EFFECT OF NITROGEN AND BORON ON THE GROWTH AND YIELD OF POTATO (*Solanum tuberosum*)

A thesis

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*This is to certify that the thesis entitled "**EFFECT OF NITROGEN AND BORON ON THE GROWTH AND YIELD OF POTATO** (Solanum tuberosum)" submitted to the **DEPARTMENT OF SOIL SCIENCE**, 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 SOIL SCIENCE**, embodies the result of a piece of bona fide research work carried out by **JAFRIN AKTER**, Registration No**.** **18-09116** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

December,2020
Dhaka, Bangladesh

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Dedicated

to

My Beloved Parents

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The Author

ABSTRACT

The experiment was conducted at the Sher-e-Bangla Agricultural University Farm, Dhaka, (AEZ -28), Bangladesh during November 2019 to February 2020 to study the effect of nitrogen and boron fertilizer on yield components and yield of potato *(Solanum tuberosum)*. Three nitrogen levels; N_0 = 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2 = 150 kg N ha^{-1} and N_3 = 200 kg N ha^{-1} and four Boron levels; B_0 = 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1} and B_2= 2 kg B ha^{-1} were considered for the present study. The experiment was laid out in the two factors Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield components and yield of potato were recorded. Most of the parameters were significantly influenced by different levels of N application. The highest tuber yield ha^{-1} (22.22 t) and marketable yield ha^{-1} (20.96 t) were found from the treatment N_2 (150 kg N ha^{-1}) compared to control treatment N_0 (0 kg N ha^{-1}). Boron treatment also significantly influenced all the studied parameters and the highest tuber yield ha^{-1} (21.73 t), and marketable yield ha^{-1} (20.32 t) were achieved from the treatment B_2 (2 kg B ha^{-1}) compared to control treatment B_0 (0 kg B ha^{-1}). Considering combined effect of N and B, the highest plant height (67.26 cm), number of stem hill^{-1} (5.33), number of leaves hill^{-1} (73.54) number of tuber hill^{-1} (7.76), weight of tuber hill^{-1} (213.66 g), weight of tuber plot^{-1} (8.26 kg), tuber yield ha^{-1} (26.62 t) and marketable yield ha^{-1} (25.53 t) was recorded from the treatment combination of N_2B_2 (150 kg N ha^{-1} + 2 kg B ha^{-1}) whereas lowest plant height (44.85 cm), number of stem hill^{-1} (2.60), number of leaves hill^{-1} (34.34), number of tuber hill^{-1} (4.57), weight of tuber hill^{-1} (91.20 g), weight of tuber plot^{-1} (3.23 kg), tuber yield ha^{-1} (9.55 t) and marketable yield ha^{-1} (8.19 t) were found from the treatment combination of N_0B_0 (0 kg N ha^{-1} + 0 kg B ha^{-1}).

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSIR	=	Bangladesh Council of Scientific and Industrial Research
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
G	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Mili Litre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^0C	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Potato (Solanum tuberosum L.) is one of the most important vegetables as well crops having high production per unit area as well as per unit time. Potato production can effectively help not only in enhancing potato requirement of large segment of population, but it also plays role in providing employment. It produces more calories per unit time than any other major food crops. Which makes it, the most suitable nontraditional crop to world off hunger.

Potato is the 3rd largest tuber and vegetable crop in Bangladesh after rice and wheat. It is also a world leading vegetable crop that furnishes appreciable amount of vitamin B and vitamin C as well as minerals. Among the major food crops, potato produces the highest dry matter and edible protein per unit area and time. Potato is the king of vegetables, it contains substantial quantity of carbohydrates (22.6 g), edible protein (2.8 g), starch (16.3 g), total sugar (0.6 g), crude fiber (0.5 g), fat (0.14 g), mineral (0.9 g), calcium (7.7 mg), iron (0.75 mg), vitamin-C 25 mg on 100 g fresh weight of tuber. As an industrial crop, potato is a raw material of various foods and confectionaries. It produces more calories and protein per unit land with minimum time and water than most of the major food crops (Upadhya, 1995). Potato can be used in numerous ways, such as, boiled, baked and fried potatoes, dehydrated potatoes, canned potatoes and as starch for culinary purposes (Hoque, 1994). Because of its high yield potential and food value, compared to rice and wheat, potato is considered as a promising candidate crop for feeding the hungry people of the world.

In 2016-2017, the area, production, and average yield of potato in Bangladesh were 0.43 million hectare,7.93 million tons and 18.24 tons per hectare, respectively (BBS,2016). The yield level of this crop in Bangladesh is low compared to other growing countries of the world (Anon.,1997).

In 2017-18 year, from 4.8 lakh hectare area produced 93.4 lakh MT potato with average yield of 19.8 t ha^{-1} (BBS, 2018).

Nitrogen is an essential and important determinant for growth and development of crop plants (Tanaka et al., 1984). Nitrogen is constituent part of proteins, the basis of life, the nucleic acid (RNA, DNA), chlorophyll, phosphamide and other organic compounds. Nitrogen is essential for building up protoplasm and protein, which induce cell division and initial meristematic activity when applied in optimum quantity (Singh and Kumar, 1969). Nitrogen has the largest effect on yield and quality of potato (Xin et al., 1997). It also promotes vegetative growth, flower, and fruit set of tomato. It significantly increases the growth and yield of potato (Bose and som, 1990).

The potato plants with sufficient nitrogen are characterized by vigorous growth, increased leaf area, large tuber size as well as number. Nitrogen is the major nutrient in potato production and much variability exists in nitrogen requirements between cultivars (Chare et al., 1990). Cultivars generally show increased yield as nitrogen rate is increased (Belanger et al., 2000; Arsenault et al., 2001). However, excessive nitrogen lead to poor tuber quality, delayed crop maturity and excessive nitrate leaching, while nitrogen deficiency usually result in poor growth and low yield (Harris, 1992). Nitrogen is necessary to the potato from germination to maturity. The demand for this nutrient increases rapidly after germination and falls when 75 per cent of the plant growth is completed. Any delay in making this nutrient available, particularly during early active phase of growth, results in a set back to the crop. Information on the optimum dose of nitrogen to be applied for potato crop under different agro-climatic condition is necessary for a judicious use of fertilizer and also to obtain higher yields.

B is the second most important non-metal essential micronutrient after Zn required for normal plant growth and obtaining quality high crop yields ((Mengel K. a., 2001); Sathya, Pitchai, and Indirani 2009; (El-Dissoky, 2013); (Murmu, 2014)). B requirements differ among plant species and cultivars, the range between toxic and deficient concentrations is less than for B than any other nutrient in all crops, including potato (Abdulnour, Donnelly, and Barthakur 2000). Because of its role in fertilization and flowering processes of crops, B is being given special importance (Sathya, Pitchai, and Indirani 2009). B plays many important roles in higher plants including sugar transport, cell wall synthesis, lignification, cell wall structure integrity, carbohydrate metabolism, protein and ribose nucleic acid (RNA) metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism and as part of the cell membranes (Parr and Loughman 1983; Welch and Shuman 1995; Ahmad et al. 2009). If B is deficient, it exerted adverse effects on yield and quality of the crops. Adverse effects of B omission on the yield can occur even through no deficiency symptoms are evident on the foliage and it is known as “hidden hunger.” Therefore, B deficiency is often understood as an unsuspected enemy of crop production (Sathya, Pitchai, and Indirani 2009).

Spectacular response of cash crops including potato has largely been observed on B-deficient soil (Sathya, Pitchai, and Indirani 2009). Potato is a highly B responsive crop (Hazra, Saha, and Mandal 2012) while growth, yield and quality is greatly influenced by the B nutrition. Effect of B nutrition on processing grade cultivars of potato is still not reported in alluvial soil of West Bengal, despite B deficiency is quite common in this region. Moreover, the range between deficiency and toxicity levels of B in soil (0.50-4.00 mg kg^{-1}) as well as in plant (15-200 mg kg^{-1}) is narrow (Das, 2000). With slight variation in the recommended dose, crops may face either deficiency or toxicity in a single growing season (Batabyal, Sarkar, and Mandal 2015).

In Bangladesh, there is limited information on the effect of nitrogen and boron on growth and yield of potato. In view of these limitations, a field experiment containing the treatments of nitrogen and boron was conducted with the following objectives:

i. to study the growth and yield performance of potato by using different doses of nitrogen and boron fertilizers.
ii. to study the interaction effect of nitrogen and boron on growth and yield of potato.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITURATURE

Potato is one of the most important tuber crops for high intensity cropping system because of its short duration with very wide regional and seasonal adaptability. It is, therefore, remunerative and very successful crop under multiple cropping in areas with sufficient irrigation facilities and fertilizers. Among the fertilizers, nitrogen and boron is the most limiting factor for potato crop as it improves the vegetative growth and increases the tuber number as well as tuber size. Research works have been done in various parts of the world including Bangladesh is not adequate and conclusive. Some of the important and informative works conducted home and abroad in this aspect, have been furnished in this chapter.

Brief review is necessary to have knowledge of research work done on the topic, which includes salient findings of research work done in the past related with the present investigation and has been presented here under following heads.

2.1. Effect of Nitrogen on Potato

Nitrogen promotes vegetative growth and encourages the formation of good quality foliage by promoting the production of carbohydrate and encouraging succulence.

Das Gupta and Ghosh (1973) reported that the rate of leaf production and number of axillary branches of potato increased with an increase in the levels of nitrogen. They also concluded that the growth (on dry weight basis) of haulm, tubers and whole plant was higher under the 200 kg N ha^{-1} than under the lower levels.

Gupta and Saxena (1976) concluded that dry matter content decreased with increasing levels of nitrogen. The highest dry matter percentage was found in control (0 kg ha^{-1}) which was statistically at par with dry matter content of potato tuber produced by applying 60 kg N ha^{-1}. (Mandal, 1978) reported that the nitrogen had no influence on emergence percentage of Potato.

Das gupta D. K. (1973) They also observed that the emergence was slow in the initial stages, but when the crop reached 15 days ages, about 90 percent germination was noted.

Singh and Shivay (2003) reported that the effective tuber hill-1was significantly affected by the level of nitrogen and increasing levels of nitrogen significantly increased the number of effective tuber hill^{-1}.

Kumar B. K., (1996) concluded that an increase in N level from 80 to 120 kg N ha^{-1} significantly increased total tuber hill^{-1}. (Thakur, 1992) stated that the yield attributes of potato like number of productive tuber m-2and tuber weight increased with increasing levels of nitrogen.

Kumar R. a., (1979) reported that levels of nitrogen increased the plant height in potato, and it was significant up to 150 kg N ha^{-1}. Beneficial effect of Nitrogen was also observed in relation to increase haulm fresh and dry weight but the number of shoots per hill were unaffected by nitrogen levels.

Grewal et al. (1979) reported that the percentage of emergence of potato was 98 to 100 and not influenced by different levels of nitrogen application. (Hooda R. S., Effect of methods and rate of nitrogen application on growth, yield and quality of potato, 1980) reported that increased levels of nitrogen increased the height of main shoot during both the years (1976-77 and 1977-1978) 60 kg N ha^{-1} as basal + 60 kg N ha^{-1} at earthing up. Had the maximum plant height. Effect of nitrogen application on number of shoots per hill was significant. Similarly, the effect of nitrogen application on dry matter percentage of tuber was significant and it decreased with increasing levels of nitrogen.

