the number of capsule (7.5 capsule plant^{-1}) and the number of branch (4.51 branch plant^{-1}) from 60 kg N ha^{-1} application.

Shah (2007) reported the effect of basal nitrogen (0, 176, 264, 352 or 442 mg N pot^{-1}) applied with or without 10^{-5} M kinetin (KIN) spray on *Nigella sativa* L. Although, N alone was found to significantly enhance all parameters, (viz, nutrient (NPK) accumulation, number of capsules, seed yield plant^{-1}, essential oil yields plant^{-1}.

Ahmad *et al.* (2004) reported that the split dose of nitrogen might increase black cumin yield.

2.2 Effect of phosphorous on growth and yield of black cumin

Approximately 80% of the world population depends on medicinal plants for their health and healing. *Nigella sativa* L. is an annual flowering plant, native to southwest Asia. The field experiment was laid out in randomized complete block design with factorial design with three replications. Treatments included phosphorus fertilizer (0, 30, 60 and 90 kg ha^{-1}) and mycorrhiza (No mycorrhiza, *Glomus intraradices* and *Glomus mosseae*). Analysis of variance showed that the effect of mycorrhiza and phosphorus on all characters was significant (Abadi *et al.*, 2015).

Shirmohammadi *et al.* (2014) studied in a field experiment at the research farm of Nour Abad in Lorestan, Iran, during 2013. Experiment was arranged as a factorial based on randomized complete block design in three replications. Treatments included biological phosphate (*Pseudomonas putida*) at two levels inoculated and non-inoculated and chemical phosphorus (P_2O_5) at three levels (0, 40 and 80 kg.ha^{-1}). Results showed that effect of treatments on plant height, capsule number per plant, grain number per capsules and grain yield were statically meaningful, however, there were no significant differences between treatments in respect of 1000 seed weight. The means showed that the greatest plant highest (32.1 cm) and grain yield (735 kg ha^{-1}) were obtained by a treatment of biological phosphate + chemical phosphorus (40 kg ha-1 P_2O_5). Results indicate that applying the combined biological phosphate and chemical phosphorus fertilizer can be practical and helpful method to increase black cumin yield, yield components and reduce the environmental pollution.

Tuncturk *et al.* (2013) carried out the experiment to determine the effects of different phosphorous doses (0, 20 and 40 kg ha^{-1}) on yield and some yield components of black cumin (*Nigella sativa* L.) in Van ecological conditions in 2006 and 2007. Field trials were designed by Completely Randomized Block Design with three replications at the experimental fields of Agricultural Faculty of Yuzuncu Yıl University. In the study, plant height (cm), number of branch plant^{-1}, number of capsule plant^{-1}, number of seeds capsule^{-1}, 1000-seed weight (g) and seed yield (kg ha^{-1}) were determined. According to statistical analysis, significant differences were determined among the phosphorous doses applications for the number of capsule, 1000-seed weight and seed yield. Seed yield increased by increasing phosphorous doses. According to the results, the highest seed yield (597 kg ha^{-1}) and thousand-seed weight (2.48 g) were obtained from 40 kg P ha^{-1} fertilizer application. The highest mean values for the number of capsule (5.68 capsules plant^{-1}) resulted in 20 kg P ha^{-1} application.

2.3 Combined effect of nitrogen and phosphorous on morphological properties and yield of black cumin

Rana *et al.* (2012) conducted during *rabi* season of 2010-11 to find out the effect of nitrogen and phosphorous on growth, yield and quality of black cumin. Among the varieties, AN-1 recorded maximum value for number of capsules per plant (30.30), number of seeds per capsules (60.33), test weight (1.46 g), seed yield (4.88 q/ha), straw yield (12.48 q/ha), harvest index (27.89 %) and biological yield (17.36 q/ha) as compared to local cultivar of nigella. Maximum plant height at harvest (45.95 cm), number of branches per plant at harvest (17.30), fresh weight per plant at 60 DAS (13.08 g) and dry weight of shoot per plant at 60 DAS (3.21 g) were recorded with the application of fertilizer 60:120 kg ha^{-1} N, P followed by 45: 90 kg ha^{-1} N, P and lowest in control at all the growth stages. Therefore, the application of 60 kg ha^{-1} N and 120 kg ha^{-1} P fertilizer with the variety AN-1 gave the maximum growth, yield and quality of nigella with the highest net return per hectare.

Nataraja *et al.* (2003) conducted to study the influence of nitrogen, phosphorous and potassium on growth and seed yield of black cumin at Sanjivini Vatika, University of Agricultural Sciences, Bangalore during 2000-2001. The experiment consisted of twenty seven treatment combinations with three levels each of nitrogen (0, 50 and 100 kg ha^{-1}), phosphorous (0, 20 and 40 kg ha^{-1}) and potassium (0. 30 and 60 kg ha^{-1}), and was laid out in factorial randomized block design with three replications. The results revealed significant differences in growth and yield parameters among the treatments. Application of nitrogen at 100 kg ha^{-1} recorded the maximum values for plant spread (427.75 cm^{-2}) and number of seeds (57.52) per pod. Significant differences were also observed with the interaction of NPK at 50:40:30 kg ha^{-1} producing pods of good size (3.84 cm^{-2}), higher test weight of 1000 seeds (2.38 g) and seed yield (17.45 q ha^{-1}).

Singh and Singh (1999) indicated that the moderate doses of nitrogen and phosphorous fertilizer increase the seed yield of black cumin.

Girma and Taddesse (2013) conducted to find out effect of nitrogen and phosphorous rates on yield and yield components of Ethiopian cumin. The treatment consisted of four levels of nitrogen (0, 50, 100 and 150 kg ha-1) and four levels of phosphorous (0, 25, 50 and 75 kg ha^{-1} in form of P_2O_5). Main and interaction effects of fertilizer significantly improved plant height, number of secondary and tertiary branches $plant^{-1}$, number of umbels $plant^{-1}$, dry matter yield, seed yield, essential oil content and essential oil yield. Number of seeds $umbel^{-1}$ was influenced only by the main effect of fertilizer while number of primary branches and 1000- seed weight were remained unaffected. Combined effect of 100 kg N ha^{-1} and 50 kg P_2O_5 ha^{-1} gave maximum significant total dry matter yield (3307 kg ha^{-1}), seed yield (1072 kg ha^{-1}) and essential oil yield (39.0 L ha^{-1}).

Hammo (2008) conducted during the season 2005-2006 in singar-Mosul city to investigate the effects of high level (280 N, 260 P_2O_5) kg ha^{-1} and very high level (320 N, 300 P_2O_5) kg ha^{-1}fertilizer, pinch and without pinch, and plant seed rate sowing (0.6, 0.8, 1.0, 1.2) g/10m^2 cultivated within 3, 4, 5, 6 rows respectively in (10) m^2 plot area on growth and yield of *Nigella sativa* L. The experiment was laid out in a Randomized Complete Block Design (factorial) with three replications. The result indicated that very high level of nitrogen and phosphorous caused a significant increase in plant length, stem diameter, fresh weight, plant seed yield and total seeds yield kg/ha, were as branch number and fruit number cannot be affected significantly by previous factor. Pinching causes a significantly increased in branch number and fruit number while plant high decreased significantly. Increased seed rate sowing from 0.6 to 1.2 g/10m^2 caused a significant increasing in branch number, fresh weight and plant seed yield while stem diameter and fruit number didn’t effected significantly by this factor except total seeds yield kg/ha which increased significantly when seed rate sowing are increased to 1.2 g/10 m^2 and they reach 651.85, 843.56, 1076.51, 1232.67 kg ha^{-1} for the four seed rate consecutively.

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out during *rabi* season (November to March) of 2013-14 to evaluate the effect of nitrogen and phosphorous on morphological parameters and yield of black cumin (*Nigella sativa* L.).

3.1 Experimental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. 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.

3.2 Climatic condition

The experimental area 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 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 Materials

3.4.1 Seed

In this experiment black cumin variety of BARI Kalozira 1 was used in the experiment as a planting material.. BARI Kalozira-1 was developed by Bangladesh Agricultural Research Institute (BARI) in 2009. The seed was collected from the Regional Spice Research Centre, BARI, Joydebpur, Gazipur.

3.4.2 Fertilizers

The recommended doses of MP, was added to the soil of experimental field along with different levels of Nitrogen (N) and Phosphorous (P). However any fertilizer was not applied to control plot.

