EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF RAPESEED

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EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF RAPESEED

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CERTIFICATE

This is to certify that thesis entitled, **"EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND YIELD OF RAPESEED"** 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 SOIL SCIENCE,** embodies the result of a piece of *bona fide* research work carried out by **MAHMUDUR RAHMAN, REGISTRATION NO. 09-03452** 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: **(Prof. Mst. Afrose Jahan)**

Place: Dhaka, Bangladesh **Supervisor**

DEDICATED TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was undertaken at the field of Sher-e-Bangla Agricultural University, during rabi season (October to March) of 2014-15 to study the effect of nitrogen and phosphorus on growth and yield of rapeseed(BARI Sarisha-14). In this experiment, the treatment consisted of four different N levels viz. N_0 = 0 kg ha^{-1}, N_1 = 90 kg ha^{-1}, N_2 = 120 kg ha^{-1} and N_3= 150 kg ha^{-1}, and four different level of P viz. P_0 = 0 kg ha^{-1}, P_1= 15 kg ha^{-1}, P_2 = 25 kg $^{-1}$ha and P_3 =35 kg ha^{-1}. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The seeds were sown at therate of 8 kg ha^{-1}. The 150 kg ha^{-1} N gave the highest plant height, number of leaves per plant, number of branches per plant, length of siliquae, number of siliquae per plant, number of seed per siliquae, thousand seed weight. The maximum yield of seed per hectare (1.43 t) was obtained from 150 kg ha^{-1} N. The highest number of siliquae per plant, thousand seed weight, seed yield (1.45 t) was recorded with 35 kg ha^{-1} P. The interaction between different levels of N and P was significantly influenced on almost all morphological parameters and yield contributing characters including seed yield. The maximum value of morphological parameters, yield contributing characters and seed yield of rapeseed were observed with the combined dose of 150 kg ha^{-1} N along with 35 Kg ha^{-1} P whereas the lowest values were obtained from control, 0 kg/ha N and 0 kg ha^{-1} P treatment combination. The maximum yield of seed per hectare (1.64 t) was obtained from 150 kg ha^{-1} N with 35 Kg ha^{-1} P treatment combination. The highest N, P and K concentration in stover and soil was recorded from 150 kg ha^{-1} N with 35 kg ha^{-1} P treatment.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
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, Phosphorus and Potassium
CV%	=	Percentage of Coefficient of Variance

CHAPTER I

INTRODUCTION

Rapeseed (*Brassica napus* L.) belongs to Brassicaceae family. It is originated from Asia Minor and pacific, but now is cultivating as a main commercial oil crop in Canada, China, Australia, India including Bangladesh. It was reported that rapeseed is a popular crop in crop rotation, which increases cropping intensity since it enhances yields of wheat and barley, and breaks disease cycles in cereal grains.

Rapeseed is the major oilseed crop in Bangladesh covering about 70 % of the total production. The area and production of mustard of our country was about 0.481 million hectares and 0.536 million tons, respectively with an average yield of 1.11 t/ha during 2010-2011 (AIS, 2012). The present domestic edible oilseed production is 267 thousand tons, which meets only one third of national demand.

Domestic production of edible oil almost entirely comes from rapeseed and mustard occupying only about 2% area of total cropped area in Bangladesh (BBS, 2002). The annual oil seed production of 0.41 million tons of which the share of rapeseed-mustard is 0.21 million tons, which comes about 52% of the total edible oil seed production. Mustard covers about 61.2% of the total acreage under oil seed and 52.6% of the total oil seed production in Bangladesh (BBS, 2005). The yield of this crop in Bangladesh is much lower compared to other countries. The average yield of rapeseed-mustard in Bangladesh is very low (0.76 t ha^{-1}) that is less than 50% of the world average (FAO, 2004).

Bangladesh is deficit in edible oil, which costs valuable foreign currency for importing seeds and oil. Annually country is producing about 2.80 Lac m tons of edible oil as against the requirement of 9.80 Lac m tons thus import oil is regular phenomenon of this country (BBS, 2010). Every year Bangladesh imports 7 lac m tons of edible oil to meet up the annul requirement of the country, which costs Tk. 64430 million (BBS, 2007). Both the acreage and production of the crop have been decreasing since 1990 mainly due to ingression of cereal crops like-rice, maize, wheat etc. Delayed harvest of transplanted aman rice and wetness of soil are another reason which hinders mustard cultivation in rabi season (BARI, 2008). Chemical fertilizers have contributed significantly towards the pollution of water, air and soil. So the current trend is to explore the possibility of supplementing chemical fertilizers with organic ones which are eco-friendly and cost effective.

Fertilizer is the depending source of nutrient that high yielding varieties of rapeseed are very responsive to fertilizers especially nitrogen (Gupta *et al*., 1972; Ali and Rahman, 1986; Sharawat *et al.*, 2002 and Patel *et al.*, 2004). Nitrogen (N) is the key element for proper growth and yield of plants. It supports the plant with rapid growth, increasing seed and fruit production and yield of mustard (Sinha *et al*., 2003; Shukla *et al.*, 2002a; Meena *et al*., 2002; Zhao *et al*., 1997 and Allen & Morgan, 2009). Previous reports showed that N has significant effect on plant height, branches plant^{-1}, siliquae plant^{-1} and other growth factors and yield of mustard (Allen and Morgan, 1972; Mondal and Gaffer, 1983). It was also reported that N significantly increased leaf area as well as photosynthetic rate and the use of N either @250 kg/ha or @180 kg/ha thereby produced higher seed yield (Hossain & Gaffer

1997; Singh & Prosad 2003). The oil content of mustard seed significantly decreased with increasing levels of N up to 80 kg/ha whereas oil content increased with increasing levels of phosphorus. In addition, the deficiency of N causes stunted or slow growth, slender fibrous stems and the classic yellowing of the leaves which reduces the seed yield of crops including mustard (Ozer, 2003). Separately, excessive use of N increases the vegetative growth thus food production may be impaired and delayed maturity (Maini *et al.*, 1959; Singh *et a*l., 1972). These results suggest that the optimum dose of N for rapeseed plant growth, seed production and oil content of rapeseed is needed to analyze.

The role of phosphorus in plant growth has been investigated by several investigators (Antoun *et al*, 1996; Hinsinger, 2001; Nikolay *et al.*, 1996; Pant and Reddy, 2003, Shafeek *et al.*, 2004; Warade *et al.*, 1996). All of them agree that the presence of phosphorus (P) in the soil encourages plant growth, because phosphorus is an essential nutrient. Currently, lack of this element would be repaired by the use of biological manure and/or chemical P fertilizers. Phosphorus is one of the key nutrient elements for plant growth and development. Therefore, phosphorus is very vital to increase yield volume of rapeseed. (Shen *et al*., 2006) showed that treating phosphorous- poor soils with phosphorous fertilizer can remarkably increase the seedling dry weight, mature seed yield and the accumulation of different nutrients.

In view of the importance of this crop, attention has to be given to increase its production in order to meet the huge shortage of edible oil in the country. Very few research works have been conducted in our country regarding the growth yield of rapeseed as influenced by different level of nitrogen and phosphorus. Keeping the above stated fact in view, the present study was undertaken in achieving the following objectives:

1. To determine the level of nitrogen on the yield and quantity of rapeseed.
2. To determine the level of phosphorus for on the growth, development and yield of rapeseed.
3. To study the interaction effect of nitrogen and phosphorus on the growth, development and yield of rapeseed.

CHAPTER II

REVIEW OF LITERATUR

Rapeseed is one of the common and most important oil crops of Bangladesh and as well as many countries of the world. In Bangladesh the average productivity of mustard is low in comparison to the developed countries. The crop has received much attention by the researchers on various aspects of its production. Many studies have been carried in many countries of the world. The work so far done in Bangladesh is not adequate and conclusive. Nevertheless some of the important and informative works and research findings about nitrogen and phosphorus have been reviewed in this chapter.