In contrast, according to Singh et al. (1986), the initial plant emergence (10 days after planting) in potato was low (5-10%) but subsequently the emergence increased at 30th day (57-75%) with increasing levels of nitrogen from 0 to 100 kg/ha.

Gupta A. a., (1989) at Shimla, studied the response of potato varieties to nitrogen fertilization under rainfed condition. They reported that nitrogen fertilization significantly increased shoot per plant and tubers ha^{-1} and reported that application of 150kg N ha^{-1} was at par with 100 kg N ha^{-1}. Satyanarayana and Arora (1985) have also reported similar increase in shoots and tubers with N fertilization.

Kushwah V. S., (1989) at Patna, Bihar studied the best combination of nitrogen and planting density for seed production of Kufri Lalima. Significant increase in plant height and decrease in number of stem per m2 was observed with an increase in nitrogen dose from 120 to 180 kg /ha^{-1}.

Singh S. a., (1986) reported that fresh weight of shoot, dry matter content and potato plant height increased with the application of 180 kg N ha^{-1}. Similarly, (Singh M. , 1995) observed that the highest germination percentage (100%) was recorded at 30 days after planting with the application of nitrogen @ 200 kg/ha^{-1}.

Chaurasia, (1993) reported that increase in the level of nitrogen, delayed the emergence from 15th day onwards. (Anabousi, Effect of rate and source of nitrogen on growth, yield and quality of potato, 1997) conducted an experiment with three nitrogen fertilizer sources (urea, ammonium sulphate and potassium nitrate) applied at 4 rates (0, 125, 250 or 375 kg N /ha^{-1}) on potato cv. Spunta "in which they found that with each nitrogen fertilizer increment resulted in a significant increase in plant height, stem number $plant^{-1}$, leaf chlorophyll and leaf N and K contents.

Sharma G. S., Effect of nitrogen and farmyard manure on growth, nutrient content and uptake of potato., (1997) at Udaipur, studied plant growth characters in potato i.e., number of branches and number of leaves $plan^{-1}$ and found significantly increase by the application of 80 kg N /ha while the higher dose i.e., 120 kg N/ha was found at par with 80 kg N /ha. Dry matter accumulation was improved significantly by increased N application at 30 days after sowing.

Gabr S. M., Response of some new potato cultivars grown in sandy soil to different nitrogen levels., (1998) at Egypt, studied the effect of nitrogen level (0, 50, 10 or 150 kg N per feddan) on growth, yield and quality of potatoes. Increasing nitrogen doses up to 150 kg N per feddan significantly increased vegetative growth, including plant height, fresh weight and leaf area, while 12 number of main stems were not affected.

Malik, Effect of spacing, nitrogen and potash on potato variety Kufri Jawahar., (1998) found that shoots per hill was not influenced by any of the N application treatment under consideration, while plant height was influenced significantly by nitrogen application with increased level of nitrogen up to 124 kg ha^{-1}.

Ananda, (1999) at Bangalore, studied thirty-day old potato seedlings transplanted at two inter row (30 to 40 cm) and within row (10 to 15 cm) spacing's treated with nitrogen and potassium at 125 or 150 kg ha^{-1}. They reported that number of leaves, leaf area per plant and dry weight per plant at 60 days after transplanting were higher at wider spacing than at narrow spacing and high rates of nitrogen and potassium produced higher dry weight of plant per hill.

Gathungu, (2000) reported that early application of nitrogen followed by split applied fertilizer led to a fast early growth (shoot, tuber, root and total dry matter, leaf area index and plant height) particularly when calcium ammonium nitrate was applied. Later, nitrogen application enhanced the growth of the shoots during the growth season with urea particularly.

Oliveria, (2000) reported that the average number of active haulms per plant was increased by applying 200 kg nitrogen. They reported that maximum stem elongation was remaining constant at the highest and lowest nitrogen levels at 70 days after planting.

Patel J. C., (2001) observed that "Kufri Badshah" recorded a higher tuber yield than "TPS C-3". The increase in nitrogen level up to 260 kg ha-1 resulted in significant increase in plant height, number and fresh weight of tubers per plant.

Kumar V. S., (2002) observed increased plant height, number of stems per hill and leaf fresh weight with increasing rates of nitrogen. Malik et al. (2002) reported that plant height, fresh weight of foliage increased with the increasing rate of nitrogen.

Das gupta D. K., Effect of nitrogen on the growth and yield of potato (Solanum tuberosum L.), (1973) reported that greater number and size of tubers accounted for higher yield under high nitrogen fertilization of 200 kg ha^{-1}.

Sagar, (1973) conducted an experiment at Pantnagar and reported that Kufri-Chandramukhi showed faster bulking rate per day as compared to Kufri-Sinduri, with the application of nitrogen @ 100 kg ha^{-1} at the time of planting which produced the maximum yield.

Shukla, (1976) found that application of 225 kg and 150 kg N ha^{-1} increased the yield of tubers and superior grade tubers significantly over 75 kg N ha^{-1} and control, which in turn differed significantly. Application of 200 kg N /ha was found to be the most effective rate of nitrogen.

Hooda R. S., (1980) observed that tuber yield was significantly higher with the application of 120 kg N ha^{-1}, than 80 kg N ha^{-1}. There was an increase in number of tubers per hill and large size tuber yield with nitrogen over control. (Kozlowski, 1989) studied potato cv. „Sokol‟ given 0-200 kg N ha-1 in addition to 30 t FYM, 120 kg P_2O_5 and 180 kg K_2O ha-1 and found that tuber yield was highest (14.8 t ha^{-1}) with 120 kg N.

Kushwah V. S., Effect of different levels of nitrogen and planting density on production of seed potato (Solanum tuberosum L.), (1989) observed significant increase in number of seed-size tubers up to 150 kg N ha^{-1}. (Gupta A. a., 1989) reported that nitrogen fertilization not only increased different grade tuber yield but also increased proportion of large and medium tubers and decreased the proportion of small tubers. The highest tuber yield (330.2q ha^{-1}) was obtained at 150 kg N ha^{-1}. (Nandekar, 1992) reported that tuber yield was highest (27.06 t ha^{-1}) with 60 kg N at planting + 40 kg N at earthing up + 2 foliar sprays.

Llerhagen P. J., (1993) reported that the tuber yield of cv., Beate " increased with increasing levels of nitrogen and reported that the dry matter content of all cultivars decreased with increasing nitrogen application.

Singh and Singh (1994) studied the effect of four rates of nitrogen (60, 120, 180 and 240 kg ha^{-1}) and four application methods (0.5 as basal + 0.5 on top dressing, 0.75 basal + 0.25 top dressing, 0.5 basal + 0.25 spray + 0.25 top dressing, 0.75 basal + 0.25 spray). They observed that yield increased by 28.4 per cent with 180 kg N compared with 60 kg N. The highest yield of tubers was achieved with the 0.75 basal dressing + 0.25 spray application.

Reust, (1995) at Faizabad, found that maximum potato tuber yield at 120 kg N ha-1 although high doses increased the frequency of large tubers. Similarly, Sharma et al. (1995) obtained the highest tuber yield (25.36 t ha^{-1}) with 160 kg N ha^{-1}.

Sings (1995) found that the application of nitrogen increased the tuber yield significantly with increasing doses up to 200 kg ha^{-1}. (Kumar B. K., 1996) reported that the application of nitrogen increased the tuber yield significantly up to 120 kg nitrogen. But tuber dry matter decreased with increasing nitrogen rate.

Anabousi, Effect of rate and source of nitrogen on growth, yield and quality of potato., (1997) conducted experiment at Central Jordan Valley and observed that increasing nitrogen application rates up to 250 kg N ha^{-1} resulted in significant increases in large and medium sized tuber yield, marketable, total yields and tuber weight with reductions in tuber dry matter. (Dubey, 1998) reported that tuber yield of potatoes cv. Kufri Chanramukhi increased with increasing nitrogen level.

Anabousi, Effect of rate and source of nitrogen on growth, yield and quality of potato., (1997) found that significantly increase in total tuber yield with the application of 75 to 100 kg N ha^{-1}. However, tuber yield was not affected with further increase in nitrogen application.

Roy, (1998) at Jalandhar, Panjab, found that total and large size (> 75 g) tuber yield increased by applying up to 240 kg N ha-1 and medium size tuber increased up to 120 kg N ha^{-1} application.

Sharma G. S., Effect of nitrogen and farmyard manure on yield and yield attributing characters of potato (Solanum tuberosum L.)., (1998) at Udaipur, reported that nitrogen application enhanced the number of tubers and weight of tubers per plant by application of 120 kg N ha^{-1}.

Deka and Dutta (1999) reported that tuber yield increased with increasing nitrogen rate, and the fertilizer also increased the number of tubers per plant, bulking rate, net profit and net production value. The optimum economic rate of nitrogen was calculated to be 247 kg ha^{-1}, with expected yield of 15.5 t ha^{-1}.

Singh M. S., (1999) carried an experiment at Faizabad, Uttar Pradesh and found that the yield of potato tubers increased significantly with increase in nitrogen levels from 0 to 200 kg ha^{-1}. revealed that the highest dry weight of tubers per plant was recorded at 260 kg N ha^{-1}.

Singh N. P., (2000) at Pantnagar, revealed that the maximum tuber yield was recorded at 160 kg N ha-1 (254.0 q ha^{-1}).

Patel J. C., (2001) reported that „Kufri Badshah" recorded higher tuber yield than „TPS C-3". The increase in nitrogen level up to 250 kg ha^{-1} resulted in significant increase in number and fresh weight of tubers per plant.

Kavvadias, (2002) reported that application of 120: 150: 250 kg NPK ha^{-1} gave the highest tuber dry matter content (26.2%), while application 360: 150: 250 kg NPK /ha + 100 kg Mg ha^{-1} gave the highest tuber yield of 39.7 t ha^{-1}, tuber mean fresh weight of 207.4g and tuber dry matter yield of 8.9 t ha^{-1}.

Veer, (2002) studied the effect of nitrogen levels (75, 100, 125, 150 and 175 kg ha^{-1}) on the bulking properties of potato cv. Kufri Sutlej. They observed that number of tubers per hill, dry matter content, yield of different grade tubers, mean total tuber yield and tuber bulking increased with increasing rates of nitrogen.

Hamedani, (2003) reported that nitrogen fertilization had no effect on the number of tubers and shoots per plant. He also reported that the effect of cultivar and nitrogen fertilization on tuber weight and yield were significant.

Pashalidis, (2003) investigate the effects of nitrogen at 330, 495 and 660 kg ha-1 and potassium fertilizers at 112, 225, 450 and 675 kg ha^{-1} on potato cv. „Spunta" and reported that at the highest nitrogen rate of 660 kg ha^{-1} tuber yield was significantly reduced. They also reported that potassium fertilizers have no response on tuber yield. The highest mean tuber yield was obtained under 495 kg N ha^{-1}, mainly due to the total number of tubers

Zebarth, Rate and timing of nitrogen fertilization of Russet Barbank potato: yield and processing quality., (2004) conducted a trials of different nitrogen rate (0-160 kg N ha^{-1} in 1999 and 0-200 kg N ha^{-1} in 2000 and 2001). They found that increasing rates of N fertilization increased tuber yield and tuber size.