3.5 Methods

3.5.1 Treatments

Factor A: 4 levels of N	Factor B: 4 level of P
N_0 = 0 kg N ha^{-1}	P_0 = 0 kg N ha^{-1}
N_1 = 30 kg N ha^{-1}	P_1= 10 kg N ha^{-1}
N_2 = 60 kg N ha^{-1}	P_2 =20 kg N ha^{-1}
N_3= 90 kg N ha^{-1}	P_3= 30 kg N ha^{-1}

3.5.2 Treatment combination

There were 16 treatment combinations of different N and P doses used in the experiment which are as follows:

1. N_0P_0	9. N_2P_0
2. N_0P_1	10. N_2P_1
3. N_0P_2	11. N_2P_2
4. N_0P_3	12. N_2P_3
5. N_1P_0	13. N_3P_0
6. N_1P_1	14. N_3P_1
7. N_1P_2	15. N_3P_2
8. N_1P_3	16. N_3P_3

3.5.3 Design and layout

The experiment consisted of 16 treatment combinations and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The total plot number was 16 x 3 = 48. The unit plot size was 3 m x 1.2 m (3.6 m^2). The distance between block to block was 1 m and distance between plot to plot was 0.5 m and used plant spacing was 15 cm X 10 cm.

3.5.4 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 16 November, 2013. According to the lay out of the experiment the entire experimental area was divided into blocks and subdivided into plot for the sowing of black cumin seed. In addition, irrigation and drainage channels were prepared around the plot.

3.5.5 Fertilization

In this experiment fertilizers were used under as follows:

Fertilizers	**Doses**
Urea	As per treatment
TSP	As per treatment
MP	75 kg ha^{-1}

The source of N, P and K were urea, triple super phosphate, muriate of potash. Half of urea and total amount of all other fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days of sowing (DAS).

3.5.6 Sowing of seed

3.5.7 Sowing was done on 20 November, 2013 in rows 10 cm apart. Seeds were sown continuously in rows at the rate of 6 kg/ha. After sowing; the seeds were covered with soil and slightly pressed by hand.

3.5.8 Thinning and weeding

The optimum plant population, 60 plants/ m^2 was maintained by thinning excess number of plants from the row at 15 days after sowing (DAS). The plant to plant and row to row distance was maintained as 10 cm and 15 cm, respectively. One weeding with khurpi was done on 25 DAS.

3.5.9 Irrigation

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

3.5.10 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 sprayed twice at 15 days interval @ 2 ml L^{-1} of water to control aphid. Ssome 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.

3.5.11 Harvesting and threshing

Previous 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 pod in terminal matures. After collecting sample plants, harvesting was started on March 15 and completed on March 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.

3.5.11 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.

3.6 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 10 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. Days to 50% germination
2. Plant height at different growth stages (from 25 DAS to 115 DAS)
3. Leaves plant $^{-1}$ at different growth stages (from 25 DAS to 115 DAS)
4. Primary branches plant^{-1}
5. Secondary branches plant^{-1}
6. Day to first flowering
7. Capsules plant^{-1}
8. Seed capsule^{-1}
9. 1000 seed weight
10. Seed yield plot^{-1}
11. Seed yield

3.6.1 Days to 50% germination

The date of 50% germination on the seed was recorded, and the period required in days from the date of sowing was calculated. The date of opening of the first germination of fifty percent was considered as the date of 50% germination.

3.6.2 Plant height

Plant height was measured ten times at 10 days interval such as 25, 35, 45, 55, 65, 75, 85, 95, 105 and 115 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 value was calculated for each treatment.

3.6.3 Leaves plant^{-1}

Number of leaves per plant was counted ten times at 10 days interval such as 25, 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS of black cumin plants. Mean values of data were calculated and recorded.

3.6.4 Primary branches plant^{-1}

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

3.6.5 Secondary branches plant^{-1}

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

3.6.6 Days to first flowering

The date of first flowering on the sample plants was recorded, and the period required in days from the date of sowing was calculated.

3.6.7 Capsules plant^{-1}

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

3.6.8 Seeds Capsule^{-1}

The number of seed from ten capsules were counted and calculated as per capsule basis.

3.6.9 1000 seed weight

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

3.6.10 Seed weight plot^{-1}

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

3.6.11 Yield

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

3.7 Data analysis

The data obtained from the experiment were subjected to statistical analysis through MSTAT-C Software following analysis of variance technique (Russell 1986). The mean differences were done through Tukey's W Test method.

CHAPTER IV

RESULTS AND DISCUSSION

The results on effectiveness of various treatments of nitrogen and phosphorous including untreated control for achieving quality and higher yield of black cumin have been described and discussed below in details under the following head:

4.1 Days to 50% germination

4.1.1 Effect of nitrogen

The different nitrogen levels had no significant effect on days to 50% germination. However, the maximum time of 50% germination was observed in N_3 (90 kg N ha^{-1}) (12.42 days) and N_1 (30 kg N ha^{-1}). The control treatment was the earliest in germination (12.08 days) (Table 1).

4.1.2 Effect of phosphorous

There was a no significant difference among the phosphorous level in respect of days to 50% germination (Table 2). Delayed germination (12.67 days) was found in 10 kg P N ha^{-1} (P_1) and the germination was the earliest (11.752 days) in 20 kg P N ha^{-1}.

4.1.3 Interaction effect of nitrogen and phosphorous

The combined effect of different nitrogen and phosphorous put no significant effect on days to 50% germination (Table 3). However, the treatment combination N_2P_2 and N_2P_1 took minimum days (11.33 days) maximum days (13.67 days), respectively to reach days to 50% germination.

Table 1. Effect of nitrogen levels on days to 50% germination and plant height of black cumin at different growth stages

Treatment	Days After Sowing (DAS)									
	Days to 50% germination	25	35	45	55	65	75	85	95	105	115
N_0 (0 kg ha^{-1})	12.08	1.28	1.95 b	4.875 b	16.42 d	28.92 b	40.42 c	52.92 c	52.5 b	53.92 b	53.92 b
N_1(30 kg ha^{-1})	12.42	1.29	2.53 ab	5.22 ab	20.42 c	31.67ab	42.00 bc	54.00 bc	53.67 b	54.75 ab	54.75 ab
N_2 (60 kg ha^{-1})	12.33	1.31	2.66 ab	5.51 ab	21.67 b	33.50 a	44.08 ab	57.58 ab	57.08 a	58.17 ab	58.17 ab
N_3 (90 kg ha^{-1})	12.42	1.31	2.91a	6.08 a	22.83 a	35.33 a	45.17 a	58.83 a	58.25 a	59.92 a	59.92 a
SE (±)	0.66	0.08	0.10	0.12	0.15	0.58	0.38	0.51	0.27	0.51	0.71
CV (%)	11.34	11.21	7.51	5.83	7.99	6.78	3.69	3.98	3.19	2.86	2.50

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey's W Test.

Table 2. Effect of phosphorous levels on days to 50% germination and plant height of black cumin at different growth stages

Treatment	Days After Sowing (DAS)										
	Days to 50% germination	25	35	45	55	65	75	85	95	105	115
P_0 (0 kg ha^{-1})	12.33	1.33	2.44	5.28	19.42 c	31.50	41.67	47.58 b	54.58	54.8 3b	55.67 b
P_1 (10 kg ha^{-1})	12.67	1.24	2.46	5.36	19.92 bc	31.67	42.42	48.50 ab	54.92	55.33 b	56.00 ab
P_2 (20 kg ha^{-1})	11.75	1.29	2.54	5.42	20.67 ab	33.08	43.75	49.42 ab	55.50	56.33 b	57.33 ab
P_3 (30 kg ha^{-1})	12.50	1.33	2.61	5.63	21.33 a	33.17	43.83	49.92 a	56.50	56.83 a	57.75 a
SE (±)	0.63	0.08	0.11	0.18	0.15	0.64	0.37	0.27	0.21	0.57	55.67
CV (%)	11.34	11.21	7.51	5.83	7.99	6.78	3.69	3.98	3.19	2.86	2.50

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey's W Test.

Table 3. Combined effect of nitrogen and phosphorous levels on days to 50% germination and plant height of black cumin at different growth stages

Treatment	Days After Sowing (DAS)									
	Days to 50% germination	25	35	45	55	65	75	95	85	105	115
N_0P_0	11.67	1.30	1.90	4.66	15.67	27.67	38.67	51.67	45.30	51.67	52.00
N_0P_1	12.67	1.23	1.83	4.67	16.00	28.33	39.67	52.00	46.30	52.33	53.00
N_0P_2	12.00	1.30	2.00	4.90	16.67	29.67	42.00	52.67	48.70	54.33	55.33
N_0P_3	12.00	1.30	2.07	5.26	17.33	30.00	41.33	53.67	49.70	53.33	55.33
N_1P_0	12.33	1.50	2.43	5.10	19.67	30.67	40.67	52.67	47.00	53.00	53.67
N_1P_1	12.00	1.20	2.47	5.13	20.00	31.00	41.67	53.00	48.00	53.00	53.67
N_1P_2	12.33	1.17	2.57	5.30	20.67	32.00	42.67	53.67	49.00	54.33	55.33
N_1P_3	13.00	1.30	2.67	5.33	21.33	33.00	43.00	55.33	49.70	55.67	56.33
N_2P_0	12.00	1.27	2.60	5.43	20.67	33.00	43.00	56.33	48.70	56.33	56.67
N_2P_1	13.67	1.30	2.63	5.56	21.33	33.00	43.67	56.67	49.30	57.33	57.67
N_2P_2	11.33	1.40	2.67	5.33	22.00	35.00	44.67	57.33	49.30	58.00	58.67
N_2P_3	12.33	1.27	2.73	5.73	22.67	33.00	45.00	58.00	48.70	58.67	59.67
N_3P_0	13.33	1.27	2.83	5.93	21.67	34.67	44.33	57.67	49.30	58.33	60.33
N_3P_1	12.33	1.23	2.90	6.06	22.33	34.33	44.67	58.00	50.30	58.67	59.67
N_3P_2	11.33	1.30	2.93	6.15	23.33	35.67	45.67	58.33	50.70	58.67	60.00
N_3P_3	12.67	1.43	2.97	6.18	24.00	36.67	46.00	59.00	51.70	59.67	59.67
SE (±)	0.6765	0.08	0.11	0.18	0.94	1.27	0.91	1.02	1.12	0.92	0.82
CV (%)	11.34	11.21	7.51	5.83	7.99	6.78	3.69	3.98	3.19	2.86	2.50

Means with without letter in a column are not significantly different at 5% level of significance by Tukey's W Test.