2.1 Effect of nitrogen on the growth and yield of rapeseed

Canola (*Brassica napus* L.) was planted for two consecutive seasons (2004-05 and 2005-06) in the Arid Land Agricultural Research Station, King Abdul Aziz University at Hada Al-Sham to determine the effect of different rates of nitrogen fertilizer (0, 60, 120 and 180 kg N ha^{-1}) on crop growth, seed yield, yield components and seed quality. Nitrogen was applied in three equal splits, 2 weeks, 4 weeks and 8 weeks after planting during each crop season. Randomized complete block design, with four replications was used. Statistical analysis of the obtained data presented that nitrogen at a rate of 180 kg N ha^{-1} dominated other N rates of 120, 60, 0 kg N ha^{-1} for plant growth, yield and quality parameters except seed oil content that were higher at 120 Kg N ha^{-1} level. An overall improvement of 59% in plant height, 112% in number of branches, 111% in number of fruits/plant, 87% in 1000 seed weights and 19% in crude protein content were documented for 180 Kg N ha^{-1}. On contrary a reduction of 5% in oil content was recorded by moving from 120 Kg N ha^{-1} to 180 Kg N ha^{-1}. Current results suggested that N at a rate of 180 Kg ha^{-1} can be adopted as best level of nitrogen fertilizer for canola cultivation under arid land conditions of Saudi Arabia (Sulaiman *et al*, 2015).

Canola is becoming a major source of vegetable oil with increasing demand in South Africa, yet low yields are presently experienced in production areas of the Western Cape Province. Crop response to fertilizer applications in field trials under rainfed conditions are often poor, because of a large number of growth factors that may limit growth and yield. To determine how canola responds to nitrogen (N) with no (low) and high sulphur (S) rates under ideal conditions in a controlled environment, a 5 x 2 factorial experiment, with N (0, 40, 80, 120 and 160 kg ha^{-1}) and S (0 and 40 kg ha^{-1}) fertilization rates, was conducted. Plants were irrigated with a nutrient solution which contained all nutrients, but with very low N and S contents. Nitrogen application significantly increased leaf area, hence dry mass accumulation and ultimately flowering and pod formation, but high N and S application levels during early growth stages may have a negative effect on growth. Significant interaction between N and S were shown, however the positive effects of S were more pronounced in the reproductive phases. In this experiment, conducted under controlled temperature and watering conditions, but short winter daylight lengths, yield components of canola as measured by the number of flowers and pods at 91 DAP tended to reach a peak at application rates of 120 kg N ha^{-1} and 40 kg S ha^{-1} (Ngezimana and Agenbag, 2013).

Taheri *et al.* (2012) conducted in order to evaluate the responses of two spring rape seed cultivars to different nitrogen levels. A split plot layout with completely randomized block design with 3 replications was used. Main plot were different level of nitrogen fertilizer (0,50,100 and 150 kg ha^{-1}) from urea source, and sub plot were different cultivars (Hyola 401 and Hyola 60). This research was conducted in 2010-2011, at research farm of farming building of Islamic Azad University Khorasgan (Isfahan) Branch located in Khatunabad village (latitude 32°/40' N and Longitude 51°/48' E). Condition represented the effect of N fertilizer was significant on seed yield, biological yield and oil yield. Effect of cultivar was significant on the number of seed per pod, seed yield, biological yield and oil percentage. The maximum of all mentioned factors except oil percentage, related to 100 kg N ha^{-1} fertilizer treatment and Hyola 401. The highest of oil percentage was achieved in 150kg N ha^{-1} and Hyola 60. N fertilizer and cultivar interaction had no significant influence on experimental characteristics.

Özden Öztürk (2010) conducted to determine the effect of year, N sources and doses on the yield and quality traits of winter rapeseed in a cereal system in calcareous soils over two seasons, 2000-2001 and 2001-2002, in Central Anatolia. Three N sources, ammonium sulfate, ammonium nitrate and urea, were applied as hand broadcast on the soil surface at five doses (0, 50, 100, 150, and 200 kg N ha^{-1}). The traits investigated were plant height, number of branches and pods per plant, number of seed per pod, thousand seed weight, seed yield, oil and protein content. There were significantly effects on seed yield, oil and protein content, and other yield components due to N sources and rates. In general, ammonium sulfate and urea gave higher seed yield than ammonium nitrate. Mean values of both seasons indicated that 100 and 150 kg N ha^{-1} rate increased significantly yield and quality traits with regard to other N treatments. The present results highlight the practical importance of adequate N fertilization and true N source in seed yield in winter rapeseed and suggest that ammonium sulfate at 150 kg N ha^{-1} will be about adequate to meet crop N requirements.

Karamzadeh *et al*. (2010) In order to investigate the effect of nitrogen and seed rates on yield and oil content of canola, the experimental design was split plot in randomized complete block design with four replicates at Neka (Iran) in 2009. Results indicated that there was significant difference in nitrogenrates on seed yield; oil yield and oil content (P 1610.01). N and N had the highest and lowest seed 921 and oil yields with 5686 and 3385 and 2263 and 1604 kg ha^{-1} 47.42%, respectively. S and S had the highest and the lowest seed and oil yields with 5020 and 2168 kg ha^{-1}, while oil content was inversion, with 39.84 and 6.10 respectively, while oil content was not significant difference. The highest and the lowest 1000-seed weight and number of pods per plant were obtained with N and N , respectively, while, number of seeds per pod 161 92 and pod length was not significant difference. Nitrogen × seed rates interaction on number of pods per plant and number of pods per main branch was significant (P 92 10 6 N ×S the lowest number of pods per plant. Interaction of N ×S had the highest and N ×S the lowest 161 6 number of pods per main branch. There is positive correlation between seed yield and number of pods per plant, 1000-seed weight, number of pods per main branch and plant height. There is strong negative correlation between seed yieldand number of sub branch. Therefore, high nitrogen and low seed rate increased seed yield and oil yield, whereas, oil content was consistent by increasing nitrogen and seeding rates.

Mirzashahi *et al.* (2010) conducted in 2007-09 at Safiabad Agricultural Research Center of Dezful, Iran. The experimental design was a complete randomized block with factorial arrangement of treatments with three replications. Factors included two levels of nitrogen: 180 and 240 kg N ha^{-1} as Urea and four levels of sulphur: control (S_0), 200 kg S ha^{-1} as sulphur powder inoculated with *Thiobacillus sp.* (S_1), 100 kg S ha^{-1} as ammonium sulphate (S_2) and 100 kg S ha^{-1} as gypsum (S_3). The results showed that nitrogen had no effect on seed and oil yield, while sulphur affected these traits significantly. Interaction ofnitrogen and sulphur was not significant on seed and oil yield. The highest seed and oil yield (2182 kg ha^{-1} and 675 kg ha^{-1}, respectively) were obtained with application of 180 kg ha^{-1} N and 100 kg S ha^{-1} as ammonium sulphate.

Narits (2010) carried out at the Jõgeva Plant Breeding Institute in 2007/2008 and 2008/2009. Ammonium nitrate (nitrogen content 34.4%) was used as top-fertilizer. Three different nitrogen rates: 120, 140 and 160 kg ha^{-1} (in active ingredient) and three different application timings were used: A) once at the beginning of spring vegetation, B) A + when the main stem was 10 cm, C) B + start of flowering in equal portions. By the results can be concluded that the amount of fertilizer had not as strong impact to seed yield and quality as fertilizer application time. The highest yields of seed and raw oil were obtained from the variant of split-N treatment (40+40+40) of 120 kg ha^{-1}.

Kazemeini *et al.* (2010) carried out to evaluate the effect of N fertilization and additive materials including wheat residue and compost on growth, yieldand yield components of canola. The experiment was conducted at the Experimental Farm of College of Agriculture, Shiraz University, Shiraz, Iran, located at Badjgah in 2006-2007 and 2007-2008 growing seasons. The experimental design was split plot withthree replications. Seed yield responded to the application of both compost and wheat straw and the maximum seed yield was recorded at 50 ton ha^{-1} of compost treatment. Increasing N caused a significant increase inseed yield. Seed yield showed a significant increase by increasing N from 0 to 100 kg ha^{-1} at 50 ton ha^{-1} compost treatment; however increasing N beyond 100 kg ha^{-1} had no significant effect on canola seed yield. Application of 100 kg ha^{-1} of N fertilizer at50 ton ha^{-1} compost was adequate for optimumseed yield. Results of stepwise regression analysis showed that contribution of yield componentof canola varieswith changein N fertilizer and organic matter application rates. Soil organic carbon was also shown to increase following application of different types of organic matter.

Namvar and Khandam (2014) study the effects of mineral nitrogen fertilization and biofertilizer inoculation on grain yield and its components of rapeseed (*Brassica napus* L.) under different levels of sulfur fertilizer, a field experiment in Factorial scheme based on Randomized Complete Block design was conducted in three replications. Experimental factors were as follows: (i) Four levels of chemical nitrogen fertilizer (0, 100, 150 and 200 kg N ha^{-1}), (ii) Two levels of biofertilizer (with and without inoculation) containing Azotobacter sp. and Azospirillum sp. and (iii) Two levels of sulfur application (0 and 50 kg S ha^{-1}). Rapeseed yield and yield components had a strong association with the N fertilization, biofertilizer inoculation and S application. Higher rates of N fertilization, biofertilizer inoculation and S application increased plant height, pods number $plant^{-1}$, grains number pod^{-1}, 1000-grains weight, grain yield and biological yield. It seems that moderate N rate (about 150 kg N ha^{-1}) and S application (about 50 kg S ha^{-1}) can be beneficial to improve growth, development and total yield of inoculated rapeseed plants. So, it is suggested to use a combination of organic and inorganic fertilizer to achieve the highest yield without a negative effect on grain quality that will lead to sustainable environment.