Baht et al. (2005) at Srinagar, found that significant increase in tuber yield of 264.86 q ha^{-1} to 314.26 q ha^{-1}, with increasing nitrogen level from 120 to 160 kg ha^{-1}. Further increase in the level of nitrogen up to 200 kg ha^{-1} significantly decreased the tuber yield to 269.78 q ha^{-1}.

Yenagi,(2005) conducted an experiment at Dharwad and observed with application of 150 kg nitrogen yield 14.98, 25.19 and 67.90 per cent more as compared to 100, 50 and 0 kg nitrogen respectively. They concluded that the increase in tuber yield with application of 150 kg nitrogen was due to the greater number of tubers and tuber weight per plant.

Das gupta D. K., Effect of nitrogen on the growth and yield of potato (Solanum tuberosum L.), (1973) reported decrease stem elongation in Bombai Red, at 200kg N ha^{-1}, with increased branch production markedly. At 100 kg N ha^{-1} in stem elongation was found to be associated negatively with number of branches. The dry weight of tubers progressively increased with increase in the levels of nitrogen.

Gupta and Pal (1989) found that varieties SLB /Z-132 and Khufri jyoti responded significant to 50 kg N ha^{-1} whereas „Khufri sherpa‟ showed response to level of 100 kg N ha^{-1}. Variety SLB/Z-132 recorded higher tuber yield at 150 kg ha^{-1} as compared to 100 kg N ha^{-1} but the other two varieties had identical yield at both of these nitrogen rates.

Llerhagen P. J., (1993) conducted a field experiment at 5 locations in Norway, where in potatoes were given 0, 50, 100 or 150 kg N ha^{-1}. They reported that the tuber yield of cv., Beate‟ increased with increasing levels of nitrogen, while for cv. Danva and Matilda yield was increased 100 kg nitrogen.

Gabr S. M., (1998) studies response of by applying new potato cultivars grown in sandy soil with different nitrogen levels. They reported that the greatest response in term of vegetative growth, yield and quality of potato was obtained with cv. Arenda receiving 150 kg N per feddan (1 feddan = 0.42 ha.)

2.2. Effect of Boron on Potato

The requirements of micronutrient for growth and development of plant relatively to a smaller amount. Boron requires for plant growth processes like new development of meristematic tissue, translocation of sugar, starch nitrogen and phosphorus and synthesis of amino acid and proteins (tisdale et al., 1984).

Sarkar, (1996) carried out an experiment at Gangachara Series of Mithapukur, Rangpur indicated that the highest tuber yield of 28.72 t/ha was produced by the combined effect of 150kg N+ 60 kg P + 120kg K+ 20kg S +20kg Zn +2kg B + 15 kg Mg + 5 t cow dung per hectare.

A field study was conducted by (Wijnholds, 1996) to investigate the effect of Nitro-Plus (12% N,12%Ca, 3.2%B) on the yield of seed potato using row application of 2 levels of Nitro-Plus (200 and 250L/ha). It was found that the treated crops grew more slowly in height and a large proportion of tubers exceeded 55 mm diameter. However, the yield of marketable tubers was unaffected.

Oyewole,(1992) found that a local variety of tomato (Ife plum cv. 51691) was grown in pots for 5 months in soil treated with B at concentrations of 0, 1, 2, 4, 8 and 16 p.p.m. as H3BO3, and Ca at 0, 40, 80 and 160 p.p.m. as Ca $(OH)_2$. The relationship between OM and water-soluble B was positive while that between pH and B was negative. Application of B at 2 p.p.m. increased leaf number, stem diameter, number of flowers and fruit yield, and reduced per cent flower abortion. Boron application at rates higher than 2 p.p.m. induced leaf chlorosis followed by necrosis of nodes and roots. Fruit yield correlated positively with soil B, stem diameter and floral number. Plant B was positively correlated with soil B. Calcium when applied singly at higher levels (80 and

160 p.p.m.) increased total chlorophyll content of the leaf. Tomato fruit yield was greatest (166 g/plant) at B: Ca treatment combination of 2 p.p.m. B (4.48 kg/ha) and 160 p.p.m. Ca (358.4 kg/ha Ca).

Gunes, Alpaslan, & Cikili, (2000) carried out a greenhouse experiment involving 4 levels of boron (0, 5, 10 and 20 mg/kg) and 3 levels of zinc (0, 10 and 20 mg/kg) was conducted on tomato cv. Lale. Boron toxicity symptoms occurred at 10-20 mg B/kg. These symptoms were partially alleviated in plants grown with applied Zn. Fresh and dry plant weights were strongly depressed by applied B. However, Zn treatments reduced the inhibitory effect of B on growth. Increased levels of B increased the concentrations of B in plant tissues to a greater extent in the absence of applied Zn. Both Zn and B treatments increased Zn concentration of the plants.

Carpena and Carpena (1987) stated that potatoes (cv. Marglobe) were grown hydroponically with automatic control of solution composition and environment, and the B supply was held constant at each of 5 levels (from 0.02 to 3.00 p.p.m.). Data on the effects of B supply on the contents of 9 leaf macro- and micro-elements at 5 growth stages (from vegetative to full fruiting) are shown graphically and discussed; and data on the ratios between leaf B and the 9 other nutrients are tabulated for the same growth stages and discussed. Such data should assist in understanding the importance of B in the general metabolism of the plant and indicate more accurately than visual symptoms what levels of B adversely affect the fruit yield.

Efkar, Jan, Khattak, & Khattak, (1995) carried out an experiment to study the response of potato cv. Desiree to the application of boron fertilizer in Pakistan using 4 levels of boron (0, 1, 1.5 and 2 kg/ha). The crop also received a basal dressing of NPK fertilizers and FYM (5 t/ha). Application of 1.5 kg B/ha gave the highest tuber yield of 10.9 t/ha compared with the control yield of 7.9 t/ha.

Pregno, (1992) conducted an experiment to find out boron deficiency and toxicity in potato cv. Sebago on an oxisol of the Atherton Tablelands at North Queensland, Australia. In this field trial 5 doses of boron (0, 2, 4, 8 and 12 kg B/ha) were used. It was observed that total tuber yield was the highest when 2 kg B/ha was applied, and it was followed by 4 kg/ha. Plant height was not increased by low rates of boron but was reduced by 8 and 12 kg B/ha compared with no B.

Palkovics, (1984) to determine the effect of boron on the growth and yield of potato cv. Somogy on rusty forest soil. It was observed that the application of boron contributed to yield increments and to the improvement of tuber quality. The critical level of B was 60 mg/kg of foliage and above this, B content depressed yield.

Quaggio, (1986) studied the influence of micronutrient boron on the production of potato. Boron was applied at the rates of 0, 3, 6, 9 and 12 kg/ha as boric acid. The authors found that the effect of boron was more pronounced on the yield of large sized tubers than on the small ones.

Omer & Hafez and Foda, (1982) stated that the boron at any concentration had little effect on plant and tuber number; but marketable tuber yield was increased with increasing concentration of boron.

Grewal J. S.,(1981) studied the effect of trace elements on potato and observed that some cultivars showed a marked response to Zn and B application while others showed little response.

Awasthi, (1977) worked with potatoes on slightly acidic soils at Shillings, India, using soil application of 25 kg ZnSo4/ha or foliar application of 0.1% boron solution. The authors observed that both Zn and B application increased tuber yield by 100-150 kg/ha.

Baevre,(1990) reported that growing the glasshouse cultivar Jet in peat with different levels of B (1.4, 2.2 or 4.6 g/m3), reduced mean fruit weight and increased the proportion of fruits weighing between 5 and 30 g. Increased B supply improved fruit shape and reduced hollowness [puffiness], especially in fruits with a salable weight. The effect of B on seed development was most marked for small fruits. B rate had no significant effect on the relationship between seed weight/fruit and fruit weight.

Carpena and Carpena (1987) stated that tomatoes (cv. Marglobe) were grown hydroponically with automatic control of solution composition and environment, and the B supply was held constant at each of 5 levels (from 0.02 to 3.00 p.p.m.). Data on the effects of B supply on the contents of 9 leaf macro- and micro-elements at 5 growth stages (from vegetative to full fruiting) are shown graphically and discussed; and data on the ratios between leaf B and the 9 other nutrients are tabulated for the same growth stages and discussed. Such data should assist in understanding the importance of B in the general metabolism of the plant and indicate more accurately than visual symptoms what levels of B adversely affect the fruit yield.

CHAPTER III

MATERIALS AND METHOD

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during November 2019 to February 2020 to examine the effect of nitrogen (N) and boron (B) on the growth and yield of Potato.

3.1. Experimental site

The experimental site was located at 23^0 77' N latitude and 90^0 3' E longitude (Fig. 1). The soil of the experimental site belongs to Tejgaon series under the Argo-ecological zone, Madhupur Tract (AEZ -28), which falls into Deep Red Brown Terrace Soil. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are shown in Appendix II

3.2. Climate

The experimental area has sub-tropical climate characterized by heavy rainfall during May to September and scant rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm. The average maximum temperature is 30.34^0 C and average minimum temperature is 21.21^0 C. The average mean temperature is 25.17^0 C. The experiment was done during the rabi season. Temperature during the cropping period was ranged between 12.20 ^{0}C to 29.2 ^{0}C. The humidity varies from 71.52 % to 81.2 5%. The day length was reduced to 10.5 – 11.0 hours only and there was a very little rainfall from the beginning of the experiment to harvesting (appendix –I).