4.2. Plant height

4.2.1. Effect of nitrogen

Plant height was significantly influenced by different levels of nitrogen at 35, 45, 55, 65, 75, 85, 95, 105 and 115 different days after sowing (DAS) except 25 DAS insignificant under the present study (Table 1). Application of 90 kg N ha^{-1} produced the tallest plant 2.91, 6.08, 22.83, 35.33, 45.17, 58.17, 58.25, 58.83, 59.92 and 59.92 cm at 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS, respectively and the control treatment gave the lowest plant height at 35, 45, 55, 65, 75, 85, 95, 105 and 115, respectively. Application of 90 and 60 kg N ha^{-1} gave identical results in respect of plant height al all DAS except 55 DAS. 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 Tuncturk *et al*. (2012).

4.1.1.2 Effect of phosphorous

Application of phosphorous fertilizer significantly increased plant height at 55, 85, 105 and 115 different days after sowing (DAS) (Table 2). The tallest plant was recorded from 30 kg P ha^{-1} at 55, 85, 105 and 115 DAS closely followed by 20 kg P ha^{-1}. The shortest plant was recorded from control treatment at55, 85, 105 and 115 DAS. It is observed that plant height increased with the increased phosphorous levels. THis result is in agreement with the reports of Girma and Taddesse (2013) and Tuncturk *et al.* (2013).

4.2.3 Combined effect of nitrogen and phosphorous

The combination of nitrogen and phosphorous levels had not significant effect on plant height at different growth stages of black cumin (Table 3). However, application of 90 kg N ha^{-1} coupled with 30 kg P ha^{-1} (N_3P_3) gave the tallest plant at different growth stages, which was closely followed by N_2P_2. The Control treatment (N_0P_0) gave the lowest plant height (1.171.83, 4.66, 15.67, 27.67, 38.67 , 51.67 , 45.30, 51.67, and 52.00 cm at 25, 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS respectively) at different days after sowing. This finding is in agreement with reports of Tuncturk *et al.* (2013).

4.3 Leaves plant^{-1}

4.3.1 Effect of nitrogen

Number of leaves plant^{-1} was significantly influenced by different levels of nitrogen application at different days after sowing (DAS) except 35 and 75 DAS (Table 4). Number of leaves plant^{-1} increased with the increase of N doses.. Application of 90 kg N ha^{-1} produced the maximum number of leaves plant^{-1} (8.58, 15.83, 17.25, 24.75, 71.08, 72.67, 74.17 and 74 at 25, 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS, respectively) which was followed by 60 Kg N ha^{-1} at 25, 45, 55 and 95 DAS and the control treatment gave the lowest result (5.50, 10.08, 13.58, 19.58, 49.92, 51.42, 51.50 and 51.92 at 25, 45, 55, 65, 85, 95, 105 and 115 DAS, respectively).

4.3.2 Effect of phosphorous

Application of phosphorous fertilizer significantly increased number of leaves plant^{-1} at 85, 105 and 115 DAS (Table 5). The maximum number of leaves plant^{-1} (62.67, 64.92 and 65.42) was observed at 85, 105 and 115 DAS, respectively when phosphorous was applied @ 30 kg ha^{-1}. The minimum number of leaves plant^{-1} (58.50, 60.67, and 60.92) was recorded at 85, 105 and 115 DAS, respectively) no phosphorous was applied to the soil.

4.3.3 Interaction effect of nitrogen and phosphorous

The combination of nitrogen and phosphorous levels had only significant effect on number of leaves plant^{-1} at 95 DAS (Table 6). Application of 90 kg N ha^{-1} along with 30 kg P ha^{-1} (N_3P_3) gave the highest number of leaves plant^{-1} (74.67) at 95 DAS closely followed by N_2P_2, N_2P_3, N_3P_0, N_3P_1 and N_3P_2 and the control treatment (N_0P_0) gave the lowest number of leaves plant^{-1} (49.30) at 95 DAS.

Table 4. Effect of nitrogen levels on number of leaves per plant of black cumin at different growth stages

Treatment	Days After Sowing (DAS)									
	25	35	45	55	65	75	95	85	105	115
N_0 (0 kg ha^{-1})	5.50 c	7.50	10.08 c	13.58 ab	19.58 c	43.58	49.92 c	51.42 c	51.50 c	51.92 c
N_1 (30 kg ha^{-1})	6.58 bc	8.42	11.75 bc	13.25 b	20.75 c	45.17	54.58 c	55.33 bc	57.33 c	57.33 c
N_2 (60 kg ha^{-1})	7.75 ab	8.42	14.00 ab	15.33 ab	22.50 b	45.08	64.75 b	66.50 ab	68.00 b	68.67 b
N_3 (90 kg ha^{-1})	8.58 a	9.75	15.83 a	17.25 a	24.75 a	47.58	71.08 a	72.67 a	74.17 a	74.75 a
SE (±)	0.19	0.36	0.40	0.53	0.22	0.98	0.85	1.63	0.82	0.77
CV (%)	9.66	8.05	6.41	10.34	7.36	6.91	5.98	5.16	4.05	4.14

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey's W Test.

Table 5. Effect of phosphorous levels on number of leaves per plant of black cumin at different growth stages

Treatment	Days After Sowing (DAS)									
	25	35	45	55	65	75	85	95	105	115
P_0 (0 kg ha^{-1})	6.83	8.25	12.17	14.58	20.92	43.75	58.50 b	59.25	60.67 b	60.92 b
P_1 (10 kg ha^{-1})	7.25	8.42	12.42	14.67	21.75	44.17	57.92 b	59.42	62.08 ab	62.58 ab
P_2 (20 kg ha^{-1})	7.25	8.67	13.17	15.08	22.25	46.08	61.25 ab	62.83	63.33 ab	63.75 ab
P_3 (30 kg ha^{-1})	7.08	8.75	13.92	15.08	22.67	47.42	62.67 a	64.42	64.92 a	65.42 a
SE (±)	0.20	0.39	0.44	0.53	0.22	0.85	0.98	1.82	0.82	0.66
CV (%)	9.66	8.05	6.41	10.34	7.36	6.91	5.98	5.16	4.05	4.14

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey's W Test.

Table 6. Combined effect of nitrogen and phosphorous on number of leaves per plant of black cumin at different growth Stages

Treatment	Days After Sowing (DAS)									
	25	35	45	55	65	75	85	95	105	115
N_0P_0	5.33	7.00	9.00	13.33	18.33	41.33	48.67	49.30 ef	49.30	49.70
N_0P_1	5.67	7.33	9.33	14.33	19.67	41.67	49.33	51.30 def	51.30	51.70
N_0P_2	5.667	8.00	10.33	13.67	20.00	44.67	49.67	51.30 def	52.00	52.70
N_0P_3	5.33	7.67	11.67	13.00	20.33	46.67	52.00	53.70 def	53.30	53.70
N_1P_0	6.33	8.33	11.33	13.67	20.00	42.67	56.67	56.30 def	56.30	56.00
N_1P_1	6.67	8.67	11.33	12.33	20.67	44.67	48.00	48.00 f	56.30	56.70
N_1P_2	6.66	8.67	12.00	13.33	21.00	45.67	56.33	58.33 cde	57.70	57.70
N_1P_3	6.66	8.00	12.33	13.67	21.33	47.67	57.33	58.67 be	59.00	59.00
N_2P_0	7.33	8.33	13.33	14.67	21.33	43.67	58.67	60.00 bcd	64.30	65.00
N_2P_1	7.67	8.33	13.67	15.00	22.33	43.33	65.00	67.00 abc	67.70	68.30
N_2P_2	8.00	8.33	14.00	15.67	23.00	46.33	66.67	68.33 ab	69.00	69.30
N_2P_3	8.00	8.67	15.00	16.00	23.33	47.00	68.67	70.67 a	71.00	72.00
N_3P_0	8.33	9.33	15.00	16.67	24.00	47.33	70.00	71.33 a	72.70	73.00
N_3P_1	9.00	9.33	15.33	17.00	24.33	47.00	69.33	71.33 a	73.00	73.70
N_3P_2	8.67	9.67	16.33	17.67	25.00	47.67	72.33	73.33 a	74.70	75.30
N_3P_3	8.33	10.67	16.67	17.67	25.67	48.33	72.67	74.67 a	76.30	77.00
SE (±)	0.40	0.39	0.48	0.88	0.93	5.23	2.07	1.83	1.47	1.51
CV (%)	9.66	8.05	6.41	10.34	7.36	6.91	5.98	5.16	4.05	4.14

Means with same or without letters in a column are not significantly different at 5% level of significance by Tukey's W Test.