Rathke *et al.,* (2005) conducted on a fertile sandy loess in the Hercynian dry region of central Germany were used to determine the productivity of winter oilseed rape (*Brassica napus* L.) as affected by previous crop and nitrogen (N) fertilization. The crop rotations compared were winter barley (*Hordeum vulgare* L.)winter oilseed rape–winter wheat (*Triticum aestivum* L.), and pea (*Pisum sativum* L.)winter oilseed rape–winter wheat. Fertilizer was applied to winter oilseed rape as either calcium ammonium nitrate (CAN) or cattle manure slurry. The N rates applied to winter oilseed rape corresponded to 0, 80, 160, and 240 kg N ha^{-1}. Management effects on seed yield, seed oil and crude protein contents, and energy and CO_2 storage in the seed were assessed. The different N management strategies influenced productivity of winter oilseed rape. Data averaged across all years indicated that the lowest productivity in terms of seed yield (2.79 t ha^{-1}), energy storage (7.90 GJ ha^{-1}), and

CO_2 storage (7.69 t ha^{-1}) occurred when unfertilised winter oilseed rape followed winter barley. Highest values for all these traits were obtained at 240 kg ha1 mineral N fertilization when the effects of the previous crop were small. Pooled maximum seed yields for the high fertilizer rate ranged from 4.79 to 4.90 t ha^{-1}. Storage of energy and CO2 by the seeds ranged from 13.6 to 13.9 GJ ha^{-1} and 13.2 to 13.5 t ha^{-1}, respectively. Under high N rates, the lowest oil contents (43.8–44.1%) were observed. In contrast, highest oil concentrations were found for the unfertilised plots (46.8–47.7%). Crude protein contents of 21.6% and 17.7% were measured at high and low N rates, respectively. Results emphasize that N fertilization rate had the strongest influence on the productivity of winter oilseed rape followed by smaller effects due to previous crop and type of fertilizer and interactions between these treatment factors.

2.2 Effect of phosphorus on the growth and yield of rapeseed

Mallick and Raj (2015) conducted during the winter seasons for two consecutive years of 2007-08 and 2008-09 at farmers field of Pingla block in Pashcim Medinipur district of West Bengal to study the contribution of these nutrients in improving yield components and yield of rapeseed crop [*Brassica campestris var* yellow sarson] cv. 'B-9' on medium deep loam soil having medium in available P and S. The experiment was carried out in a factorial randomised block design with three replications. The results revealed that successive increase in P, S and B levels increased yield attributes and seed yield of yellow sarson crop. The increase in seed yield was significant up to 60 kg P_2O_5 ha^{-1} and 40 kg S ha^{-1} while uptake of P and S was significant up to 60 kg P_2O_5 ha^{-1} and 20 kg S ha^{-1}. Seed-yield response to tested different levels of P and S was found quadratic. Based on the response equation, optimum dose of P_2O_5 was 48.1 kg $ha^{-1}$and response was 8.3 kg seeds kg^{-1} P_2O_5. Corresponding figures for S application were 27.3 kg S ha^{-1} and 13.5 kg seed kg^{-1} S. Net returns were the maximum with 60 kg P_2O_5 ha^{-1} (Rs 40852.75 ha^{-1}) and 20 kg S ha^{-1} (Rs 38477 ha^{-1}), whereas benefit: cost ratio was the highest with 30 kg P_2O_5 ha^{-1}(2.87) and 20 kg S ha^{-1} (2.48). Boron application also recorded marked improvement in seed yield (14.38%), uptake of P (12.75%), S (12.78%) and net returns (13.9%) and benefit: cost ratio (7.11) as compared to control.

Karamanos *et al*., (2014) reported that improved phosphorus (P) fertilizer management is viewed as a way to improve yields in highly productive cropping system. A study was conducted at numerous sites during the 1990's to assess plant density and yield of canola (Brassica napus L.), barley (Hordeumvulgare L.), spring wheat (Triticumaestivum L.), and winter wheat respond to greater P fertilizer rates (0, 15, 30, 45, and 60 kg P ha^{-1}) when seed placed and side banded. We did find that canola stand was insensitive to rates of P tested when banded, but greater rates of seed-placed P caused stand thinning. It is thought the compensatory growth of canola was the reason why canola yield did not respond to P treatment. Both barley and winter wheat yielded most when the greatest rates of P were applied. Spring wheat showed a similar response when P was side banded, thus indicating improved tolerance with P placed away from seed. Therefore, spring wheat was the only crop that fit with our hypotheses; side banding P will allow crops to respond positively to greater rates of P fertilizer. The fact the cereal crop density was unresponsive to P management indicates that seedlings show early-season better tolerance than canola. Unlike canola, yield forming factors for cereal crops responded to greater rates of P.

Madani *et al.*, (2014) conducted an experiment to investigate different phosphorus fertilizer sources and their importance in rapeseed farms on 2007 at Arak, Iran. Ammonium phosphate fertilizer with 50% P_2O_5 (APF) was used as a chemical phosphorus source with 3 rates of application, whereas phosphorus solubilizing bacteria (PSB) was a biological source of phosphorus used in 4 rates. Experiment was a factorial arrangement in complete randomized block design with 3 replications. APF levels were: control (AP_0), 125 kg ha^{-1} APF (AP_1) and 250 kg ha^{-1} (AP_2) application and PSB levels were: control (PSB_0), PSB at sowing time only (PSB_1), PSB as top dress fertilizer after over wintering only (PSB_2) and PSB at dual fertilizing in sowing time and also after over wintering (PSB_3). The statistical analyses showed that the PSB_3 treatment was the best treatment for the seed yield increase. The highest rate of seed yield (9.9 t ha^{-1}) was recorded in dual fertilizing applied both, in sowing time and after over wintering stage of rosette. The interaction effects of phosphorus solubilizing bacteria and ammonium phosphate fertilizer application had not significant effect on plant height, biomass yield, number of silique per plant, seed oil percent and seed yield. Interaction effects of phosphorus solubilizing bacteria and ammonium phosphate fertilizer application were significant for phosphorus content in plant tissues.

Yang *et al*., (2010) by using rapeseed (*Brassia napus* L.) cultivars with different seed yields, we measured the organ dry weight and phosphorus content, and then used cluster analysis (average linkage method) to classify different cultivars' yields, and further investigated different cultivars' phosphorus accumulation and allocation. Our study showed that, different cultivars' yields have distinct change and can be divided into six types according to clustering dendrogram. Different cultivars' yields are significantly different. Both phosphorus absorption total volume and phosphorus utilization efficiency for grain production (PUEg) for different types are significantly different. When yield increases, different types' phosphorus absorption total volume and PUEg values are increased significantly. The accumulation and allocation ratio of phosphorus in seeds from High-yield cultivars are significantly higher than those from low-yield cultivars. The implication is, if we'd like to increase rapeseed's PUEg, the priority method is to select high PUEg cultivars, and the second choice is to employ appropriate planting strategies so that more phosphorus can be transported to seeds from stems and leafs.

2.3 Combined effect of nitrogen and phosphorus on the growth and yield of rapeseed

Khan *et al*, (2000) conducted an experiment to determine the effect of nitrogen alone and in combination with phosphorus on the growth and yield of *Brassica juncea* L Cv. The N-P levels (kg ha^{-1}) 0-0, 50-0, 100-0, 50-50, 100-50 and 150-50 were applied. The results revesied that plant height at maturity, number of branches, number of pods per plant, number of seed per pod and 1000 seed weight were affected significantly by N and N-P levels. Application of N-P @ 100-50 kg ha^{-1}

gave the highest seed yield. It was also noted that application of nitrogen over 100 kg ha^{-1} did not produces higher seed yield then 100-50 kg ha^{-1} N-P application.

Chapter III

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm during rabi season (October to March) of 2014-15 to study the effect of nitrogen and phosphorus on growth and yield of rapeseed (BARI Sarisha-14).