3.3. Seed and Variety

The variety, Cardinal was used for the present study and were collected from the Tuber Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.4. Design and Layout of Experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of N (0,100, 150 and 200 kg N/ha designated as N_0, N_{100}, N_{150} and N_{200}, respectively) and 3 levels of B (0, 1, and 2 kg B/ha designated as B_0, B_1, B_2 respectively). There were 12 treatment combinations. The treatment combinations were as follows:

N_0B_0 = Control (without N and B application)

N_0B_1 = 0 kg N/ha +1 kg B/ha

N_0B_2 = 0 kg N/ha + 2 kg B/ha

N_1B_0 = 100 kg N/ha + 0 kg B/ha

N_1B_1 = 100 kg N/ha + 1 kg B/ha

N_1B_2 = 100 kg N/ha + 2 kg B/ha

N_2B_0 = 150 kg N/ha + 0 kg B/ha

N_2B_1 = 150 kg N/ha + 1 kg B/ha

N_2B_2 =150 kg N/ha + 2 kg B/ha

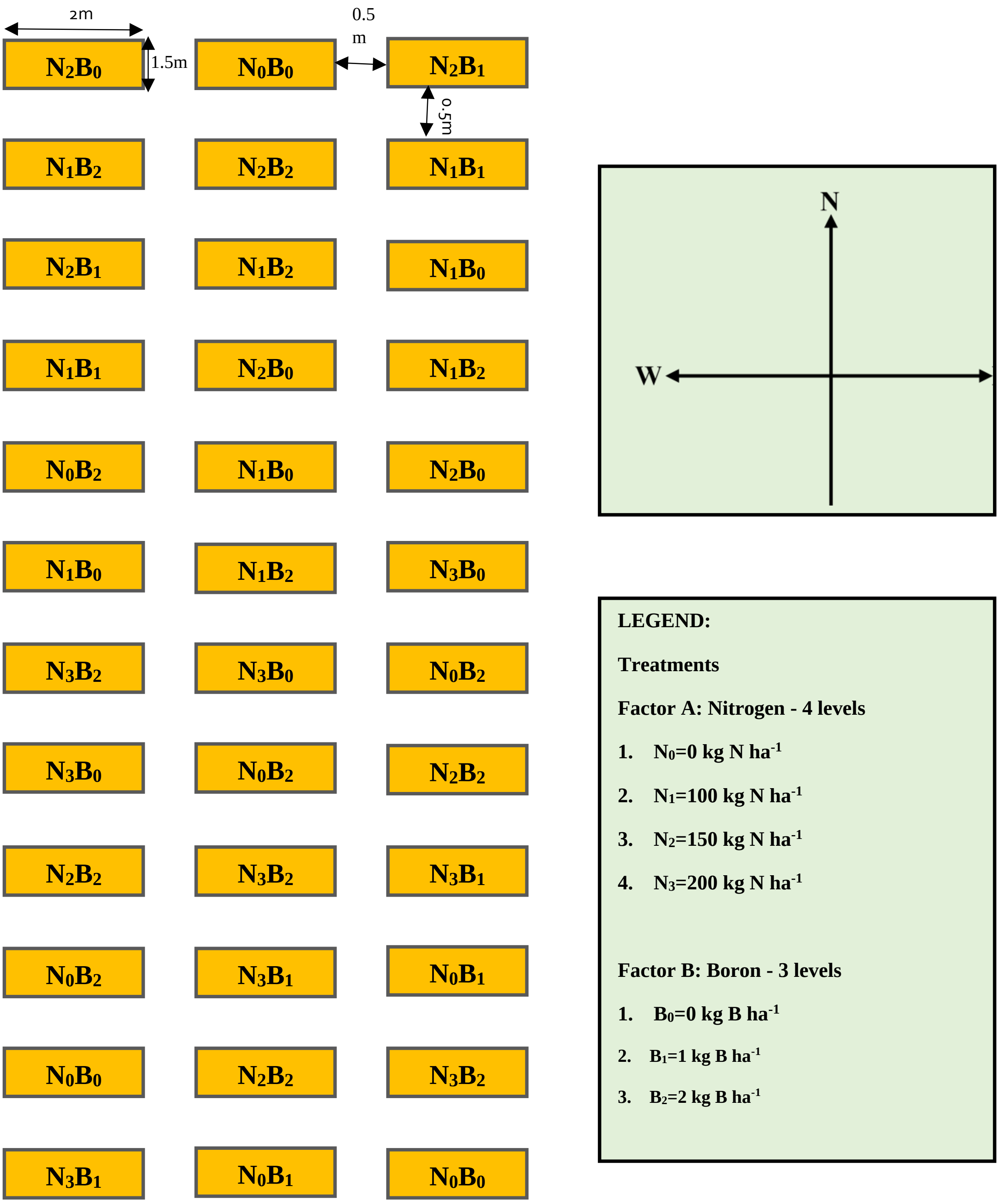
N_3B_0 = 200 kg N/ha + 0 kg B/ha

N_3B_1 =200 kg N/ha + 1 kg B/ha

N_3B_2= 200 kg N/ha + 2 kg B/ha

Fertilizer treatments were randomly distributed in each block. Each block consisted of 12 plots and individual plot was 2 m × 1.5 m i.e., 3.00 sq. m in size. The adjacent block and neighboring plots were separated by 0.5 m and 0.5 m, respectively. The layout of the experiment is shown in (fig: 1)

Figure 1. Layout of the experimental field



3.5. Collection and Processing of Soil Sample

Soil samples from the experimental field were collected before land preparation to a depth of 0-15 cm from the surface of the basis of composite sampling method. The collected soil was air dried ground and passed through a 2-mm sieve and stored in a clean, dried plastic container for physical and chemical analysis.

3.6. Land Preparation

The land of the experimental site was first opened in the first week of November 2019 with power tiller. Later on, the land was ploughed and cross-ploughed four times followed by laddering to obtain the desirable tilth. The corners of the land were spaded, and weeds and stubbles were removed from the field. The land was finally prepared on 1 November 2019 three days before planting the seed. In order to avoid waterlogging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @10 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cut worm.

3.7. Application of Fertilizer and Manure

The crop was fertilized as per recommendation of TCRC (2004). Triple superphosphate (TSP), zinc sulphate and boric acid were used as sources of nitrogen, phosphorus, zinc and boron, respectively. The recommended doses of fertilizers were 150, 250, 120, 10 and 10000 kg ha^{-1} for TSP, MoP, gypsum, $ZnSO_4$ and cow dung respectively. Under the present study, urea and boric acid were applied as per treatment. Cow dung was applied 10 days before of final land preparation. Total amount of TSP, ZnO and half of urea was applied at basal doses during final land preparation. The remaining 50% urea was side dressed in two equal splits at 25 and 45 days after planting (DAP) during first and second earthing up.

3.8. Seed Preparation and Sowing

The seedling tubers were taken out of the cold store about three weeks before planting. The tubers were kept under diffuse light conditions to have healthy and good sprouts. Planting was done on 3 November 2019. The well sprouted seed tubers were planted at a depth of 5-7 cm in furrow made 45 cm apart. Hill to hill distance was 15. After 2planting, the seed tubers were covered with soil.

3.9. Intercultural Operation

3.9.1. Weeding

First weeding was done two weeks after emergence 20 November 2019. Another weeding was done before 2nd top dressing of urea on 30 November 2019.

3.9.2. Earthing up

Earthing up was done twice during growing period. The first earthing up was done at 25 DAP on 29 November 2019 and second earthing up was done after 15 days of first earthing up on 14 November 2019.

3.9.3. Irrigation

Three irrigations were provided throughout the growing period in controlled way. The first irrigation was given at 25 DAP on 29 November 2019. Subsequently, another two irrigations were given at 45 and 60 DAP on 19 November 2019.

3.9.4. Plant protection

Furadan 5G @ 10 kg ha-1 was applied in soil at the time of final land reparation to control cut worm. Dithane M-45 was sprayed in 2 installments at an interval of 15 days from 50 DAP as preventive measure against late blight disease.

3.10. Harvesting

The crop was harvested to study growth and development rate from 30 DAP to 70 DAP at 20 days interval and the final harvest was taken at 85 DAP. The harvested plants were tagged separately plot wise. Ten sample plants were randomly selected from each plot and tagged for recording necessary data and then all plots were harvested with the help of spade. The maturity of plant was indicated by the plants showing 80 to 90% of leaf senescence and the top started drying. Haulm cutting was done before 7 days of harvesting. The yield of tuber was taken plot wise and converted into tons ha^{-1}. Care was taken to avoid injury in potatoes during harvesting.

3.11. Collection of Experimental Data

Ten (10) plants from each plot were selected as random and were tagged for the data collection. The sample plants were uprooted and dried properly in the sun. Data were recorded on the following parameters from the sample plants during the course of experiment.

1. **Plant height**
2. **Number of stems per hill**
3. **Number of leaves per hill**
4. **Number of tubers per hill**
5. **Weight of tuber per hill**
6. **Tuber weight/plot (kg)**
7. **Yield (t ha^{-1})**
8. **Marketable yield (t ha^{-1})**

3.12. Methods for Soil Analysis

1. **Particle size analysis of soil**

   Particle size analysis of the soil was done by hydrometer method (Bouyoucos, 1927). The textural class was determined using Marshall's Triangular Co-ordinate as designated by USDA.

2. **Organic carbon (%)**

   Organic carbon in soil was determined by Walkley and Black's (1934) wet oxidation method. The underlying principle is to oxidize the organic carbon with an excess of 1 N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and to titrate the residual $K_2Cr_2O_7$ solution with 1 N $FeSO_4$ solution. The result was expressed in percentage.

3. **C/N ratio**

The C/N ratio was calculated from the percentage of organic carbon and total N.

4. **Soil organic matter**

   Soil organic matter content was calculated by multiplying the percent value of organic carbon with the Van Bemmelen factor, 1.724 as described by Piper (1942). % Organic matter = % organic carbon × 1.724

5. **Soil pH**

   The PH of the soil was determined with the help of a glass electrode pH meter using soil: water ratio being 1:2.5 (Jackson, 1973).

6. **Total nitrogen (%)**

   Total nitrogen content in soil was determined by Kjeldahl method by digesting the soil sample with conc. H_2SO_4, 30% H_2O_2 and catalyst mixture (K_2SO_4: $CuSO_4.5H_2O$: Se = 10:1:0.1) followed by distillation with 40% NaOH and by titration of the distillate trapped in H_3BO_3 with 0.01 N H_2SO_4 (Black, 1965).

7. **Available boron (ppm)**

   Available boron (B) content in the soil samples was determined by the method described by Hunter (1984). The extracting agent used was monocalcium phosphate [$CaH_4(Po_4)_2$. H_2O] solution and color was developed by curcumin solution. The absorbance was read on spectrophotometer at 555 nm wavelengths.

3.13. Statistical Analysis

The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan`s Multiple Range Test (DMRT) with Least Significant Difference value was determined with appropriate levels of significance and the means were tabulated. The mean comparison was carried out by DMRT technique (Gomez and Gomez, 1984).

CHAPTER IV

RESULT AND DISCUSSION

CHAPTER IV

RESULT AND DISCUSSIONS

The research work was accomplished to investigate the response of nitrogen and Boron fertilizer on yield components, yield in potato (Solanum tuberosum). Some of the data have been presented and expressed in table(s) and others in Figures for easy discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix. The results of each parameter have been discussed and possible interpretations wherever necessary have been given under following headings.

4.1.Growth parameter of tuber

4.1.1. Plant height of tuber

Effect of Nitrogen

Different nitrogen (N) levels had significant influence on plant height at different growth stages of potato (Fig.2 and Appendix IV). Results revealed that the highest plant height (25.04, 53.09 and 63.73 cm at 30, 50 and 70 DAS, respectively) was found in the treatment N_2 (150 kg N ha^{-1}). At all growth stages, N_2 (150 kg N ha^{-1}) was significantly different from all other treatments. The lowest plant height (14.32, 38.82 and 48.69 cm at 30, 50 and 70 DAS, respectively) was observed from the control treatment N_0 (0 kg N ha^{-1}) which was significantly different from all other treatments at all growth stages. Similar result was also observed by the findings of Gabr and Sarg (1998) and Kushwah (1989) which supported the present study.