4.4 Days to first flowering

4.4.1 Effect of nitrogen

Different nitrogen levels had significant effect on days to first flowering (Table 7). Application of 90 kg N ha^{-1} took maximum days (60.92) to reach 1^{st} flowering stage which was statistically similar to 60 kg and 30 kg N ha^{-1}. The control treatment was found the earliest in flowering (58.00 days).

4.4.2 Effect of phosphorous

There was a no significant difference among different phosphorous levels in respect of days to first flowering (Table 8). However, delayed flowering was found in 30 kg P ha^{-1} (P_3) 59.17 days) and the earliest flowering was found in control treatment (58.75 days).

4.4.3 Interaction effect of nitrogen and phosphorous

The combined effect of different nitrogen and phosphorous levels put no significant effect on days to first flowering (Table 9). However, maximum days required for first flowering were found in N_3P_3 (61.33 days), while it was minimum in N_0P_0 treatment combination (57.33 days).

4.5 Primary branches $plant^{-1}$

4.5.1 Effect of nitrogen

Number of primary branches $plant^{-1}$ was significantly influenced by different rates of nitrogen application at different days after sowing (DAS) under the present study (Table 7). The highest number of primary branches $plant^{-1}$ was recorded from 90 kg N ha^{-1} (N_3) (9.17). The lowest number of primary branches $plant^{-1}$ was observed from control treatment (N_0) (4.92). Number of primary branches $plant^{-1}$ increased with the increased nitrogen doses. These findings were in consonance with those of Tuncturk *et al*. (2012).

4.5.2 Effect of phosphorous

Application of phosphorous fertilizer significantly influenced number of primary branches $plant^{-1}$ (Table 8). The maximum number of primary branches $plant^{-1}$ was recorded 30 kg P ha^{-1} (7.33) which was identical with 20 kg P ha^{-1}. The minimum number of primary branches $plant^{-1}$ was recorded from control treatment (6.58). This corroborates the results of Rana *et al.* (2012).

Table 7. Effect of nitrogen on days to first flowering, yield attributes and yield of black cumin

Treatment	Days to first flowering	Primary branches plant^{-1} (no.)	Secondary branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	1000 seed weight (g)	Seed yield plot^{-1} (g)	Seed yield (kg/ha)
N_0 (0 kg ha^{-1})	58.00 b	4.92 b	8.25 c	10.42 c	70.56 c	2.13 b	238.90 c	607.70 d
N_1 (30 kg ha^{-1})	57.92 ab	6.92 b	9.67 bc	15.44 b	84.48 b	2.54 ab	313.00 b	865.70 c
N_2 (60 kg ha^{-1})	59.00 ab	6.92 b	12.00 ab	20.11 a	90.53b	2.79 ab	473.80 a	1283.00 b
N_3 (90 kg ha^{-1})	60.92 a	9.17 a	13.67 a	20.91 a	101.00 a	3.04 a	488.70 a	1330.00 a
SE (±)	0.35	0.28	0.41	0.49	4.50	0.09	4.50	5.01
CV (%)	2.95	10.48	6.53	3.39	10.08	4.71	6.80	8.23

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey;s W Test. Plot area: 3.6 m^2

Table 8. Effect of phosphorous on days to first flowering, yield attributes and yield of black cumin

Treatment	Days to first flowering	Primary branches plant^{-1} (no.)	Secondary branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	1000 seed weight (g)	Seed yield plot^{-1} (g)	Seed yield (kg/ha)
P_0 (0 kg ha^{-1})	58.75	6.58 b	10.00 c	13.43 b	78.52 c	2.44 b	312.00 c	806.10 c
P_1 (10 kg ha^{-1})	58.92	6.75 b	10.50 c	15.56 b	83.69 bc	2.61 ab	365.60 b	1008.00 b
P_2 (20 kg ha^{-1})	59.00	7.25 a	10.83 b	18.70 a	89.95 ab	2.67 ab	414.70 a	1130.00 a
P_3 (30 kg ha^{-1})	59.17	7.33 a	12.25 a	19.18 a	94.43 a	2.79 a	422.00 a	1142.00 a
SE (±)	0.23	0.38	0.37	0.37	4.86	0.08	4.54	4.66
CV (%)	5.95	10.5	6.53	3.39	15.08	4.71	6.80	8.23

Means with uncommon letters in a column are significantly different at 5% level of significance by Tukey's W Test. Plot area: 3.6 m^2

Table 9. Combined effect of nitrogen and phosphorous on days to first flowering, yield attributes and yield of black cumin

Treatment	Days to first flowering	Primary branches plant^{-1} (no.)	Secondary branches plant^{-1} (no.)	Capsules plant^{-1} (no.)	Seeds capsule^{-1} (no.)	1000 seed weight (g)	Seed yield plot^{-1} (g)	Seed yield (kg ha^{-1})
N_0P_0	57.33	4.67	7.333	7.00 h	59.67	1.87	184.30 g	333.30 g
N_0P_1	59.00	4.67	8.333	10.00 g	67.00	2.07	237.90 fg	645.20 f
N_0P_2	57.67	5.33	8.00	12.00 f	75.63	2.10	265.10 f	721.80 ef
N_0P_3	58.00	5.oo	9.33	12.70 ef	79.93	2.47	268.30 f	730.40 ef
N_1P_0	58.67	6.67	8.66	12.80 ef	72.27	2.30	265.10 f	728.00 ef
N_1P_1	57.67	7.00	9.33	14.20 e	79.57	2.57	288.90 ef	837.80 def
N_1P_2	60.00	7.00	10.00	17.20 cd	91.36	2.64	348.10 de	947.60 cde
N_1P_3	59.67	7.00	10.67	17.50 cd	94.72	2.67	349.80 de	949.30 cde
N_2P_0	58.00	6.33	11.33	16.60 d	89.29	2.63	390.40 cd	1052.00 bcd
N_2P_1	58.33	6.33	11.00	18.60 bc	91.33	2.83	464.50 abc	1265.00 ab
N_2P_2	57.67	7.33	11.33	22.40 a	104.30	2.83	511.20 a	1378.00 a
N_2P_3	57.67	7.67	14.33	22.80 a	97.26	2.87	532.60 a	1435.00 a
N_3P_0	61.00	8.67	12.67	17.30 cd	92.88	2.94	408.30 bcd	1111.00 bc
N_3P_1	60.67	9.00	13.33	19.40 b	96.88	2.97	471.20 ab	1283.00 ab
N_3P_2	60.67	9.33	14.00	23.25 a	106.50	3.10	534.40 a	1440.00 a
N_3P_3	61.33	9.67	14.67	23.7 a	107.90	3.17	545.90 a	1471.00 a
SEm (±)	1.00	0.42	0.411	0.33	7.54	0.07	14.85	42.56
CV(%)	5.95	10.50	6.53	3.39	15.08	4.71	6.8	8.23

Means without letters in a column are not significantly different at 5% level of significance by Tukey's W Test. DAS = Days after sowing, Plot area: 3.6 m^2
N_0 (0 kg ha^{-1}), N_1 (30 kg ha^{-1}), (60 kg ha^{-1}), (90 kg ha^{-1}), P_0 (0 kg ha^{-1}), P_1 (10 kg ha^{-1}), P_2 (20 kg ha^{-1}) and P_3 (30 kg ha^{-1}).

4.6 Secondary branches plant^{-1}

4.6.1 Effect of nitrogen

Number of secondary branches plant^{-1} was significantly influenced by different levels of nitrogen at different days after sowing (DAS) under the present study (Table 7). The highest number of secondary branches plant^{-1} was recorded from 90 kg N ha^{-1} (N_3) (13.67) which were identical with 60 kg N ha^{-1}. The lowest number of secondary branches plant^{-1} was observed from control treatment (N_0) (8.25). Number of secondary branches plant^{-1} increased with the increase of nitrogen doses. These findings were in agreement with those of Tuncturk *et al*. (2012.