3.1 Experiniental site

The experiment was carried out at Sher-e-Bangla Agricultural University Farm, Dhaka-1207, Bangladesh. It is located at 90°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 and high temperature, high humidity and heavy rainfall with occasional gusty winds during kharif season April-September. Details of the meteorological data of air temperature, relative humidity and rainfall during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e Bangla Nagar.

3.3 Soil condition

The soil of experimental area situated to the Modhupur Tract (UNDP, 1988) under the AEZ no. 28 and Tejgoan soil series (FAO, 1988). 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 I.

3.4 Materials

3.4.1 Plant materials

A newly developed, moderately salinity tolerant and high yielding variety of rapeseed, BARI Sarisha- 14 developed by the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur was used in the experiment as a planting material. The seed was collected from the Bangladesh Agricultural Research Institute (BARI); Joydebpur, Gazipur. The rapeseed(*Brassica napus*)was used as the test crop in this experiment.BARI Sarisha-14 is new developed moderate saline tolerant variety. Before sowing germination test was done in the laboratory and percentage of germination was over 95%.

3.5 Methods

3.5.1 Treatments

Factor A: 4 Nitrogen (N)

N_0 = 0

N_1= 90 kg/ha

N_2= 120 kg/ha

N_3= 150 kg/ha

Factor B: 4 Phosphorus (P)

P_0=0

P_1= 15 kg/ha

P_2= 25 kg/ha

P_3= 35 kg/ha

Treatment combinations

N_0P_0	N_1P_0	N_2P_0	N_3P_0
N_0P_1	N_1P_1	N_2P_1	N_3P_1
N_0P_2	N_1P_2	N_2P_2	N_3P_2
N_0P_3	N_1P_3	N_2P_3	N_3P_3

3.5.2 Design and layout

The two factors experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Experimental variables consisted of four N treatments as factor A and four P levels as factor B.The total plot number was 16 × 3 = 48. The unit plot size was 2.5 m × 1.5 m = 3.75 m^2. The distance between block to block is 1 m and distance between plots to plot is 0.5 m and plant spacing is 30 cm × 5 cm.

3.5.3 Land preparation

The land was ploughed with a rotary plough and power tiller for four times. Ploughed soil was then brought into desirable fine tilth and leveled by laddering. The weeds were clean properly. The final ploughing and land preparation were done on 14 November, 2014. According to the lay out of the experiment the entire experimental area was devided into blocks and subdivided into plot for the sowing of mustard seed. In addition, irrigation and drainage channels were prepared around the plot.

3.5.4 Fertilization

In this experiment fertilizers were used according to BARI and under as follows:

Fertilizers	**Rate of application per ha.**
Urea	As per treatment
TSP	As per treatment
MoP	110 kg
Gypsum	180 kg
$ZnSO_4$	5 kg
Boric Acid	10 kg

The amounts of fertilizer as per treatment in the forms of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid required per plot were calculated. 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 after sowing (DAS).

3.5.5 Sowing of seed

Sowing was done on 16 November, 2014 in rows 30 cm apart. Seeds were sown continuously in rows at a rate of 8 kg/ha. After sowing; the seeds were covered with the soil and slightly pressed by hand.

3.5.6 Thinning and weeding

The optimum plant population, 60 plants/ m^2 was maintained by thinning excess plant at 15 DAS. The plant to plant distance was maintained as 5 cm. One weeding with khurpi was given on 25 DAS.

3.5.7 Irrigation and drainage

One post sowing irrigation was given by sprinkler after sowing of seeds to bring proper moisture condition of the soil to ensure uniform germination of the seeds. A good drainage system was maintained for immediate release of rainwater from the experimental field during the growing period.

3.5.8 Crop protection

Aphid infection was found in the crop during the siliqua development stage. To control aphids Malathion-57 EC at the rate of 2ml/liter of water was applied. The insecticide was applied in the afternoon.

3.5.10 General observation of the experimental field

The field was investigated frequently in order to reduce losses with weeds competition and insects infestation and diseases infection.

3.5.11 Harvesting and threshing

Previous randomly selected ten plants, those were considered for the growth analysis was collected from each plot to analyse the yield and yield contributing characters. Rest of the crops was harvested when 80% of the siliquae in terminal raceme turned golden yellow in colour. After collecting sample plants, harvesting was started on February 14 and completed on February 17, 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.

3.5.12 Drying and weighing

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

3.6 Data collection

Ten (10) 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 from each plot of the field. Data were taken from Selected plants which were marked by tag. Final field data were collected at harvesting stage.

Data were collected on the following parameters:

1. Plant height (cm)
2. No. of leaf plant^{-1}
3. No. of branches plant^{-1}
4. No. of inflorescence
5. Total dry matter
6. No. of siliqua plant^{-1}
7. No. seed per silliqua
8. Yield (t ha^{-1})
9. Stover yield

3.6.1 Plant height (cm)

Plant height was measured three times at 20 days interval such as 20, 40, and 60 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.

3.6.2 Number of leaves per plant

Number of leaves per plant was counted three times at 20 days interval such as 20, 40 and 60 DAS of rapeseed plants. Mean value of data were calculated and recorded.

3.6.3 Number of branches per plant

The number of branches per plant was counted three times at 20 days interval such as 20, 40, and 60 DAS of rapeseed plants. Mean value of data were calculated and recorded.

3.6.4 Number of siliqua plant^{-1}

Number of siliqua was counted from randomly selected ten plants after harvest and averaged them to have number of siliqua plant^{-1}.

3.6.5 Siliqua length (cm)

Siliqua length was recorded from the base to the apex of each siliqua from randomly selected 10 siliqua of each treatment and then means value was calculated.

3.6.6 Number of seeds siliqua^{-1}

Total number of seed was counted from the selected 20 siliqua and averaged them to have number of seeds siliqua^{-1}.

3.6.7 1000- seed weight

One thousand clean sun dried seeds were counted from the seed stock obtained from the sample plants and weighed by electronic balance and expressed in gram(g).

3.6.8 Yield (t/ha)

After threshing, cleaning and drying, total seed from harvested area were recorded and was converted to t $^{-1}$ ha.

3.7 Chemical analysis of plant samples

3.7.1 Collection and preparation of plant samples

Stover samples were collected after threshing for N, P and K analyses. The plant samples were dried in an oven at 70^0C for 72 hours and then ground by a grinding machine (wiley-mill) to pass through a 20-mesh sieve. The samples were stored in plastic vial for analyses of N, P and K. The stover samples were analyzed for determination of N, P and K concentrations. The methods were as follows:

3.7.2 Digestion of plant samples with sulphuric acid for N

For the determination of nitrogen an amount of 0.5 g oven dry, ground sample were taken in a micro kjeldahl flask. 1.1 g catalyst mixture (K_2SO_4: $CuSO_{4.}$ $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml conc. H_2SO_4 were added. The flasks were heated at 160^0 C and added 2 ml 30% H_2O_2 then heating was continued at 360^0 C until the digests become clear and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner. Nitrogen in the digest was estimated by distilling the digest with 10 N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

3.7.3 Digestion of plant samples with nitric-perchloric acid for P and K

A sub sample weighing 0.5 g was transferred into a dry, clean 100 ml digestion vessel. Ten ml of di-acid (HNO_3: $HClO_4$ in the ratio 2:1) mixture was added to the flask. After leaving for a while, the flasks were heated at a temperature slowly raised to 200^0C. Heating were stopped when the dense white fumes of $HClO_4$ occurred. The content of the flask were boiled until they were became clean and colorless. After cooling, the content was taken into a 50 ml volumetric flask and the volume was made up to the mark with de-ionized water. P, K and S were determined from this digest by using different standard methods.

3.7.4 Determination of P and K from plant samples

3.7.4.1 Phosphorus

Plant samples (grain and straw) were digested by diacid (Nitric acid and Perchloric acid) mixture and P content in the digest was measured by blue color development (Olsen *et al.*, 1954). Phosphorus in the digest was determined by using 5 ml for stover sample from 50 ml digest by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page *et al.*, 1982).

3.7.4.2 Potassium

One milli-liter of digest sample for the stover was taken and diluted 20 ml volume to make desired concentration so that the flame photometer reading of samples were measured within the range of standard solutions. The concentrations were measured by using standard curves.

3.8 Post harvest soil sampling

After harvest of crop soil samples were collected from each plot at a depth of 0 to 15 cm. Soil sample of each plot were air-dried, crushed and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

3.9 Soil analysis

Soil samples were analyzed for both physical and chemical characteristics viz. organic matter, pH, total N and available P and K contents. The soil samples were analyzed by the following standard methods as follows:

3.9.1 Textural class

Mechanical analysis of soil were done by hydrometer method (Bouyoucos, 1926) and the textural class was determined by plotting the values of % sand, % silt and % clay to the Marshall's textural triangular co-ordinate following the USDA system.