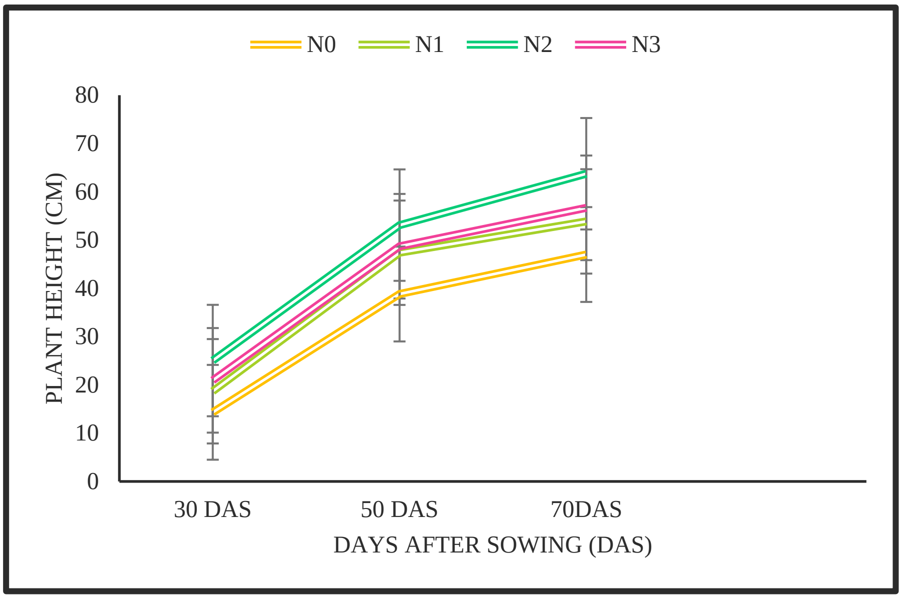


Figure 2 Plant height of potato influenced by Nitrogen

N_0= 0 kgha^{-1}, N_1 = 100 kgha^{-1}, N_2= 150 kgha^{-1}, N_3= 200 kgha^{-1}

Effect of Boron

There was a significant variation on plant height influenced by different Boron (B) levels at different growth stages (Fig. 3 and Appendix IV). Results showed that the highest plant height (19.04, 50.51 and 58.51 cm at 30, 50 and 70 DAS, respectively) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was significantly different from one another at all growth stages. The lowest plant height (20.30, 44.20 and 53.20 cm at 30, 50 and 70 DAS, respectively) was obtained from the control treatment B_0 (0 kg B ha^{-1}) which was significantly different from all other treatments.

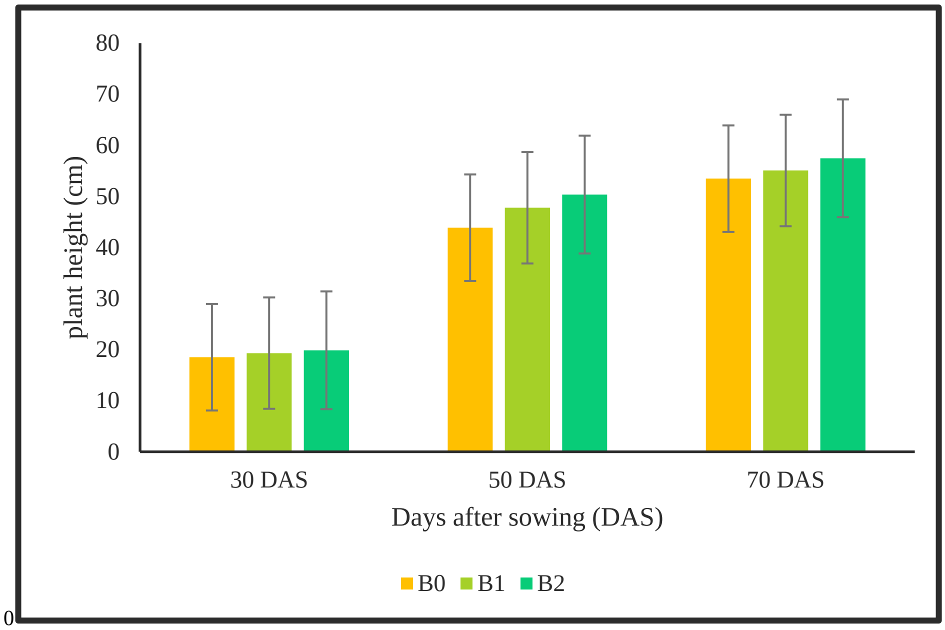


Figure 3 Plant height of potato influenced by Boron

B_0 = 0 kg B ha^{-1}, B_1= 1 kg B ha^{-1}, B_2=2 kg B ha^{-1}

Combined effect of Nitrogen and Boron

Plant height was significantly influenced by combined effect of different N and B levels at different growth stages of potato (Table 1 and Appendix IV). The highest plant height (26.15, 58.70 and 67.26 cm at 30, 50 and 70 DAS, respectively) was recorded from the treatment combination of N_2B_2. At 30, 50,70 DAS, the treatment combination was not significantly different from one another. The lowest plant height (13.56, 35.09 and 44.85 cm at 30, 50 and 70 DAS, respectively) was found from the treatment combination of N_0B_0. At 30 DAS, it was significantly same with the treatment combination of N_0B_1. Similar trend was also observed at 50 and 70 DAS. The result obtained from the present study was similar with the findings of (Zelalem, 2009).

Table 1 Interaction effect of N and B on plant height

Treatment	Plant height (cm)		
	30 DAS	50 DAS	70 DAS
N_0B_0	13.56 f	35.09 e	44.85 e
N_0B_1	14.32 f	36.87 e	47.26 de
N_0B_2	15.10 f	44.51 cd	53.98 bc
N_1B_0	17.93 e	43.56 d	51.70 cd
N_1B_1	18.77 e	48.22 bcd	54.30 bc
N_1B_2	19.35 de	50.33 bc	55.59 bc
N_2B_0	23.95 b	47.90 bcd	58.86 b
N_2B_1	25.04 ab	52.66 b	65.06 a
N_2B_2	26.15 a	58.70 a	67.26 a
N_3B_0	20.72 cd	50.24 bc	57.40 bc
N_3B_1	21.49 c	47.44 bcd	55.39 bc
N_3B_2	20.62 cd	48.48 bcd	57.21 bc
$LSD_{0.05}$	1.62	5.75	5.96
CV%	2.77	4.12	3.61

In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differs significantly by LSD at 0.05 levels of probability

N_0 = 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2 = 150 kg N ha^{-1}, N_3 = 200 kg N ha^{-1}
B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.1.2. Number of stems per hill of potato

Effect of Nitrogen

The number of stem hill^{-1} at different growth stages was significantly influenced by different nitrogen (N) levels (Fig. 4 and Appendix V). Results revealed that the highest number of stem hill^{-1} (3.86, 3.97 and 4.48 at 30, 50 and 70 DAS, respectively) was found the treatment N_2 (150 kg N ha^{-1}). At 30 DAS, all treatment were significantly different from other. At 50 and 70 DAS, similar trend was also found. The lowest number of stem hill^{-1} (1.94, 2.14 and 2.92 at 30, 50 and 70 DAS, respectively) was observed from the control treatment N_0 (0 kg N ha^{-1}). Similar result was also observed by Hooda and Pandita (1980) and Anabousiet al. (1997) which supported the present study.

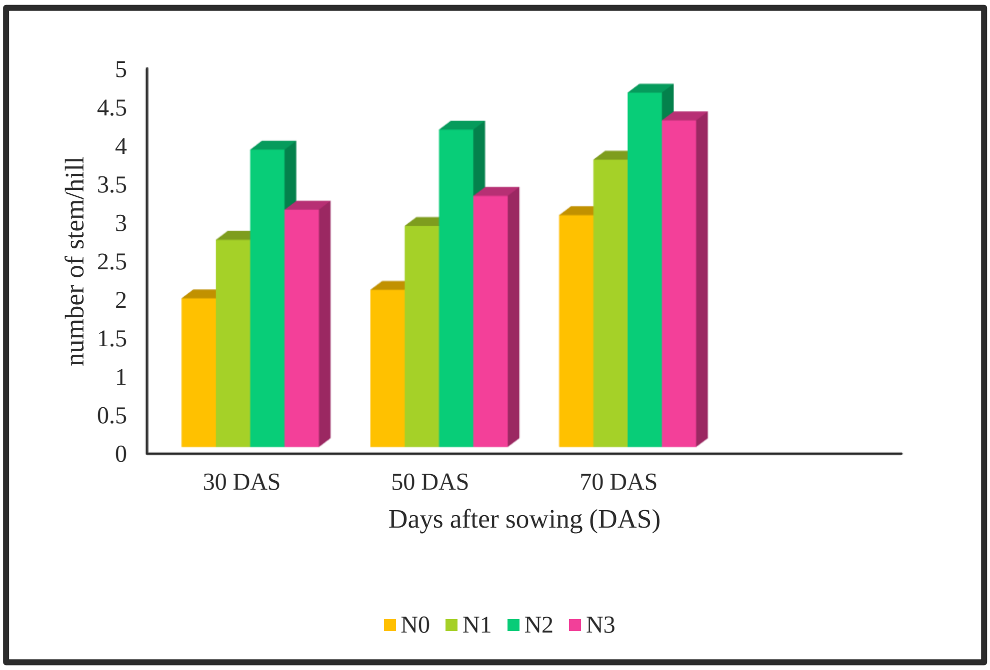


Figure 4 Number of stems /hill of potato influenced by nitrogen

N_0= 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2= 150 kg N ha^{-1}, N_3= 200 kg N ha^{-1}

Effect of Boron

Number of stem hill^{-1} was significantly varied due to different boron (B) levels at different growth stages (Fig. 5 and Appendix V). The highest number of stem hill^{-1}

(3.42, 3.93 and 4.37 at 30, 50 and 70 DAS, respectively) was achieved from the treatment B_2 (2 kg B ha-^{1}) which was significantly different from all other treatments at all growth stages. The lowest number of stem hill^{-1} (2.34, 2.17 and 3.17 at 30, 50 and 70 DAS, respectively) was obtained from the control treatment B_0 (0 kg B ha^{-1}). At all growth stages, it was also observed that all the treatment was significantly different from one another. The result obtained from the present study was similar with the findings of Admire et al. 2014 and Shayanowako et al. (2015).