4.6.2 Effect of phosphorous

Application of phosphorous fertilizer significantly influenced number of secondary branches plant^{-1} (Table 8). The maximum number of secondary branches plant^{-1} was recorded from the application of 30 kg P ha^{-1} (12.25). The minimum number of branches plant^{-1} was recorded from control treatment (10.00).

4.6.3 Interaction effect of nitrogen and phosphorous

The combination of nitrogen and phosphorous levels had not significant effect on number of secondary branches plant^{-1} of black cumin (Table 9). However, the highest number of secondary branches plant^{-1} was observed at 90 kg N ha^{-1} along with 30 kg P ha^{-1} (N_3P_3) (14.67) . The lowest number of secondary branches plant^{-1} was recorded from N_0P_0 treatment (7.33).

4.7 Capsules plant^{-1}

4.7.1 Effect of nitrogen

The number of capsules plant^{-1} was significantly affected by different levels of nitrogenous fertilizers (Table 7). Number of capsules plant^{-1} increased with the increase level of nitrogen. The highest number of capsules plant^{-1} was recorded at 90 kg N ha^{-1} (20.91) which was statistically similar to 60 kg N ha^{-1}. The lowest number of capsules plant^{-1} was recorded from no nitrogen application (control) (10.42). Number of capsules plant^{-1} increased with the increase in nitrogen doses. These findings are in agreement with those of Tuncturk *et al*. (2012).

4.7.2 Effect of phosphorous

Significant variations were clearly evident in case of number of capsules plant^{-1} with different phosphorous levels (Table 8). The highest number of capsules plant^{-1} resulted from 30 kg P ha^{-1}(19.18) which was identical with 20 kg Pha^{-1} and the lowest (13.43) was obtained from control treatment. Increase in phosphorous level increased number of capsules plant^{-1}.

4.7.3 Interaction effect of nitrogen and phosphorous

The combination of 90 kg N ha^{-1} and 30 kg P ha^{-1}(N_3P_3) gave the highest number of capsules plant^{-1} (23.71) closely followed by N_3P_2 (23.25), N_3P_2 and N_3P_2 (Table 9). The lowest number of capsules plant^{-1} (7) was obtained from the control combination (N_0P_0) (7.00). The result agreed with Shirmohammadi *et al.* (2014)

4.8 Seeds capsule^{-1}

4.8.1 Effect of nitrogen

Different levels of N fertilizer had significant effect on number of seeds capsule^{-1} of black cumin (Table 7). Number of seeds capsule^{-1} increased with the increase of N levels. Maximum number of seeds capsule^{-1} was recorded from 90 kg N ha^{-1} (100.00) followed by 60 kg N ha^{-1} (90.53) and the control treatment gave the lowest one (70.56).

4.8.2 Effect of phosphorous

Phosphorous levels had significant effect on number of seeds capsule^{-1} (Table 8). Application of 30 kg P ha^{-1} gave the highest number of seeds capsule^{-1} (94.43) which was statistically similar to20kg P ha^{-1} where the control treatment gave the lowest (78.52) number of seeds capsule^{-1}.

4.8.3 Interaction effect of nitrogen and phosphorous

The treatment combination of nitrogen and phosphorous had not significant effect on number of seeds capsule^{-1} under the present study (Table 9). However, the combination of 90 kg N ha^{-1} with 30 kg P ha^{-1} (N_3P_3) supported plants to produce maximum number of seeds capsule^{-1} (107.90) where the lowest one (59.67) was achieved from control treatment (N_0P_0).

4.9 1000 seed weight

4.9.1 Effect of nitrogen

Different levels of N fertilizer had significant effect on 1000 seed weight of black cumin (Table 7). Application of nitrogen at different levels significantly increased the 1000-seed weight up to 90 kg ha^{-1} which produced maximum seed weight (3.04 g) where control treatment gave the lowest seed weight (2.23 g). No significant difference was observed between 90 and 60 kg N ha^{-1} in respect of 1000 seed weight.

4.9.2 Effect of phosphorous

It reveals that phosphorous levels had significant effect on 1000-seed weight (Table.8).The application of phosphorous significantly increased 1000-seed weight. Application of 30 kg P ha^{-1} gave the highest 1000-seed weight (2.79g) where as control treatment gave the lowest (2.44g) 1000-seed weight. . Seed yield increased with the increased phosphorous doses. There was no significance difference observed among 10, 20 and 30 kg P ha^{-1} in respect of 1000 seed weight. Similar findings were also obtained by Tuncturk *et al.* (2013).

4.9.3 Interaction effect of nitrogen and phosphorous

The treatment combination of nitrogen and phosphorous had not significant effect on 1000-seed weight under the present study (Table 12). However, the combination of 90 kg N ha^{-1} with 30 kg P ha^{-1} (N_2P_2) supported plant to produce maximum 1000-seed weight (3.17 g) where the lowest one (1.87 g) was obtained from control treatment (N_0P_0).

4.10 Seed yield plot^{-1}

4.10.1 Effect of nitrogen

In the present study, significant variation was found in seed yield per plot (3.6 m^2) at different nitrogen levels (Table 7). Application of nitrogen at 90 kg ha^{-1} (N_3)

produced the highest seed yield (488.70 g $plot^{-1}$) which was identical with 60 kg N ha^{-1} (473.80 g $plot^{-1}$) and the control treatment gave the lowest seed yield (238.90 g $plot^{-1}$). Seed yield $plot^{-1}$ increased with the increase of nitrogen doses. These findings are in agreement with Tuncturk *et al*. (2012).

4.10.2 Effect of phosphorous

Significant variation in seed yield per plot (3.6 m^2) was observed among the application of different phosphorous levels represented in Table 8. Application of phosphorous @ 30 kg ha^{-1} gave the highest seed yield (422.00 g $plot^{-1}$) which was statistically similar with P_2 (414.70 g $plot^{-1}$). Seed yield increased with the increasing application of phosphorous fertilizer. The lowest seed yield (312.00 g $plot^{-1}$) was obtained from control treatment. Similar findings were also obtained by Tuncturk *et al.* (2013).

4.11.3 Interaction effect of nitrogen and phosphorous

Nitrogen and phosphorous fertilizer in combination put significant effect on per plot (3.6 m^2) seed yield and it was significantly superior (545.90 g $plot^{-1}$) at 90 kg N ha^{-1} with 30 kg P ha^{-1} (N_3P_3). There was no significant difference among N_3P_3, N_3P_2, N_3P_1, N_2P_3, N_2P_2 and N_2P_1 in respect of seed yield $plot^{-1}$. But control treatment (N_0P_0) gave the lowest seed yield (184.30 g $plot^{-1}$).

4.11 Seed yield

4.11.1 Effect of nitrogen

Significant variation was found in seed yield per hectare at different nitrogen levels (Table 7). Nitrogen at 90 kg ha^{-1} (N_2) produced the highest seed yield (1330.00 kg ha^{-1}) and control treatment gave the lowest seed yield (607.70kg ha^{-1}). Application of 60 kg N ha-1 gave the second highest seed yield per hectare.

Relationship between seed yield of black cumin with nitrogen

There was a significant and high degree positive linear correlation between seed yield of black cumin with nitrogen levels (Fig. 1). The regression line (y = 8.614 N + 633.9, R^2 = 0.929**) stated that seed yield increased at the rate of 8.614 kg ha^{-1}

for per unit change of nitrogen levels. The R^2 value indicated that 92.9% seed yield was attributed due to N levels. These findings were in agreement with those of Tuncturk *et al*. (2012).

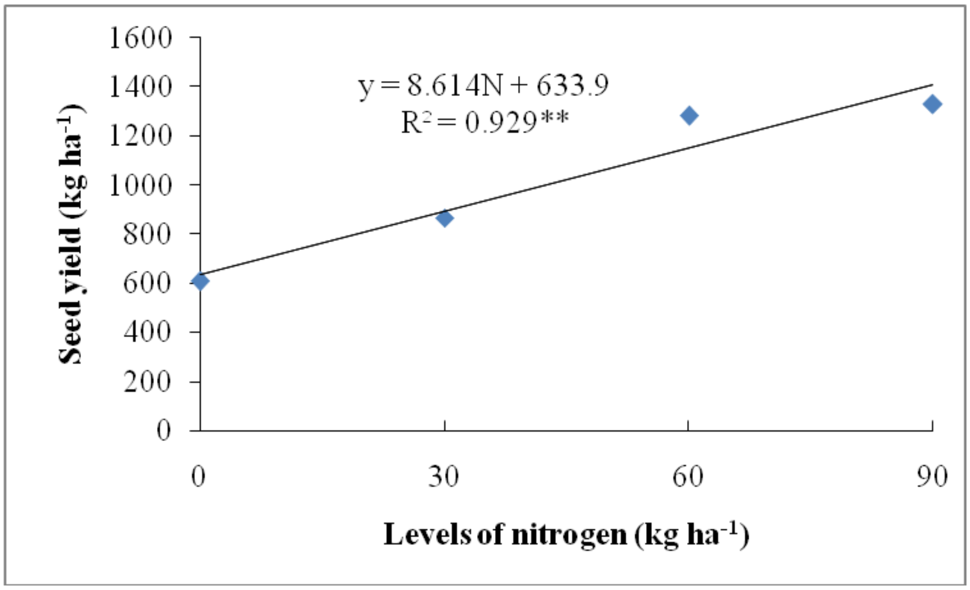


Fig. 1. Relationship between nitrogen levels and seed yield of black cumin

4.11.2 Effect of phosphorous

Significant variation was observed in seed yield per hectare among the application of different phosphorous levels (Table 8). Application of 30 kg P ha^{-1} gave the highest seed yield which was statistically similar with 20 kg p ha^{-1} (P_2 treatment) (1142.00 kg ha^{-1}). The lowest seed yield was obtained from control treatment (806.10 kg ha^{-1}).