3.9.2 Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1: 2.5 (Jackson, 1962).

3.9.3 Organic matter

Organic carbon in soil sample was determined by wet oxidation method of Walkley and Black (1935). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$. To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.73 (Van Bemmelen factor) and the results were expressed in percentage (Page *et al.*, 1982).

3.9.4 Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro kjeldahl flask to which 1.1 gm catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: Se in the ratio of 100: 10: 1), and 7 ml H_2SO_4 were added. The flasks were swirled and heated 160 ^{0}C and added 2 ml H_2O_2 and then heating at 360 ^{0}C was continued until the digest was clear and colorless. After cooling, the content was taken into 50 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page *et al*., 1982).

Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add sufficient amount of 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked.

Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water.

Finally the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink.

The amount of N was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100 / S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight in gram

3.9.5 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen *et al.*, 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phosphomolybdate complex and the color intensity were measured colorimetrically at 660 nm wavelength and readings were calibrated the standard P curve (Page *et al*. 1982).

3.9.6 Available potassium

Exchangeable K was determined by 1N NH_4OAc (pH 7) extraction methods and by using flame photometer and calibrated with a standard curve (Page *et al*. 1982).

3.10 Statistical analysis

The data obtained from the experiment on various parameters were statistically analyzed in MSTAT-C computer program (Russel, 1986). The mean values for all the parameters were calculated and the analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Duncan Multiple Range Test at 5 % levels of probability (Gomez and Gomez, 1984).

Chapter IV

RESULTS AND DISCUSSION

The results obtained with different levels of nitrogen (N) and Phosphorus (P) and their combination are presented and discussed in this chapter. Data about morphological parameters, yield contributing characters, seed yield of rapeseed have been presented in both Tables and Figures.

4.1 Plant height

The results of this study showed that nitrogen (N) levels showed significant effect on rapeseed plant height (Fig. 1). The tallest plant (75.71 cm) was recorded with $N_{3,}$ 150 kg N ha^{-1}. In contrast, the shortest plants were recorded from control, N_0 and height was 68.68 cm, respectively. The N fertilizer's requirements can differ very much according to soil type, climate, management practice, timing of nitrogen application, cultivars, etc. These findings are in agreement with those of Singh *et al.* (2003), Tripathi and Tripathi (2003), Singh (2002). Similar findings were reported by Tomar *et al.* (1996), FAO (1999), Ali and Ullah (1995), Shamsuddin *et al.* (1987), Ali and Rahman (1986) and Hasan and Rahman (1987). All together, these results suggest that higher doses of N increase rapeseed plant height.

Data pertaining to Fig. 2 revealed that plant height was not significantly affected by different doses of P. However, plant height increased with increasing levels of P up to higher level. The tallest plant (80.10 cm) was produced with $P_{3,}$ 35 kg P/ha and shortest plant (73.12 cm) was found in no P condition.

The plant height of rapeseed significantly increased with the by the interaction between N and P (Table 1). The tallest plant (88.30 cm) was found in N_3P_3 treatment combination, 150 kg N/ha with 35 kg P/ha whereas the shortest plant (66.67 cm) was observed in the control treatment combination. Singh (2002) reported that plant height increased significantly with successive increase in nitrogen up to 150 kg/ha. All together these results indicate that plant height of rapeseed increase with combined use of N and P.

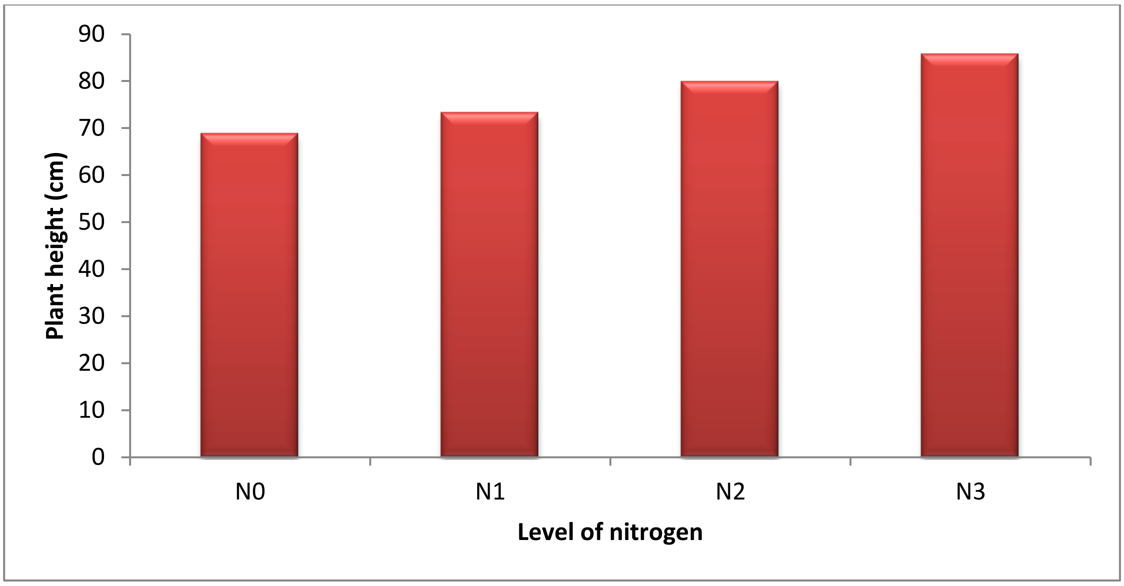

Fig. 1: Effect of different doses of nitrogen on the plant height of rapeseed at harvest

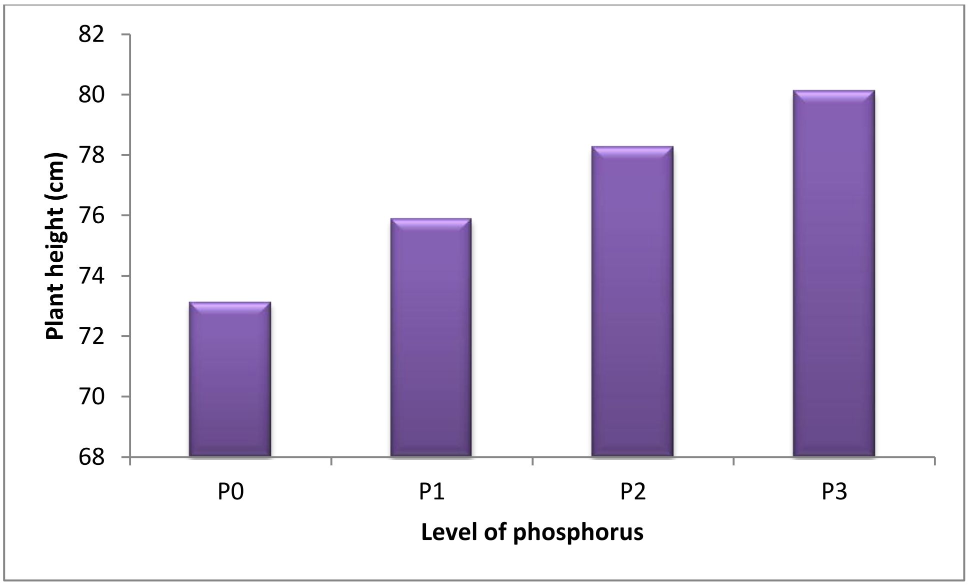

Fig. 2: Effect of different doses of Phosphorus on the plant height of rapeseed at harvest

Table 1: Interaction effect of nitrogen (N) and Phosphorus (P) on the growth of rapeseed

Treatments	Plant Height (cm)	Number of Leaf per plant	Number of Primary Branches per plant	Number of Siliqua per plant