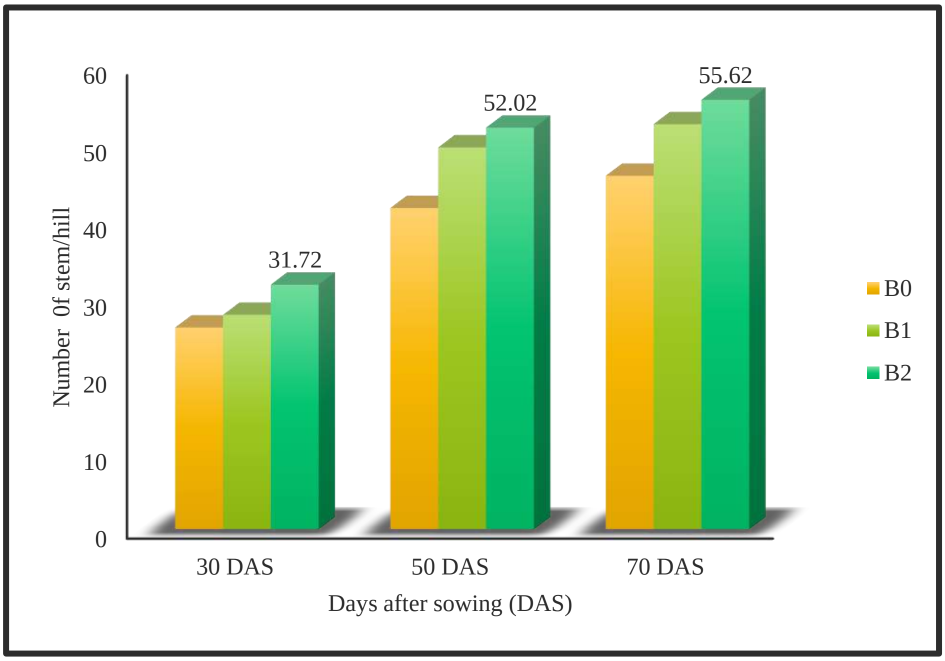


Figure 5 Number of stems/hill of potato influenced by Boron

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Nitrogen and Boron

Remarkable variation was observed on number of stem hill^{-1} at different growth stages influenced by combined effect of different N and B levels (Table 2 and Appendix V). The highest number of stem hill^{-1} (4.86, 5.35 and 5.33 at 30, 50 and 70 DAS, respectively) was recorded from the treatment combination of N_2B_2. At 30, 50 and 70 DAS, N_2B_2 was significantly different from all other treatment. The lowest number of stem hill^{-1} (1.63, 1.64 and 2.60 at 30, 50 and 70 DAS, respectively) was found from the treatment combination of N_0B_0 which was statistically similar with N_0B_1 at 30 DAS but at 50 and 70 DAS, it was statistically different from one another.

Table 2 Interaction effect of N and B on number of stems per hill

Treatment	Number of stems per hill		
	30 DAS	50 DAS	70 DAS
N_0B_0	1.63 g	1.64 e	2.60 d
N_0B_1	1.80 g	2.30 de	2.66 d
N_0B_2	2.37 f	2.48 cde	3.51 cd
N_1B_0	2.32 f	2.34 de	3.45 cd
N_1B_1	2.80 de	2.94 bcde	3.53 cd
N_1B_2	2.95 de	3.68 bcd	4.12 bc
N_2B_0	2.79 de	2.63 cde	3.34 cd
N_2B_1	3.93 b	3.93 abc	4.79 ab
N_2B_2	4.86 a	5.35 a	5.33 a
N_3B_0	2.64 ef	2.10 de	3.25 cd
N_3B_1	3.08 d	3.33 bcd	4.02 bc
N_3B_2	3.52 c	4.21 ab	4.12 bc
$LSD_{0.05}$	0.345	1.58	0.967
CV%	4.02	17.32	8.65

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differs significantly by LSD at 0.05 levels of probability.

N_0= 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2= 150 kg N ha^{-1}, N_3= 200 kg N ha^{-1}
B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

4.1.3. Number of leaves hill^{-1} of potato

Effect of nitrogen

Different nitrogen (N) levels had significant influence on number of leaves hill^{-1} at different growth stages of potato (Fig. 6 and Appendix VI). Results showed that the highest number of leaves hill^{-1} (33.91, 58.80 and 65.21 at 30, 50 and 70 DAS, respectively) was found the treatment N_2 (150 kg N ha^{-1}) which was significantly different from all other treatments followed by N_3 (200 kg N ha^{-1}). The lowest number of leaves $hill^{-1}$ (22.30, 35.75 and 37.96 at 30, 50 and 70 DAS, respectively) was observed from the control treatment N_0 (0 kg N ha^{-1}) which was also significantly different from all other treatments. The lowest number of leaves $hill^{-1}$ (22.77, 35.46 and 35.91 at 30, 50 and 70 DAS, respectively) was observed from the control treatment N_0 (0 kg N ha^{-1}) which was also significantly different from all other treatments.

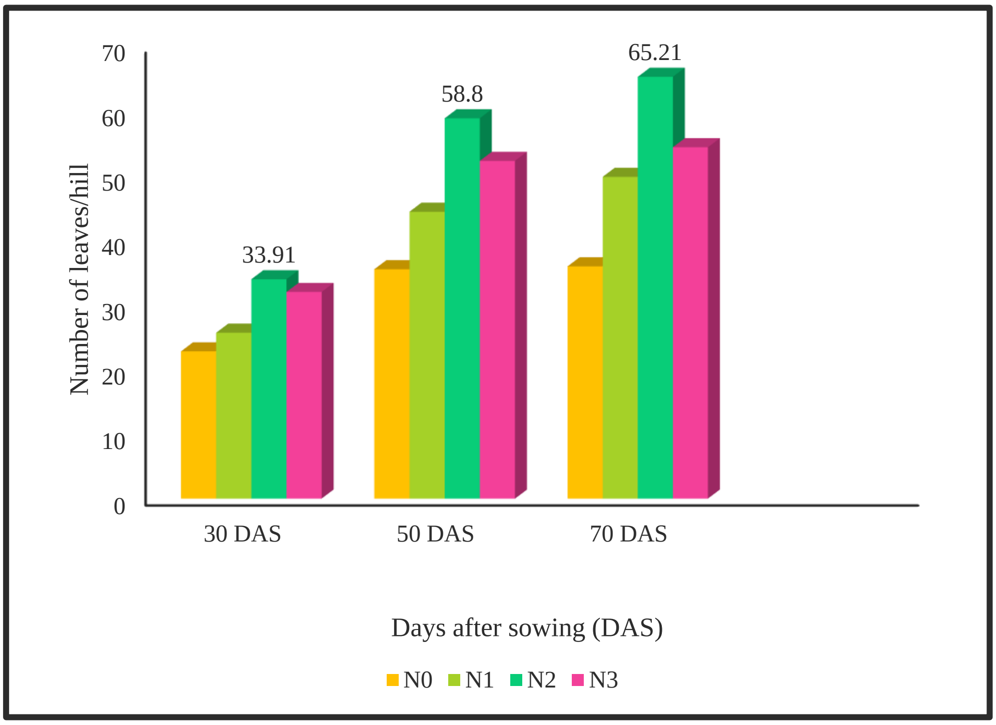


Figure 6.Number of leaves /hill influenced by Nitrogen

N_0= 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2= 150 kg N ha^{-1}, N_3= 200 kg N ha^{-1}

Effect of Boron

There was a significant variation on number of leaves $hill^{-1}$ influenced by different boron (B) levels at different growth stages (Fig. 7 and Appendix VI). The highest number of leaves $hill^{-1}$ (31.72, 52.02 and 55.62 at 30, 50 and 70 DAS, respectively) was achieved from the treatment B_2 (150 kg B ha^{-1}) which was significantly different from all other treatments at all growth stages. The lowest number of leaves $hill^{-1}$ (26.17, 41.63 and 45.79 at 30, 50 and 70 DAS, respectively) was obtained from the control treatment B_0 (0 kg B ha^{-1}) which was also significantly different from all other treatments at all growth stages.

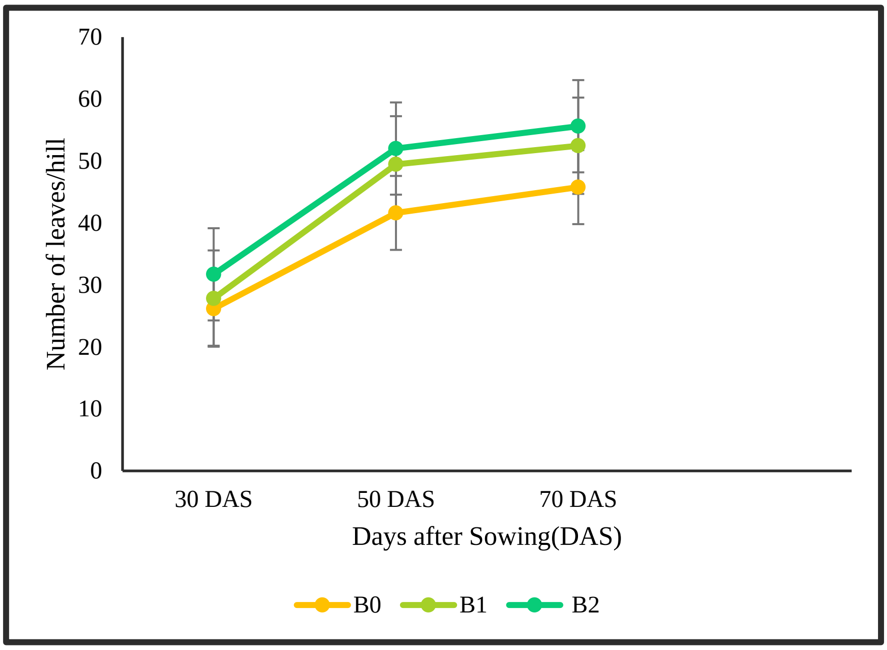


Figure 7.Number of leaves /hill influenced by boron

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

Combined effect of Nitrogen and Boron

Number of leaves $hill^{-1}$ was significantly influenced by combined effect of different N and B levels at different growth stages (Table 3 and Appendix VI). The highest number of leaves $hill^{-1}$ (45.41, 67.64 and 73.54 at 30, 50 and 70 DAS, respectively) was recorded from the treatment combination of N_2B_2. At all growth stages, N_2B_2 was significantly different from all other treatment combinations. The lowest number of leaves $hill^{-1}$(22.45, 32.95 and 34.34 at 30, 50 and 70 DAS, respectively) was found from the treatment combination of N_0B_0 which was statistically different from all other treatment combinations. The result obtained from the present study was similar with the findings of Zelaleme. Et. al. (2009).

Table 3 Interaction effect of N and B on number of leaves per hill

Treatment	Number of leaves per hill		
	30 DAS	50 DAS	70 DAS
N_0B_0	22.45 g	32.95 f	34.34 e
N_0B_1	22.58 g	36.09 ef	35.86 e
N_0B_2	23.29 fg	37.35 ef	37.55 e
N_1B_0	24.43 ef	40.33 de	44.72 d
N_1B_1	25.26 e	44.44 cd	50.59 cd
N_1B_2	27.26 d	48.28 c	53.91 bc
N_2B_0	26.15 de	45.77 cd	54.06 bc
N_2B_1	30.18 c	63.01 a	68.02 a
N_2B_2	45.41 a	67.64 a	73.54 a
N_3B_0	31.67 bc	47.49 c	50.06 cd
N_3B_1	33.24 b	54.36 b	55.42 bc
N_3B_2	30.94 c	54.79 b	57.49 b
$LSD_{0.05}$	1.751	5.896	6.215
CV%	2.06	4.16	4.08

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differs significantly by LSD at 0.05 levels of probability.