Relationship between seed yield of black cumin with phosphorous

There depicted a significant positive linear correlation between seed yield per hectare with phosphorous levels (Fig. 2). The regression line (y = 11.29P + 852.0, R^2 = 0.875**) stated that seed yield increased at the rate of 11.29 kg ha^{-1} for per unit change of nitrogen levels. The R^2 value indicated that 87.50% seed yield was attributed due to P levels. These findings were in agreement with those of Tuncturk *et al.* (2013).

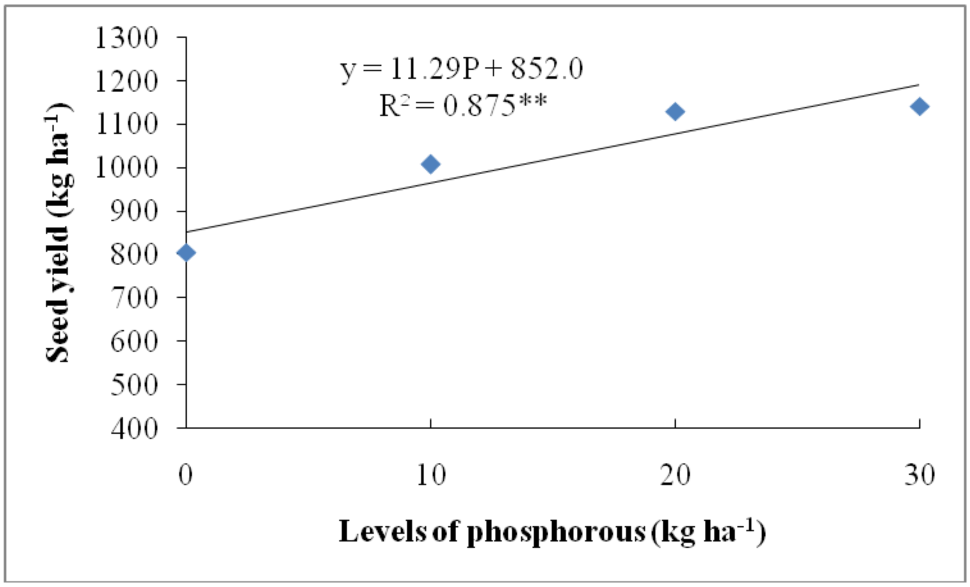


Fig. 2. Relationship between phosphorous and seed yield of black cumin

4.11.3 Interaction effect of nitrogen and phosphorous

Nitrogen and phosphorous in combination influenced per hectare seed yield (Table 9). Application of 90 kg N ha^{-1} coupled with 30 kg P ha^{-1} (N_3P_3) gave the maximum seed yield(1471.00 kg ha^{-1}) closely followed by N_3P_2 (1440.00 kg), N_2P_3 (1435.00 kg ha^{-1}), N_2P_2 (1378.00 kg ha^{-1}), N_3P_1 (1283.00 kg ha^{-1}),and N_2P_1 (1265.00 kg ha^{-1}). But the treatment combination (N_0P_0) gave the lowest seed yield (333.30 kg ha^{-1}). Girma and Taddesse (2013) observed significantly higher seed yield up to 100 kg N ha^{-1} in combination up to 50 P_2O_5 kg ha^{-1} (22.00 kg P ha^{-1}) for black cumin plant. But Nataraja *et al.* (2003) obtained higher seed yield of black cumin at 50 kg N ha^{-1} in combination with 40 kg P ha^{-1}.

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted at the Farm of Sher-e-Bangla Agricultural University, Dhaka to evaluate the effect of nitrogen and phosphorous on morphological parameters and yield of black cumin. The experiment comprised of four levels of nitrogen viz. N_0 (0 kg N ha^{-1}), N_1 (30 kg N ha^{-1}), N_2 (60 kg N ha^{-1}) and N_3 (90 kg N ha^{-1}) and four levels of phosphorous viz. P_0 (0 kg P ha^{-1}), P_1 (10 kg P ha^{-1}), P_2 (20 kg P ha^{-1}), and P_3 (30 kg P ha^{-1}). The experiment was set up in Randomized Complete Block Design (factorial) with three replications. There were 16 treatment combinations in all.

Data on different growth and yield parameters such as days to 50% germination Plant height, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant, days to first flowering, number of capsule per plant, number of seed per capsule, 1000 seed weight, Seed yield per plot and Seed yield per hectare were recorded and analyzed statistically.

The different nitrogen and phosphorous levels independently had no significant effect on days to 50% germination. However, the maximum time of 50% germination was observed in N_3 (90 kg N ha^{-1}) and in 10 kg P N ha^{-1} (P_1) (12.67 days). Plant height was significantly influenced by different levels of nitrogen at 35, 45, 55, 65, 75, 85, 95, 105 and 115 different days after sowing (DAS) except 25 DAS insignificant under the present study. Application of 90 kg N ha^{-1} produced the tallest plant 2.91, 6.08, 22.83, 35.33, 45.17, 58.17, 58.25, 58.83, 59.92 and 59.92 cm at 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS, respectively and the control treatment gave the lowest plant height at 35, 45, 55, 65, 75, 85, 95, 105 and 115, respectively. Application of phosphorous fertilizer significantly increased plant height at 55, 85, 105 and 115 different days after sowing (DAS) The tallest plant was recorded from 30 kg P ha^{-1} at 55, 85, 105 and 115 DAS closely followed by 20 kg P ha^{-1}. The shortest plant was recorded from control treatment at55, 85, 105 and 115 DAS.

Number of leaves plant^{-1} was significantly influenced by different levels of nitrogen application at different days after sowing (DAS) except 35 and 75 DAS. Number of leaves plant^{-1} increased with the increase of N doses. Application of 90 kg N ha^{-1} produced the maximum number of leaves plant^{-1} (8.58, 15.83, 17.25, 24.75, 71.08, 72.67, 74.17 and 74 at 25, 35, 45, 55, 65, 75, 85, 95, 105 and 115 DAS, respectively) which was followed by 60 Kg N ha^{-1} at 25, 45, 55 and 95 DAS and the control treatment gave the lowest result. Application of phosphorous fertilizer significantly increased number of leaves plant^{-1} at 85, 105 and 115 DAS. The maximum number of leaves plant^{-1} (62.67, 64.92 and 65.42) was observed at 85, 105 and 115 DAS, respectively when phosphorous was applied @ 30 kg ha^{-1}. Application of 90 kg N ha^{-1} took maximum days (60.92) to reach 1st flowering stage which was statistically similar to 60 kg and 30 kg N ha^{-1}. The control treatment was found the earliest in flowering (58.00 days). But there was a no significant difference among different phosphorous levels in respect of days to first flowering. The highest number of primary branches plant^{-1} was recorded from 90 kg N ha^{-1} (N_3) (9.17) and the lowest number of primary branches plant^{-1} was observed from control treatment (N_0) (4.92). On the other hand the maximum number of primary branches plant^{-1} was recorded 30 kg P ha^{-1} (7.33) which was identical with 20 kg P ha^{-1}. The minimum number of primary branches plant^{-1} was recorded from control treatment (6.58). The highest number of secondary branches plant^{-1} was recorded from 90 kg N ha^{-1} (N_3) (13.67) which was identical with 60 kg N ha^{-1}. The lowest number of secondary branches plant^{-1} was observed from control treatment (N_0) (8.25). In case of phosphorous fertilization, the maximum number of secondary branches plant^{-1} was recorded from the application of 30 kg P ha^{-1} (12.25). The minimum number of branches plant^{-1} was recorded from control treatment (10.00).