N_0P_0	66.97	h	6.13	k	2.68	j	74.67	h
N_0P_1	67.29	h	8.83	j	3.99	i	86.36	g
N_0P_2	69.25	gh	9.73	ij	4.15	hi	94.17	efg
N_0P_3	71.20	fgh	10.43	hi	4.89	ghi	100.50	ef
N_1P_0	68.39	gh	10.18	ij	4.60	hi	91.92	fg
N_1P_1	72.30	efgh	10.83	ghi	5.15	fgh	97.17	ef
N_1P_2	75.00	defg	11.86	fgh	5.90	efg	103.20	de
N_1P_3	77.00	cdef	12.61	ef	6.40	cde	111.20	cd
N_2P_0	73.90	efgh	12.22	efg	6.05	def	102.20	def
N_2P_1	79.10	bcde	13.22	def	7.00	bcd	115.20	c
N_2P_2	82.30	abcd	13.48	de	7.30	bc	119.60	bc
N_2P_3	83.90	abc	15.30	c	7.99	ab	121.20	bc
N_3P_0	83.23	abc	14.50	cd	7.20	bc	120.20	bc
N_3P_1	84.85	ab	15.83	bc	7.65	b	125.90	b
N_3P_2	86.47	ab	17.03	ab	8.05	ab	129.50	ab
N_3P_3	88.30	a	18.22	a	8.97	a	136.20	a
$LSD_{(0.05)}$	6.74		1.44		0.96		9.63	
CV(%)	5.26		6.91		9.43		5.34	

$N_0 = 0$ P_0=0

N_1= 90 kg/ha P_1= 15 kg/ha

N_2= 120 kg/ha P_2= 25 kg/ha

N_3= 150 kg/ha P_3= 35 kg/ha

4.2 Number of leaves plant^{-1}

The N showed significant variation in the number of leaves per plant (Table 2). The maximum number of leaves per plant (16.40 cm) was produced by 150 kg N/ha and without N produced the lowest number of leaves per plant (8.78 cm). It is reported that better growth and development of crop depend on a good number of leaves and producing more foliage related to the yield of rapeseed (through higher siliquae yield and stover yield) to the seed production those are linked to use of amount of N fertilizer and suggesting that the greater number of leaf, the greater the photosynthetic area which may result higher seed yield. These indicate number of leaves per plant increased with increasing N levels; those are consistent with Patil *et al.*, (1997) findings.

Number of leaves per plant due to the influence of P was significant (table 3). With the 35 kg P/ha had the highest number of leaves per plant (14.14). However, the lowest number of leaves per plant (10.76) was obtained from the control. So, P has important role on increasing number of rapeseed leaves.

A significant variation in the number of leaves per plant was found between the N and P (Table 1). The maximum number of leaves per plant (18.22) was found in combined use of 150 kg/ N and 35 kg P/ha, N_3P_3 treatment, whereas the lowest number of leaves per plant (6.13) was found in control treatment. It is well established that mineral nutrition influences plant growth and absorption of elements, proper N application enhance P accumulation in plants which trigger

Table 2: Effect of nitrogen (N) on the growth parameters of rapeseed

Treatments	Number of leaf per plant		Number of primary branches per plant		Number of siliqua per plant	
N_0	8.78	c	3.93	d	88.93	d
N_1	11.37	b	5.51	c	100.90	c
N_2	13.56	b	7.09	b	114.50	b
N_3	16.40	a	7.97	a	127.90	a
LSD $_{(0.05)}$	2.28		0.82		11.84	
CV(%)	6.91		9.43		5.34	

Table 3: Effect of Phosphorus (P) on the growth parameters of rapeseed

Treatments	Number of leaf per plant		Number of primary branches per plant		Number of siliqua per plant	
P_0	10.76	b	5.13	b	97.23	c
P_1	12.18	ab	5.95	ab	106.10	bc
P_2	13.03	a	6.35	ab	111.60	ab
P_3	14.14	a	7.06	a	117.30	a
LSD $_{(0.05)}$	2.25		1.50		9.49	
CV(%)	6.91		9.43		5.34	

N_0 = 0

N_1= 90 kg/ha

N_2= 120 kg/ha

N_3= 150 kg/ha

P_0=0

P_1= 15 kg/ha

P_2= 25 kg/ha

P_3= 35 kg/ha

both vegetative growth and reproductive development (Hemlin *et al*. 2003). The result of leaves number plant^{-1} of this study is consistent with the plant height (Table 1) and suggesting that combined use of N and P increase rapeseed canopy structure.

4.3 Number of Primary branches plant^{-1}

The tabe 2 showed that different levels of N had significant effect on number of primary branches per plant. The maximum number of branches per plant (7.97) was produced by 150 kg N ha^{-1}. Control produced the minimum number of branches per plant (3.93). Tomar *et al.* (1991, 1996), Ali and Ullah (1995) also obtained highest number of branch per plant with 150 kg N ha^{-1}. In contrast, Mondal and Gaffer (1983) also reported that N fertilizer application had no significant effect on number of primary branches per plant of rapeseed. Altogether, it suggests that N involve in initiating primary branches by sprouting lateral buds of rapeseed plants.

The P influenced significantly on number of primary branches per plant (Table 3). The highest number of branches per plant (7.06) was obtained from $P_{3,}$ 35 kg P ha^{-1} and the lowest number of branches per plant (5.13) was obtained from the control, P_0 and indicating that P increased number of primary branches per plant as dose dependent manner.

Interaction effect between N and P was found significant on the number of primary branches per plant (Table 1). The maximum number of branches per plant (8.97) was found in N_3P_3 treatment combination, 150 kg N/ha and 35 kg P/ha whereas the lowest number of branches per plant (2.68) was found in N_0P_0, control treatment, that are correlate with Murtuza and Paul (1989) findings, they observed significant effect of nitrogen on the number of primary branches plant^{-1}. Alltogether, the result of this study suggests that N and P show synergistic effect on primary branches per plant of rapeseed plants.

4.4 Number of siliquae plant^{-1}

The number of siliquae per plant of rapeseed was highly affected nitrogen rates and their interaction.The N showed significant variation in the number of siliquae per plant (Table 2). The Maximum number siliquae per plant (127.9) was obtained in plots which received 150 kg N ha^{-1}. The minimum number of siliquae per plant (88.93) produced in control plots (no nitrogen application). Similar result also obtained by Shukla *et al*. (2002), Singh *et al*. (2003) in rapeseed. These are consistent with the length of siliquae of rapeseed.

There was a significant difference among the P in the number of siliquae per plant (Table 3). The maximum number of siliquae per plant (117.3) was produced in P_3 or with 35 kg P ha^{-1} and the minimum number of siliquae per plant (97.23) was produced in P_0 or control condition.

A significant variation indicated among the treatment combinations of N and P in number of siliquae per plant (Table 1). The maximum number of siliquae per plant (136.2) was found in N_3P_3, whereas the minimum number of siliquae per plant (74.67) was found in N_0P_0 treatment combination.

4.5 Length of siliquae

The N showed significant variation in the length of siliquae (table 4). The longest length of siliquae (4.85 cm) was produced by 150 kg N ha^{-1} whereas N_3 and N_0 treatment produced the shortest length of siliquae (3.01).

There was no significant difference among the P treatments in the length of siliquae (Table 5). As evident from fig 8, the maximum length of siliquae (4.42) was produced from 35kg P ha^{-1}. The minimum length of siliquae (3.53) was produced in control.

A significant indicated variation among the treatment combinations in length of siliquae. The maximum length of siliquae (5.20) was found in N_3P_3 treatment combination, 150 kg N ha^{-1} and 35 kg P ha^{-1} whereas the minimum length of siliquae (2.03) was found in control (Table 6).

Table 4: Effect of nitrogen (N) on the yield and yield contributing characters of rapeseed

Treatments	Length of siliqua (cm)	Number of seed pod	1000 Seed weight (g)	Yield (t/ha)
N_0	3.01 b	23.84 b	3.08	1.08 c
N_1	3.83 ab	28.51 ab	3.41	1.19 bc

N_2	4.38 a	30.89 a	3.61	1.28 ab
N_3	4.85 a	33.46 a	3.65	1.43 a
LSD $_{(0.05)}$	1.05	5.26	1.14	0.16
CV(%)	14.38	8.66	7.92	6.79

Table 5: Effect of Phosphorus (P) on the growth and yield contributing characters of rapeseed

Treatments	Length of siliqua (cm)	Number of seed per pod	1000 Seed weight (g)	Yield (t/ha)
P_0	3.53	25.82 b	3.16	1.00 c
P_1	3.97	28.40 ab	3.40	1.19 b
P_2	4.15	30.14 ab	3.57	1.34 ab
P_3	4.42	32.33 a	3.62	1.45 a
LSD $_{(0.05)}$	0.98	4.58	0.95	0.18
CV(%)	14.38	8.66	7.92	6.79

N_0 = 0 P_0=0

N_1= 90 kg/ha P_1= 15 kg/ha

N_2= 120 kg/ha P_2= 25 kg/ha

N_3= 150 kg/ha P_3= 35 kg/ha

Table 6: Interaction effect of nitrogen (N) and Phosphorus (P) on the yield and yield contributing characters of rapeseed