N_0= 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2= 150 kg N ha^{-1}, N_3= 200 kg N ha^{-1}

4.2.Yield contributing parameters and yield of potato

4.2.1. Number of tubers per hill of potato

Effect of nitrogen

The recorded data on number of tuber $hill^{-1}$ showed significant differences with the application of different nitrogen (N) levels (Table 4 and Appendix VII). Results revealed that the highest number of tuber $hill^{-1}$ (6.54) was found from the treatment N_2

(150 kg N ha^{-1}) which was statistically different from all other treatments. The lowest number of tuber $hill^{-1}$ (4.95) was observed from the control treatment N_0 (0 kg N ha^{-1}) which was significantly different from all other treatments. Jenkins and Ali (2000) also observed that the number of tubers varied considerably as a result of N fertilization and doubled when N level was increased to higher levels.

Effect of Boron

Considerable influence was observed on number of tuber $hill^{-1}$ influenced by different boron levels (Table 4 and Appendix VII). The highest number of tuber $hill^{-1}$ (6.28) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically different from all other treatments. Where the lowest number of tuber $hill^{-1}$ (4.98) was obtained from the control treatment B_0(0 kg B ha^{-1}).

Combined effect of Nitrogen and Boron

Remarkable variation was identified on number of tuber $hill^{-1}$ due to the combined effect of different N and B levels (Table 4 and Appendix VII). The highest number of tuber $hill^{-1}$ (7.76) was recorded from the treatment combination of N_2B_2 which was statistically different from all other treatment combination. The lowest number of tuber $hill^{-1}$ (4.57) was found from the treatment combination of N_0B_0 which was statistically similar with the treatment combination of N_3B_0.

4.2.2. Weight of tuber $hill^{-1}$ of potato

Effect of nitrogen (N)

Significant influence was noted on weight of tuber $hill^{-1}$ affected by different nitrogen (N) levels (Table 4 and Appendix VII). The highest weight of tuber $hill^{-1}$ (181.41) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically identical with N_3 treatment. The lowest weight of tuber $hill^{-1}$ (108.33g) was observed from the control treatment N_0 (0 kg N ha^{-1}) which was also significantly different from all other treatments. Guler (2009) and Zamilet al. (2010) also found similar result which supported the present study.

Effect of Boron

Weight of tuber hill^{-1} varied significantly due to different boron (B) levels (Table 4 and Appendix VII). The highest weight of tuber hill^{-1} (173.38) was achieved from the treatment B_2 (1 kg B ha^{-1}) which was statistically identical with B_1 (186.61 kg B ha^{-1}). The lowest weight of tuber hill^{-1} (118.37) was obtained from the control treatment B_0 (0 kg B ha^{-1}).

Combined effect of Nitrogen and Boron

Significant variation was remarked on weight of tuber hill^{-1} as influenced by combined effect of different N and B levels (Table 4 and Appendix VII). The highest weight of tuber hill^{-1} (213.66 g) was recorded from the treatment combination of N_2B_2 which was statistically different from all other treatment combination. The lowest weight of tuber hill^{-1} (91.20 g) was found from the treatment combination of N_0B_0 which was significantly different from all other treatment combinations.

4.2.3. Weight of tuber per plot

Effect of Nitrogen

Effect of nitrogen Application of different nitrogen (N) levels showed significant influence on weight of tuber plot^{-1} (Table 4 and Appendix VII). The highest weight of tuber plot^{-1} (7.03 kg) was found from the treatment N_2 (150 kg N ha^{-1}) where the lowest weight of tuber plot^{-1} (3.73 kg) was observed from the control treatment N_0 (0 kg N ha^{-1}).

Effect of Boron

Variation on weight of tuber plot^{-1} was noted as significant influenced by different boron (B) levels (Table 4 and Appendix VII). The highest weight of tuber plot^{-1} (6.21 kg) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically different from all other treatments. The lowest weight of tuber plot^{-1} (4.67 kg) was obtained from the control treatment B_0 (0 kg B ha^{-1}).

Combined effect of N and B

Weight of tuber plot^{-1} of potato was significantly varied due to the combined effect of different N and B levels (Table 4 and Appendix VII). The highest weight of tuber plot^{-1} (8.26 kg) was recorded from the treatment combination of N_2B_2 which was statistically different from all other treatment combinations. The lowest weight of tuber plot^{-1} (3.22 kg) was found from the treatment combination of N_0B_0 which was significantly different from all other treatment combinations followed by N_0B_1.

4.2.4. Tuber yield (t/ha)

Effect of nitrogen

The recorded data on tuber yield ha^{-1} was significant with the application of different nitrogen (N) levels (Table 4 and Appendix VII). The highest tuber yield ha^{-1} (22.22 t) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically identical with N_3 (200 kg N ha^{-1}) where the lowest tuber yield ha^{-1} (11.64 t) was observed from the control treatment N_0 (0 kg N ha^{-1}). (Guler, 2009) and (Zamil, 2010) also reported that the maximum tuber yield was obtained when the crop received 300 and 254 kg nitrogen per ha, respectively. They also noted a reduction in tuber yield when N was applied above the rates. The yield reduction due to excess rates of N may be explained by the fact that excessive N application stimulates shoot growth more than tuber growth which may result in deterioration of canopy structure and physiological conditions.

Effect of Boron

Considerable influence was observed on tuber yield ha^{-1} persuaded by different) boron levels (Table 4 and Appendix VII). The highest tuber yield ha^{-1} (21.73 t) was achieved from the treatment B_2 (50 kg B ha^{-1}). The lowest tuber yield ha^{-1} (14.97 t) was obtained from the control treatment B_0 (0 kg B ha^{-1}). (Sharma U. C., 1987) and Mulubrhan (2004) reported that yield response to increasing levels of P fertilizer was generally positive up to a particular level, above which the response became negative noted that increasing P application from 0 to 39.6 kg ha^{-1} highly significantly increased total tuber yield by 24.27%.

Combined effect of Nitrogen and Boron

Remarkable variation was identified on tuber yield ha^{-1} due to the combined effect of different N and B levels (Table 4 and Appendix VII). The highest tuber yield ha^{-1} (26.62 t) was recorded from the treatment combination of N_2B_2 which was statistically

Table 4 Yield Contributing parameter and yield of potato influenced by nitrogen and boron

Treatment	Yield contributing parameters and yield				
	Number of tubers $hill^{-1}$	Weight of tuber $hill^{-1}$ (g)	Weight of tuber $plot^{-1}$ (kg)	Tuber weight ha^{-1} (t)	Marketable yield ha^{-1} (t)
Effect of nitrogen (N)					
N_0	4.95 c	108.33 c	3.73 d	11.64 c	10.27 c
N_1	5.67 b	149.60 b	5.03 c	19.16 b	17.48 b
N_2	6.54 a	181.41 a	7.04 a	22.22 a	20.96 a
N_3	5.15 c	174.48 a	6.33 b	21.86 a	20.53 a
$LSD_{0.05}$	0.345	8.932	0.534	1.523	1.33
CV%	4.72	4.45	7.38	6.21	5.90
Effect of boron (B)					
B_0	4.98 c	118.37 b	4.67 c	14.97 c	13.55 c
B_1	5.48 b	168.61 a	5.71 b	19.46 b	18.07 b
B_2	6.28 c	173.38 a	6.21 a	21.73 a	20.32 a
$LSD_{0.05}$	0.27	6.998	0.419	1.19	1.04
CV%	4.72	4.45	7.38	6.21	5.90
Combined effect of Nitrogen (N) and Boron (B)					
N_0B_0	4.57 e	91.20 g	3.22 f	9.55 g	8.19 f
N_0B_1	4.94 de	113.66 f	3.93 ef	10.79 g	9.45 f
N_0B_2	5.05 de	120.14 ef	4.06 ef	14.58 f	13.18 e
N_1B_0	5.35 de	113.79 f	4.52 de	16.78 ef	14.98 de
N_1B_1	5.26 de	163.06 d	4.92 cde	18.77 de	17.07 d
N_1B_2	5.35 de	171.94 cd	5.65 cd	21.92 cd	20.39 c
N_2B_0	5.63 cd	134.91 e	5.95 bc	17.16 ef	15.80 de
N_2B_1	6.25 bc	195.66 ab	6.89 b	22.89 bc	21.55 bc
N_2B_2	7.76 a	213.66 a	8.26 a	26.62 a	25.53 a
N_3B_0	4.67 e	133.59 ef	5.01 cde	16.38 ef	15.22 de
N_3B_1	5.49 cd	202.08 ab	7.09 ab	25.38 ab	24.20 ab
N_3B_2	5.31 de	187.77 bc	6.89 b	23.82 abc	22.18 bc
$LSD_{0.05}$	0.78	17.2	1.212	3.45	3.033
CV%	4.72	4.45	7.38	6.21	5.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differs significantly by LSD at 0.05 levels of probability.

N_0= 0 kg N ha^{-1}, N_1 = 100 kg N ha^{-1}, N_2= 150 kg N ha^{-1}, N_3= 200 kg N ha^{-1}

B_0 = 0 kg B ha^{-1}, B_1 = 1 kg B ha^{-1}, B_2 = 2 kg B ha^{-1}

different from all other treatment combinations. The lowest tuber yield ha^{-1} (9.55 t) was found from the treatment combination of N_0B_0 which was statistically similar with N_0B_1 treatment combinations.

4.2.5. Marketable yield ha^{-1} of potato

Effect of nitrogen (N)

Variation on marketable yield ha^{-1} of potato was found significant as influenced by different nitrogen (N) levels (Table 4 and Appendix VII). The highest marketable yield ha^{-1} (20.96 t) was found from the treatment N_2 (150 kg N ha^{-1}) which was statistically identical with N_3 (200 kg N ha^{-1}). The lowest marketable yield ha^{-1} (10.27 t) was observed from the control treatment N_0 (0 kg N ha^{-1}) followed by N_1 (100 kg N ha^{-1})

Effect of boron

Considerable influence was observed on marketable yield ha^{-1} of potato affected by different boron (B) levels (Table 4 and Appendix VII). It was found that the highest marketable yield ha^{-1} (20.32 t) was achieved from the treatment B_2 (2 kg B ha^{-1}) which was statistically different from all other treatments. The lowest marketable yield ha^{-1} (13.55) was obtained from the control treatment B_0 (0 kg B ha^{-1}) which was significantly different from all other treatments followed by B_1 (100 kg B ha^{-1}). Zelalemet al. (2009) reported that application of 2 kg B ha^{-1} increased marketable tuber number by 43.5% over the control.

Combined effect of Nitrogen and Boron

The recorded data on marketable yield ha^{-1} was influenced significantly by combined effect of different N and B levels (Table 4 and Appendix VII). Results indicated that the highest marketable yield ha^{-1} (25.53 t) was recorded from the treatment combination of N_2B_2 which was statistically different from all other treatment combinations. The lowest marketable yield ha-1 (8.19 t) was found from the treatment combination of N_0B_0 which was significantly different from all other treatment combinations followed by the treatment combination of N_0B_1 and N_0B_2.