Number of capsules plant^{-1} increased with the increase level of nitrogen. The highest number of capsules plant^{-1} was recorded at 90 kg N ha^{-1} (20.91) which was statistically similar to 60 kg N ha^{-1} and the lowest number of capsules plant^{-1} was recorded from control (10.42). The highest number of capsules plant^{-1} resulted from 30 kg P ha^{-1}(19.18) which was identical with 20 kg P ha^{-1} and the lowest (13.43) was obtained from control treatment. Maximum number of seeds capsule^{-1} was recorded from 90 kg N ha^{-1} (100.00) followed by 60 kg N ha^{-1} (90.53) and the control treatment gave the lowest one (70.56). Regarding phosphorous application of 30 kg P ha^{-1} gave the highest number of seeds capsule^{-1} (94.43) which was statistically similar to 20 kg P ha^{-1} where the control treatment gave the lowest (78.52) number of seeds capsule^{-1}. Application of nitrogen at different levels significantly increased the 1000-seed weight up to 90 kg ha^{-1} which produced maximum seed weight (3.04 g). Application of 30 kg P ha^{-1} gave the highest 1000-seed weight (2.79g) where as control treatment gave the lowest (2.44g) 1000-seed weight.

Application of nitrogen at 90 kg ha^{-1} (N_3) produced the highest seed yield (488.70 g plot^{-1}) which was identical with 60 kg N ha^{-1} (473.80 g plot^{-1}) and the control treatment gave the lowest seed yield (238.90 g plot^{-1}). Application of phosphorous @ 30 kg ha^{-1} gave the highest seed yield (422.00 g plot^{-1}) which was statistically similar with P_2 (414.70 g plot^{-1}). Seed yield increased with the increasing application of phosphorous fertilizer. The lowest seed yield (312.00 g plot^{-1}) was obtained from control treatment. Nitrogen at 90 kg ha^{-1} (N_2) produced the highest seed yield (1330.00 kg ha^{-1}) and control treatment gave the lowest seed yield (607.70kg ha^{-1}). Application of 30 kg P ha^{-1} gave the highest seed yield which was statistically similar with 20 kg p ha^{-1} (P_2 treatment) (1142.00 kg ha^{-1}). The lowest seed yield was obtained from control treatment (806.10 kg ha^{-1}).

There was a significant and high degree positive linear correlation between seed yield of black cumin with nitrogen levels. The regression line (y = 8.614 N + 633.9, R^2 = 0.929**) stated that seed yield increased at the rate of 8.614 kg ha^{-1} for per unit change of nitrogen levels. The R^2 value indicated that 92.9% seed yield was attributed due to N levels. There also depicted a significant positive linear correlation between seed yield per hectare with phosphorous levels (Fig. 2). The regression line (y = 11.29P + 852.0, R^2 = 0.875**) stated that seed yield increased at the rate of 11.29 kg ha^{-1} for per unit change of nitrogen levels. The R^2 value indicated that 87.50% seed yield was attributed due to P levels.

The combined effect of different nitrogen and phosphorous put no significant effect on days to 50% germination and plant height. The combination of nitrogen and phosphorous levels had only significant effect on number of leaves $plant^{-1}$ at 95 DAS and the interaction gave the highest number of leaves $plant^{-1}$ (74.67) at 95 DAS closely followed by N_2P_2, N_2P_3, N_3P_0, N_3P_1 and N_3P_2 and the control treatment (N_0P_0) gave the lowest number of leaves $plant^{-1}$ (49.30) at 95 DAS. The combination of nitrogen and phosphorous levels had not significant effect on days to first flowering, number of primary branches $plant^{-1}$ number of secondary branches $plant^{-1}$, number of seeds $capsule^{-1}$ and 1000 seed weight of black cumin.

Nitrogen and phosphorous fertilizer in combination put significant effect on per plot (3.6 m^2) seed yield and it was significantly superior (545.90 g $plot^{-1}$) at 90 kg N ha^{-1} with 30 kg P ha^{-1} (N_3P_3). There was no significant difference among N3P3, N_3P_2, N_3P_1, N_2P_3, N_2P_2 and N_2P_1 in respect of seed yield $plot^{-1}$. But control treatment (N_0P_0) gave the lowest seed yield (184.30 g $plot^{-1}$). Application of 90 kg N ha^{-1} coupled with 30 kg P ha^{-1} (N_3P_3) gave the maximum seed yield(1471.00 kg ha^{-1}) closely followed by N_3P_2 (1440.00 kg ha^{-1}), N_2P_3 (1435.00 kg ha^{-1}), N_2P_2 (1378.00 kg ha^{-1}), N_3P_1 (1283.00 kg ha^{-1}),and N_2P_1 (1265.00 kg ha^{-1}). But the treatment combination (N_0P_0) gave the lowest seed yield (333.3 kg ha^{-1}).

The results of the present study generated some information which may help increase the higher seed yield of black cumin. Hence the present study may be concluded as follows:

I. Application of 90 kg N ha^{-1} coupled with 30 kg P ha^{-1} gave the higher seed yield of black cumin.

II. Application of 90 kg N ha^{-1} in combination with 20 kg P ha^{-1} or application of 60 kg N ha^{-1} coupled with 30 kg P ha^{-1} gave the reasonable seed yield of black cumin.

RECOMMENDATION

i. Application of 60 kg N ha^{-1} coupled with 30 kg P ha^{-1} was suitable for black cumin cultivation.

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

REFERENCES

Abadi, B. H. M., H. R Ganjali, and H. R Mobasser. 2015. Effect of mycorrhiza and phosphorous fertilizer on some characteristics of black cumin. *An International Journal.* **7**(1): 1115-1120.

Ahmad, Z., A. Ghafoor and M. Aslam, 2004. *Nigella sativa* – A Potential Commodity in Crop Diversification Traditionally Used in Healthcare. Ministry of Food, Agriculture and Livestock, Pakistan. Available on *www.pakistan.gov.pk/fooddivision/ publications/kalingi.pdf.*

Aliyu, L. 2003. Effect of manure type and rate on growth, yield and yield components of pepper. *J. Sustainable Agric. and the Environ.* **5**: 92–98.

Bagshaw, R., L.V. Vaidyanathan and P.H. Nye. 1972. The supply of nutrient ions by diffusion to plants roots in soil. V. Direct determination of labile phosphate concentration gradients in a sandy soil induced by plant uptake. *Plant Soil*. **37**: 617–626.

Balasubramanian, P and S.P. Palaniappan 2001. Principles and Practices of Agronomy. Tata McGraw-Hill Publishing Co. Ltd., New Delhi, India.

Barber, S.A. 1984. Soil nutrient bioavailability: A mechanistic approach. John Wiley & Sons Inc., New York, NY. Pp. 398.

Champawat R. S.V. N. Pathak. 1982. Role of nitrogen, phosphorous and potassium fertilizers and organic amendments in cumin (Cuminum cyminum L.) with incites by *Fusarium oxysporum fsp. cumin*. *Indian J. Agric. Sci.* **58** (9): 728-730.

Ehteramian K. 2002. Effects of nitrogen fertilizer levels on yield and yield components of cumin cultivation in Kooshkak Fars Province, Shiraz University Master's thesis wilderness resource management (In Persian).

Girma, A. and M. Taddesse. 2013. Yield components, agronomic and essential oil yields of white cumin as affected by varying doses of nitrogen and phosphorous. *Intl. J. Agron. Plant. Prod*. **4** (11), 3096-3102.

Hammo, Y. H. 2008. Effect of high level of nitrogen and phosphorous fertilizer, pinching and seed rate on growth and yield components of *Nigella sativa* L. *Mesopotamia J. of agric.* 36 (1).

Hassan, F.A.S., E. F. Ali, and S. A. Mahfouz. 2012. Comparison between different fertilization sources, irrigation frequency and their combinations on the growth and yield of coriander plant. *Australian J. Basic. Appl. Sci.* **6** (3): 600-615.

Kaheni, A., S. H. Ramazani, R. Ganjali, and H. R. Mobaser. 2013. Effect of nitrogen and planting dates on yield of black cumin. *Intl J Agri Crop Sci*. **6** (5), 248-251.

Nataraja, A., A. A. Farooqi, B. S. Sreeramu and K. N. Srinivasappa. 2003. Influence of nitrogen, phosphorous and potassium on growth and yield of black cumin (*Nigella sativa* L.). *J. Spices and Aromatic Crops.* **12** (1): 51-54.

Riaz, M., M. Sayed and F. M. Chaudhary 1996. Chemistry of the medicinal plants of the genus *Nigella*. *Hamdard Medicus*. **39**:40-45.

Sen, N. and Y. Kar. 2012. Pyrolysis of black cumin seed cake in a fixed-bed reactor. *J. Biomass Bioenergy*. **35**: 4297-4304.

Shah, S. H. 2007. Influence of combined application of nitrogen and kinetin on nutrient uptake and productivity of black cumin (*Nigella sativa* L.). *Asian J. Plant Sci.* **6** (2): 403-406.

Shirmohammadi, A. M. Khaje, G. H. Talaei and H. Shahgholi. 2014. Effect of biological phosphate and chemical phosphorous fertilizer on yield and yield components of black cumin (*Nigella sativa* L.). *Agric. Sci. Dev.* **3** (9): pp. 279-283.