Treatments	Length of siliqua (cm)	Number of seed per pod	1000 Seed weight (g)	Yield (t/ha)
N_0P_0	2.03 h	18.58 h	2.32 b	0.77 i
N_0P_1	3.14 g	23.17 g	3.28 ab	1.04 gh
N_0P_2	3.30 fg	26.22 efg	3.33 ab	1.20 defg
N_0P_3	3.58 defg	27.42 def	3.37 ab	1.31 bcde

N_1P_0	3.40	efg	25.89	fg	3.32	ab	0.98	h
N_1P_1	3.72	cdefg	28.52	cdef	3.39	ab	1.13	efgh
N_1P_2	3.92	bcdefg	29.17	cdef	3.44	a	1.29	cdef
N_1P_3	4.28	abcdef	30.47	bcde	3.49	a	1.36	bcd
N_2P_0	4.17	abcdefg	28.91	cdef	3.42	ab	1.08	fgh
N_2P_1	4.32	abcdef	29.68	cdef	3.68	a	1.21	defg
N_2P_2	4.42	abcde	30.94	bcd	3.71	a	1.36	bcd
N_2P_3	4.62	abcd	34.04	ab	3.79	a	1.46	abc
N_3P_0	4.52	abcd	29.92	bcdef	3.58	a	1.18	defgh
N_3P_1	4.72	abc	32.25	bc	3.23	ab	1.36	bcd
N_3P_2	4.96	ab	34.25	ab	3.80	a	1.52	ab
N_3P_3	5.20	a	37.42	a	3.83	a	1.64	a
$LSD_{(0.05)}$	0.96		3.85		0.96		0.19	
CV(%)	14.38		8.66		7.92		6.79	

N_0 = 0 P_0=0

N_1= 90 kg/ha P_1= 15 kg/ha

N_2= 120 kg/ha P_2= 25 kg/ha

N_3= 150 kg/ha P_3= 35 kg/ha

4.6 Number of seed siliquae^{-1}

The number of seed per siliquae of rapeseed was highly affected nitrogen rates and their interaction.The N showed significant variation in the number of seed per siliquae (Table 4). The Maximum number siliquae per plant (33.46) was obtained in plots which received 150 kg N ha^{-1}. The minimum number of seed per siliquae (23.84) produced in control plots (no nitrogen application).

There was a significant difference among the P in the number of seed per siliquae (Table 5). The maximum number of seed per siliquae (32.33) was produced in P_3 or with 35 kg P ha^{-1} and the minimum number of seed per siliquae (25.82) was produced in P_0 or control condition.

A significant variation indicated among the treatment combinations of N and P in number of seed per siliquae (Table 6). The maximum number of seed per siliquae (37.42) was found in N_3P_3, whereas the minimum number of siliquae per plant (18.58) was found in N_0P_0 treatment combination.

4.7 1000- Seed weight

The application of nitrogen was not influenced significantly on the thousand seed weight (Table 4). The maximum thousand seed weight (3.65 g) was produced by N_3, and N_0 produced the lowest thousand seed weight (3.08 g). Ozer (2003), Singh (2002) and Shamsuddin et al. (1987) also obtained highest 1000 seed weight with 150 kg N ha^{-1}.

The weight of thousand seed was not significantly influenced by P (Table 5). The highest thousand seed weight (3.62 g) was obtained from P_3 treatment. The lowest thousand seed weight (3.16 g) was obtained from without P.

Thousand seed weight was significantly affected by both N and P (Table 7). The highest thousand seed weight (3.83 g) was found in N_3P_3 treatment combination, 150 kg N/ha and 35 kg P/ha whereas the lowest thousand seed weight (2.32 g) was found in N_0P_0 treatment (Table 6). These results suggest that combined use of appropriate doses of N and P produced maximum thousand seed weight than the use of same dose of N or P along.

4.8 Seed yield

The different dose of N had significant effect on rapeseed yield per ha (Table 4). The maximum yield of seed per ha (1.43 t) was obtained from $N_{3,}$ 150 kg N ha^{-1}, whereas the minimum yield of seed per hectare (1.08 t) was obtained from $N_{0,}$ without N. Further increase in N level beyond 150 kg ha^{-1} could not improve the seed yield. These results is consistent with the N-induced increase of growth parameters along with number of siliquae $plant^{-1}$, and thousand seed weight (Table 5). The higher seed yield ha^{-1} was also obtained with same N rate reported by Singh and Prasad (2003), Singh *et al*. (2003), Shukla *et al*. (2002). Therefore, N can enhance the seed yield (t ha^{-1}) of rapeseed variety BARI sarisha-14.

The total yield of rapeseed varied significantly due to the application of different levels of P fertilizer (Table 5). The highest yield of seed (1.45 t ha^{-1}) was obtained from $P_{3,}$ 35 kg P ha^{-1} while P_0 gave the lowest (1.00 t ha^{-1}) yield. This result showed that the yield of mustard increased gradually with the higher doses of P fertilizer. Interestingly, this result is consistent with the P-induced yield components such as number of siliqua plant^{-1}, thousand seed weight and seed yield (Table 6) rather than growth parameters. Therefore, higher dose of P can increase seed yield of rapeseed.

The combined effect of N and P fertilizer was significant on yield of seed per hectare (Table 6). The highest yield of seed per hectare (1.64 tones) was obtained from N_3P_3 treatment combination, 150 kg N ha^{-1} and 35 kg P ha^{-1}. The lowest yield of seed per hectare (0.77 tones) was obtained from N_0P_0 treatment. These results are consistent with the results of plant height, number of leaves and primary branch and length of siliquae. Nitrogen (N) increases crop yield by influencing different growth parameters and by producing more vigorous growth and development as reflected via increasing plant height, number of flowering branches, and number of siliquae and seeds per plant (Alien and Morgan, 1972). Therefore, these results suggest that the combined use of 150 kg N ha^{-1} and 2 kg P ha^{-1} produce the highest seed yield of rapeseed.

4.9 Nitrogen concentrations in stover of rapseed

N concentration of stover was not significantly influenced by the application levels of nitrogen (Table 7). The highest N concentration in rapseed stover (0.832 %) was recorded in N_3 (150 kg ha^{-1}). Otherwise, the lowest N concentration in rapseed stover (0.718 %) was recorded in N_0 treatment.

N concentration of stover was significantly influenced by application levels of phosphorus (Table 8). The highest N concentration in rapseed stover (0.875 %) was recorded in P_3 (35 kg ha^{-1}). The lowest N concentration in rapseed stover (0.665 %) was recorded in P_0 treatment.

Significant effect was observed in combined application of different doses of nitrogen and Phosphorus fertilizer on the N concentration in stover of rapseed (Table 9). The highest concentration of N in the stover (0.907 %) was recorded in the treatment combination of N_3P_3.The lowest nitrogen concentration (0.577 %) in stover was found in N_0P_0.

Table 7. Effects of nitrogen on N, P and K content of stover of rapseed

Treatments	**%N**	**%P**	**%K**
N_0	0.718 a	0.479 b	0.942 c
N_1	0.797 a	0.648 a	1.271 b
N_2	0.823 a	0.680 a	1.537 a
N_3	0.832 a	0.756 a	1.586 a
LSD $_{(0.05)}$	0.142	0.116	0.116

CV(%)	5.810	5.740	6.050

Table 8. Effects Phosphorus on the N, P and K content of stover of rapseed

Treatments	%N	%P	%K
P_0	0.665 a	0.515 b	1.209 a
P_1	0.769 a	0.624 ab	1.299 a
P_2	0.859 a	0.691 a	1.392 a
P_3	0.875 a	0.733 a	1.435 a
LSD $_{(0.05)}$	0.285	0.164	0.232
CV(%)	5.810	5.740	6.050

$N_0 = 0$ $P_0=0$

$N_1= 90$ kg/ha $P_1= 15$ kg/ha

$N_2= 120$ kg/ha $P_2= 25$ kg/ha

$N_3= 150$ kg/ha $P_3= 35$ kg/ha

Table 9. Combined effects of nitrogen and Phosphorus on the N, P, and K content of stover of rapseed

Treatments	%N	%P	%K
N_0P_0	0.577 g	0.366 g	0.707 j
N_0P_1	0.660 f	0.491 fg	0.960 i
N_0P_2	0.810 cd	0.515 f	1.033 h
N_0P_3	0.823 abcd	0.543 ef	1.067 h

N_1P_0	0.680	f	0.538	ef	1.167	g
N_1P_1	0.770	de	0.637	cdef	1.190	g
N_1P_2	0.863	abc	0.682	bcde	1.343	f
N_1P_3	0.873	abc	0.735	abcd	1.383	f
N_2P_0	0.693	ef	0.548	ef	1.457	e
N_2P_1	0.817	bcd	0.651	cdef	1.500	de
N_2P_2	0.883	abc	0.742	abcd	1.573	bc
N_2P_3	0.897	ab	0.779	abc	1.617	b
N_3P_0	0.710	ef	0.607	def	1.507	de
N_3P_1	0.830	abcd	0.717	bcd	1.547	cd
N_3P_2	0.880	abc	0.823	ab	1.617	b
N_3P_3	0.907	a	0.876	a	1.673	a
$LSD_{(0.05)}$	0.075		0.140		0.053	
CV(%)	5.810		5.740		6.050	

N_0 = 0 P_0=0

N_1= 90 kg/ha P_1= 15 kg/ha

N_2= 120 kg/ha P_2= 25 kg/ha

N_3= 150 kg/ha P_3= 35 kg/ha

4.10 Phosphorus concentrations in stover of rapseed

P concentration of stover was significantly influenced by the application levels of nitrogen (Table 7). The highest P concentration in rapseed stover (0.756 %) was recorded in N_3 (150 kg ha^{-1}). Otherwise, the lowest P concentration in rapseed stover (0.478 %) was recorded in N_0 treatment where no nitrogen was applied.