CHAPTER V

SUMMARY AND CONCLUSION

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A field experiment was conducted at the research farm of Sher-e-Bangla Agricultura University, Dhaka, during November 2019 to February 2020 to study the effects of nitrogen and boron on growth and yield of potato. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications of each treatment. The unit plot size was 3 m2. There were 12 treatments combinations in the experiment comprising 4 levels of N (0, 100, 150 & 200 kg/ha designated as N_0, N_{100}, N_{150} & N_{200}, respectively) and 3 levels of B (0, 1 &2 kg/ha designated as B_0, B_1 & B_2, respectively). The individual and combined effects of nitrogen (N) and boron (B) on growth, yield and nutrient content in plants of potato were studied.

Nitrogen and Boron fertilization at different levels individually influenced plant characters. The individual and interaction effect of N and B on growth, yield and nutrient content was found positive.

Most of parameters were significantly affected by different levels of N application. It was found that the highest plant height (25.04, 53.09 and 63.73 cm at 30, 50 and 70 DAS, respectively),number of stem per hill (3.86, 3.97 and 4.48 at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (33.91, 58.80 and 65.21 at 30, 50 and 70 DAS, respectively) was found from the treatment N_2 (150 kg N ha^{-1}) where the lowest plant height (14.32, 38.82 and 48.69 cm at 30, 50 and 70 DAS, respectively), number of stem hill^{-1} (1.94, 2.14 and 2.92 at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (22.30, 35.75 and 37.96 at 30, 50 and 70 DAS, respectively) was observed from the control treatment N_0 (0 kg N ha^{-1}). Again, the highest number of tuber hill^{-1} (6.54), weight of tuber hill^{-1} (181.41), weight of tuber plot^{-1} (7.04 kg), tuber yield ha^{-1} (22.22 t) and marketable yield ha^{-1}(20.96 t) was found from the treatment N_2 (150 kg N ha^{-1}) whereas the lowest number of tuber hill^{-1} (4.95), lowest weight of tuber hill^{-1}(108.33), lowest weight of tuber plot^{-1} (3.73 kg), lowest tuber yield ha^{-1} (10.27 t) and lowest marketable yield ha^{-1} (11.64 t) were also observed from the control treatment N_0 (0 kg N ha^{-1}).

Regarding B treatment, all the studied parameters were significantly affected by different levels of B. Results revealed that the highest plant height (19.04, 50.51 and 58.51 cm at 30, 50 and 70 DAS, respectively), number of stem hill^{-1} (3.42, 3.93 and 4.37 at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (32.27, 54.53 and 58.79 at 30, 50 and 70 DAS, respectively) were achieved from the treatment B_2 (2 kg B ha^{-1}), number of tuber hill^{-1} (6.28), weight of tuber hill^{-1} (173.38), weight of tuber plot^{-1} (6.21 kg), tuber yield ha^{-1} (21.73 t) and marketable yield ha^{-1} (20.32 t) was achieved from the treatment B_2 (2 kg B ha^{-1}) Again, the lowest plant height (20.30, 44.20 and 53.20 cm at 30, 50 and 70 DAS, respectively), number of stem hill^{-1} (26.17, 41.63 and 45.79 at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (26.17, 41.63 and 45.79 at 30, 50 and 70 DAS, respectively). Likewise, the lowest number of tuber hill^{-1} (4.98), weight of tuber hill^{-1} (118.37), weight of tuber plot^{-1} (4.67 kg), tuber yield ha^{-1} (14.97 t) and marketable yield ha^{-1} (13.55 t) were also obtained from the control treatment B_0 (0 kg B ha^{-1}).

Considering combined effect of N and B, the highest plant height (26.15, 58.70 and 67.25 cm at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (45.42, 67.66 and 73.54 at 30, 50, 70 DAS, respectively), number of stem hill-1 (4.86, 5.23 and 5.44 at 30, 50 and 70 DAS, respectively) were recorded from the treatment combination of N_2B_2. Similarly, the highest number of tuber hill^{-1} (7.76), weight of tuber hill^{-1} (213.66 g), weight of tuber plot^{-1} (8.26 kg), tuber yield ha^{-1} (26.62 t) and marketable yield ha^{-1} (25.53 t) was recorded from the treatment combination of N_2B_2.The lowest plant height (13.16, 36.47 and 44.20 cm at 30, 50 and 70 DAS, respectively), number of stem hill^{-1} (1.63, 1.64 and 2.60 at 30, 50 and 70 DAS, respectively), number of leaves hill^{-1} (22.45, 32.95 and 34.34 at 30, 50 and 70 DAS, respectively) were found from the treatment combination of N_0B_0. Again, the lowest number of tuber hill^{-1} (4.57), weight of tuber hill^{-1} (91.20 g), weight of tuber plot^{-1} (3.22 kg), tuber yield ha^{-1} (9.55 t) and marketable yield ha^{-1} (8.19 t) were also found from the treatment combination of N_0B_0.

Considering the above results, it may conclude that N and B positively influenced the entire physiology, growth and yield of potato. At all stage of growth and yield, N_2 (150 kg N ha^{-1}) and B_2 (2 kg B ha^{-1}) gave better result which produced height growth and yield. So, it may be recommended that N_2 (150 kg N ha^{-1}) with B_2 (2 kg B ha^{-1}) was better for growth and yield of potato.

From the present study, the following conclusion may be drawn –

- Individual effect of N and B on growth and yield of potato was found positive and significant.
- The combined effect of N and B enhanced growth yield and yield attributes of potato.
- Application of N @ 150 kg/ha and B @ 2 kg/ha was the most suitable combination to give the highest yield of potato.

Further research works at different regions of the country are needed to be carried out for the confirmation of the present findings

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APPENDICES

Appendix I . Agro-Ecological Zone of Bangladesh showing the experiment location

Appendix II. Monthly records of air temperature, relative humidity, and rainfall during the period from November 2019 to February 2020.

Month	Temperature (Maximum^{0}C)	Temperature (Minimum^0 C)	Humidity (%)	Precipitation (mm)
November	30.20	20.11	68.03	30
December	26.30	13.4	51.6	9
January	25.23	12.89	47.2	7
February	25.33	14.4	54.6	6

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological Features	**Characteristics**
Location	Sher-e-Bangla Agriculture University Farm, Bangladesh
AEZ No. and name	AEZ-28, Modhupur Tract
General soil type	Deep Red Brown Terrace Soil
Soil Series	Tejgaon
Topography	Fairly leveled
Depth of Inundation	Above flood level
Drainage condition	Well drained
Land type	High land

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Soil properties	**Value**
A. Physical properties	
1. Particle size analysis of soil.	
% Sand	31.50
% Silt	39.34
% Clay	29.16
2. Soil texture	Silty Clay Loam
B. Chemical properties	
1. Soil pH	5.8
2. Organic carbon (%)	0.78
3. Organic matter (%)	1.34
4. Total N (%)	0.08
5. C: N ratio	10:1
6. Available P (ppm)	33.5
7. Exchangeable K (me/100g soil)	0.21
8. Available S (ppm)	36.75
9. Available B (ppm)	0.36

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of potato influenced by nitrogen and boron

Sources of variation	Degrees of freedom	Plant height (cm)		
		30 DAS	50 DAS	70 DAS
Replication	2	2.091	1.31	2.35
Factor A	3	13.42*	17.92*	18.79*
Factor B	2	2.23*	11.12*	9.23*
AB	6	0.94*	5.2*	4.26*
Error	22	0.55	1.93	2.009

NS = Non-significant * = Significant at 5% level

Appendix V. Number of stem/hill influenced by nitrogen and boron

Sources of variation	Degrees of freedom	Number of stem/hill (cm)		
		30 DAS	50 DAS	70 DAS
Replication	2	0.062	0.25	0.82
Factor A	3	2.41*	2.26*	1.95*
Factor B	2	1.873*	3.04*	2.07*
AB	6	0.59*	0.74 NS	0.65*
Error	22	0.116	0.53	0.33

NS = Non-significant * = Significant at 5% level

Appendix VI. Number of leave/hill influenced by nitrogen and boron

Sources of variation	Degrees of freedom	Number of leaves/hill (cm)		
		30 DAS	50 DAS	70 DAS
Replication	2	0.697	4.092	2.067
Factor A	3	9.881*	18.09*	17.38*
Factor B	2	15.69*	30.22*	36.04*
AB	6	8.62*	7.30*	6.25*
Error	22	0.589	1.98	2.09

NS = Non-significant * = Significant at 5% level

Appendix VII. Yield contributing parameters and yield of potato influenced by nitrogen and boron

Sources of variation	Degrees of freedom	Number of tuber $hill^{-1}$	Weight of tuber $hill^{-1}$ (g)	Weight of tuber plot (kg)	Tuber weight ha^{-1} (t)	Marketable yield ha^{-1} (t)
Replication	2	0.16	5.495	1.33	1.656	1.758
Factor A	3	2.131*	99.11*	4.37*	14.743*	14.827*
Factor B	2	2.276*	105.56*	2.72*	11.92*	11.94*
AB	6	0.799*	22.00*	0.853*	3.4*	3.5*
Error	22	0.263	6.819	0.408	1.164	1.02

NS = Non-significant * = Significant at 5% level

Plate 1. Layout of the experimental field

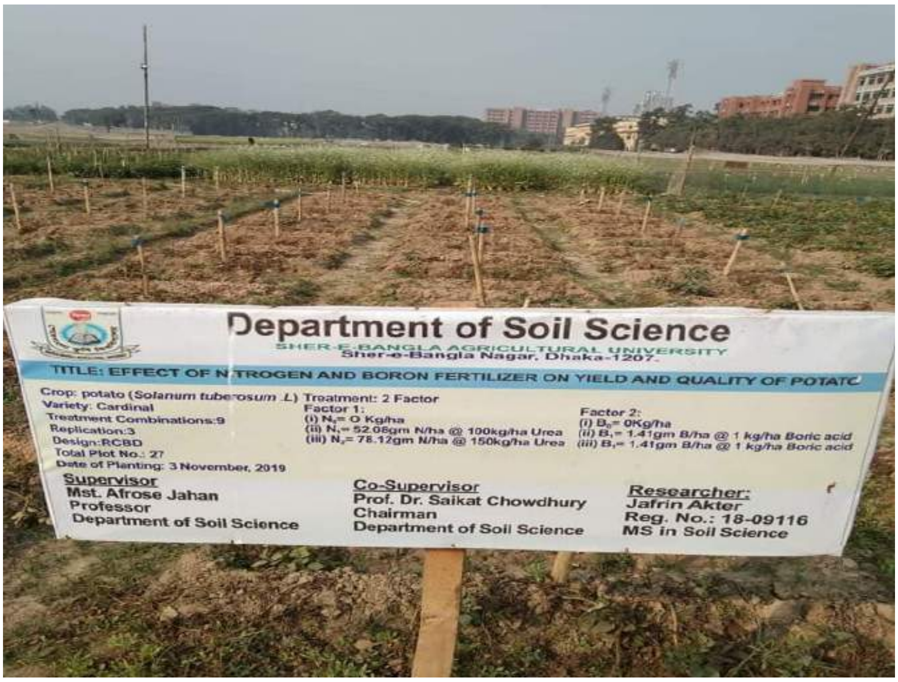

Plate 2. Experimental field showing signboard

Plate 3.Field condition after weeding

Plate 4. Vegetative stage of potato

Plate 5. Measuring Plant height

Plate 6. Harvested potato