Singh, K. K and T. K. Goswami. 2000. Thermal properties of cumin seed. *J. Food Engineering.* **45**(4): 181-187.

Singh, S. K. and S. Singh. 1999. Response of nigella (*Nigella sativa L.*) to nitrogen and phosphorous. *Crop Res. Hisar*. **8**(3): 478-479.

Sushama, P. K. and A. L. Jose. 1994. Nutrition of ginger. *In*: Advances in Horticulture. Vol.9, Plantation and Spices Crops Part 1 (Eds. Chadha, K.L. and P. Rethinam,). Malhotra publishing House, New Delhi. pp. 490-497.

Troug, E. 1973. Mineral nutrition in relation to autogency of plants. *In*: Nutrition of plants. Oxford and IBH publishers, New Delhi, pp. 345.

Tuncturk, M., R. Tuncturk and B. Yıldırım. 2013. The effects of varying phosphorous doses on yield and some Yield Components of black cumin (*Nigella Sativa* L.). *Adv. Environ. Biol*. **5**(2): 371-374.

Tuncturk, R., M. Tuncturk, V. Ciftci. 2012. The effects of varying nitrogen doses on yield and some Yield Components of black cumin (*Nigella Sativa* L.)**.** *Adv. Environ. Biol.,* **6**(2): 855-858.

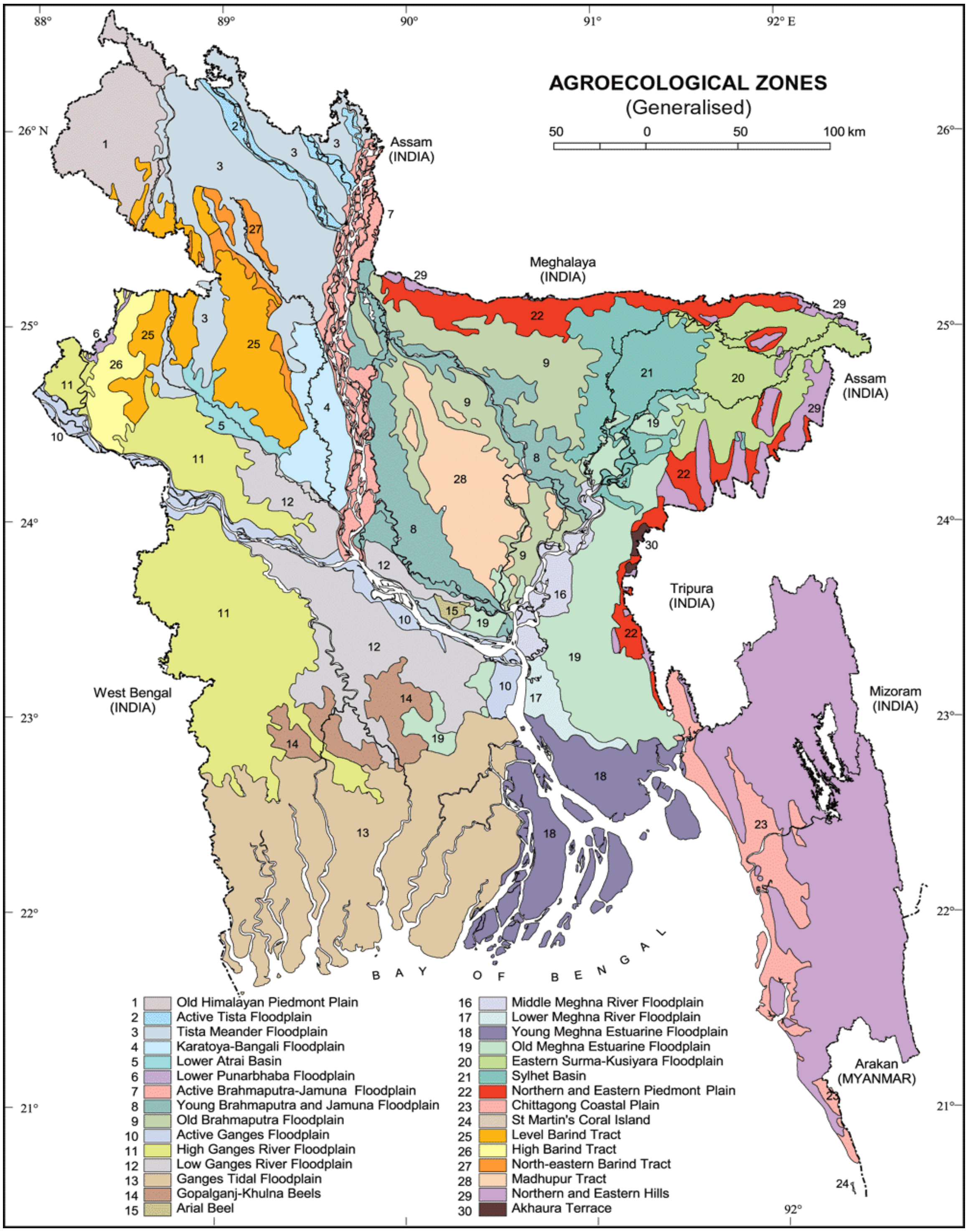
Ustun, G., L. Kent, N. Cekin and H. Civelekoglu. 1990. Investigation of the technological properties of *Nigella sativa* L. seed oil. *JAOCS*, **67**(12): 71**-**86.

Vijay, O. P. and S. K Malhotra. 2002. Seed spices in India and world. Seed spices *Newsletter*. **2(1)**: 1-4.

Zargari, A. 1990. Herbal plants. Tehran university publication, Tehran, Iran, pp 33-34.

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 are analyzed by Soil Resources Development Institute (SRDI), Farmgate, Dhaka.**

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy 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 on days to 50% flowering plant height of black cumin as influenced at nitrogen and phosphorous

Sources of Variation	Degrees of freedom	Mean Square										
		Days to 50% germination	Plant height									
			Days After Sowing (DAS)									
			25	35	45	55	65	75	85	95	105	115
Replication	2	20.438	0.026	0.016	0.97	15.396	0.521	47.146	11.521	5.813	5.146	2.313
Factor A (Nitrogen)	3	0.299	0.002	1.979	3.16**	93.5**	89.91**	54.056	19.021**	89.472**	95.722**	96.188**
Factor B (Phosphorous)	3	1.91	0.021	0.072	0.265	8.5	9.576	13.389	12.743**	8.472	10.00**	12.243**
AB	9	1.373	0.028	0.004	0.048	0.074	1.243	0.444	2.225	0.231	0.981	2.262
Error	30	1.949	0.021	0.036	0.1	2.64	4.81	2.501	3.788	3.124	2.546	2.001

*'**' indicates significant at 1% level of significance*

Appendix IV: Analysis of variance of the data on Number of leaves per plant of black cumin as influence at nitrogen and phosphorous

Sources of Variation	Degrees of freedom	Mean Square									
		Leaves plant^{-1}									
		Days After Sowing (DAS)									
		25	35	45	55	65	75	85	95	105	115
Replication	2	1.271	0.271	1.396	0.646	23.396	121.396	2.646	46.646	85.75	107.646
Factor A (Nitrogen)	3	21.799**	10.299	76.278**	40.632**	60.688**	32.854	1105.556**	1157.58**	1255.222**	1300.06**
Factor B (Phosphorous)	3	0.465	0.632	7.5	0.854	6.799	35.076	60.944**	78.743	39.278**	43.222**
AB	9	0.113	0.502	0.333	1.058	0.15	2.873	22.685	25.595**	2.019	1.796
Error	30	0.471	0.471	0.685	2.357	2.596	9.818	12.89	10.046	6.461	6.846

*'**' indicates significant at 1% level of significance*

Appendix V: Analysis of variance of the data on growth, yield and yield contributing character of black cumin of black cumin as influenced at nitrogen and phosphorous

Sources of Variation	Degrees of freedom	Mean Square							
		Primary branches plant^{-1}	Secondary branches plant^{-1}	Days to first flowering	Capsules plant^{-1}	Seeds capsule^{-1}	1000 seed weight	Seed yield plot $^{-1}$	Seed yield
Replication	2	0.646	4.396	41.271	0.562	185.124	0.015	106.419	3267.209
Factor A (Nitrogen)	3	36.188**	69.632**	23.361**	281.51**	1941.936**	1.841**	179943.1**	1435093**
Factor B (Phosphorous)	3	1.632*	11.188**	0.361**	88.522**	584.836**	0.263**	31155.62**	291579.5**
AB	9	0.243	0.891	1.713	0.706**	170.924	0.026	638.854**	9045.853**
Error	30	0.535	0.507	3.026	0.312	170.782	0.015	301.828	3075.203

*'**', '*' indicates significant at 1% & 5% level of significance, respectively*