P concentration of stover was significantly influenced by application levels of Phosphorus (Table 8). The highest P concentration in rapseed stover (0.733%) was recorded in P_3 (35 kg ha^{-1}). The lowest P concentration in rapseed stover (0.515 %) was recorded in P_0 treatment where no Phosphorus was applied.

Significant effect was observed in combined application of different doses of nitrogen and Phosphorus fertilizer on the P concentration in stover of rapseed (Table 9). The highest concentration of P in the stover (0.876%) was recorded in the treatment combination of $N_3P_{3.}$The lowest P concentration (0.366 %) in stover was found in $N_0P_{0.}$

4.11 Potassium concentration in stover of rapseed

The effect of different doses of nitrogen fertilizer showed a statistically significant variation in the potassium concentration in stover (Table 7) of rapseed field. The total K content of the stover varied from 0.912 % to 1.586 %. Among the different doses of nitrogen fertilizer, N_3 (150 kg ha^{-1}) treatment showed the highest potassium concentration (1.586%) in stover. The lowest value was 0.942 % under control treatment and N_0.

The effect of different doses of Phosphorus fertilizer was not showed a statistically significant variation in the potassium concentration in stover (Table 8) of rapseed field. The total K content of the stover varied from 1.209 % to 1.435 %. The highest total K content (1.435 %) was observed in P_3 (35 kg ha^{-1}) treatment. The lowest value of K (1.209 %) was observed under control (K_0) treatment.

Significant effect of combined application of different doses of nitrogen and Phosphorus fertilizer on the potassium concentration was observed stover of rapseed (Table 9). The highest concentration of potassium in stover (1.673 %) was recorded in the treatment combination of N_3P_3. On the other hand, the lowest potassium concentration (0.706 %) in stover was found in N_0P_0.

Chapter V

SUMMARY AND CONCLUSION

The experiment was undertaken during rabi season (November to February) of 2014-15 to effect of nitrogen and phosphorus on growth and yield of rapeseed. In this experiment, the treatment consisted of four different N levels viz. N_0 = 0 kg N/ha, N_1 = 90 kg N/ha, N_2 = 120 kg N/ha and N_3= 150 kg N/ha, and four different level of P viz. P_0 = 0 kg/ha, P_1= 15 kg P/ha, P_2 =25 kg P/ha and P_3 =35 kg P/ha. The experiment was laid out in two factors Randomized Complete Block Design (RCBD) with three replications. The amount of fertilizers in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid as a source of N, P, K, S, Zn and B respectively were applied according to treatment and area of experimental unit plot. The collected data were statistically analyzed for evaluation of the treatment effect. Results showed that a significant variation among the treatments in respect majority of the observed parameters.

There is significant difference among the different levels of N in respect of almost all parameters. The tallest plant (75.71 cm) was recorded with $N_{3,}$ 150 kg N ha^{-1}. The maximum number of leaves per plant (16.40) was produced by 150 kg N ha^{-1}. The maximum number of branches per plant (7.97) was produced by 150 kg N ha^{-1}. The maximum number siliquae per plant (127.90) was obtained in plots which received 150 kg N ha^{-1}. The longest length of siliquae (4.85) was produced by $N_{3,}$ 150 kg N ha^{-1}. The maximum number seed per siliquae (33.46) was obtained in plots which received 150 kg N ha^{-1}. The maximum thousand seed weight (3.65 g) was produced by N_3. The maximum yield of seed per hectare (1.43 t) was obtained from $N_{3,}$ 150 kg N ha^{-1}, whereas the minimum yield of seed per hectare (1.08 t) was obtained from $N_{0,}$ without N.

N, P, K concentration of stover was significantly influenced by the application levels of nitrogen. The highest N concentration in rapseed stover (0.832 %), phosphorus concentration (0.756%) and potassium concentration (1.586%) was recorded in N_3 (150 kg ha^{-1}).

The effect of different doses of nitrogen fertilizer showed a statistically significant variation in the N, P, K concentration in post harvest soil. The N_3 (150 kg ha^{-1}) treatment showed the highest N concentration (0.299 %), P concentration (27.170%) and potassium concentration (76.28%) in soil.

Plant height, number of leaves, branches per plant and length of slliqua was influenced by statistically significant application of P. The tallest plant (80.10 cm) was produced with $P_{3,}$ 35 kg P ha^{-1}. The maximum number of leaves per plant (14.14), number of branches per plant (7.06), length of siliqua (4.42 cm) was produced with P_3, 35 kg P ha^{-1}. the maximum number of siliquae per plant (117.30), Number of Seed per pod (32.33) and thousand seed weight (3.62g) was produced in P_3, 35 kg P ha^{-1}. The highest yield of seed (1.45 t/ha) was obtained from $P_{3,}$ 35kg P ha^{-1} while P_0 gave the lowest (1.00 t ha^{-1}) yield.

N, P, K concentration of stover was significantly influenced by the application levels of phosphorus. The highest N concentration in rapseed stover (0.875%), total P content (0.733%) and potassium (1.435%) were recorded in P_3 (35 kg ha^{-1}).

The effect of different doses of phosphorus fertilizer showed a statistically significant variation in the nitrogen concentration in post harvest soil of rapseed field. The highest total N content (0.283%), P concentration (24.950%), potassium concentration (66.21 %) were observed in P_3 (20 kg ha^{-1}) treatment.

The combinations of N and P had significant effect on almost all parameter. The tallest plant (88.30 cm) was found in N_3P_3 treatment combination. The maximum number of leaves per plant (18.22), number of branches per plant (8.97) and length of siliquae (5.20 cm) was found in N_3P_3 treatment combination, 150 kg N ha^{-1} and 35 kg P ha^{-1}. The maximum number of siliquae per plant (136.20), number of seed per siliquae (37.42),, thousand seed weight (3.83 g) was found in $N_3P_{3,}$ 150 kg N ha^{-1} with 35 kg P ha^{-1}. The highest yield of seed per hectare (1.64 tones) was obtained from N_3P_3 treatment combination, 150 kg N ha^{-1} and 35 kg P ha^{-1}. The lowest yield of seed per hectare (0.77 tones) was obtained from N_0P_0 treatment.

Significant effect was observed in combined application of different doses of nitrogen and phosphorus fertilizer on the N, P, K concentration in stover of rapseed. The highest concentration of N in the stover (00.907%), phosphorus in stover (0.876 %) and potassium in the stover (1.673%), was recorded in the treatment combination of $N_3P_{3.}$

Considering the above results, it may be summarized that growth and seed yield contributing parameters of rapeseed are positively correlated with N and P application. Therefore, the present experimental results suggest that the combined use of 150 kg N ha^{-1} and 35 kg P ha^{-1} along with recommended doses of other fertilizer would be beneficial to increase the seed yield of rapeseed variety BARI sarisha-14 under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability and other performance.
2. The results are required to substantiate further with different varieties of rapeseed and mustard.
3. It needs to conduct more experiments with N and P whether can regulate the morphological charecters, yield and seed quality of rapeseed BARI sarisha 14.

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APPENDIES

Appendix I: **Soil characteristics of experimental farm of Sher-e-Bangla Agricultural University are 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**

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 (%)	1.08
Total N (%)	0.02
Available P (µgm/gm soil)	0.64
Available K (me/100g soil)	0.13
Available S (µgm/gm soil)	9.40