PRODUCTION OF QUALITY HYBRID TRUE POTATO SEED (TPS) AS INFLUENCED BY NITROGEN SPLITTING AND BORON

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JUNE, 2015

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REGISTRATION NO. 08-02902

A Thesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE

IN

AGRONOMY

SEMESTER: JANUARY−JUNE, 2015

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CERTIFICATE

*This is to certify that the thesis titled, "**PRODUCTION OF QUALITY HYBRID TRUE POTATO SEED (TPS) AS INFLUENCED BY NITROGEN SPLITTING AND BORON”** submitted to the **Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka**in partial fulfilment of the requirements for the degree of**MASTER OF SCIENCE (M.S.)**in**AGRONOMY** embodies the result of a piece of bona fide research work carried out by **RAJESH CHAKRABORTY**, **REGISTRATION NO. 08-02902** 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 by the Author.

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Dated:
Place: Dhaka, Bangladesh

Dedicated to

Those who:

"Working to feed the hunger world"

ACKNOWLEDGEMENTS

Today the author is nothing but author would like to express his profound gratefulness and all the credits to the Almighty GOD, the merciful and the magnificent to all creations for blessing to present this thesis.

Finishing of this thesis would have been less fun and more difficult without the support of his honorable teacher and research supervisor **Professor Dr. Tuhin Suvra Roy**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka as he gave scholastic guidance, outstanding assistance, valuable advice and suggestions for the successful completion of the research work and preparation of this manuscript. Therefore, the author expresses his heartfelt gratitude to his honorable supervisor.

The author sincerely expresses his heartfelt gratitude and deepest sense to his co-supervisor, **Professor Dr. Md. Shahidul Islam**, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his co-operation and constructive suggestions in all phases of the research.

The author would like to pay his gratefulness to all the honorable teachers of Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for their valuable suggestions during the study period and research work.

The author feels much pleasure to convey the special word of thanks to Md. Tanvir Ehsan Chowdhury and all the members of Agronomy Laboratory, Sher-e-Bangla Agricultural University, Dhaka for their cordial co-operation and inspiration during the research.

The author enjoyed very much while working in the field and also grateful to all field labors for their sincere help, support and companionship for successful completion of research work.

Author would like to pay his deepest sense to the Farm division of this institution for giving the opportunities and facilities to work.

The author is also very much grateful to his parents who have, brought him on the earth and dedicate their all efforts and times to become a position to submit this manuscript and also grateful to all of his relatives and two beloved sisters, Aparna and Maya.

The Author

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ABSTRACT

Quality True Potato Seed (TPS) is the main bottleneck for the utilization and expansion of potato production through TPS technology in Bangladesh. Some plant nutrients *viz*., Nitrogen (N), Phosphorus (P), Potassium (K) and Boron (B) may put contribution for the production of quality TPS. To partially solve this problem an experiment was conducted in research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2013 to April, 2014 to investigate the effect of split application of nitrogen (SN) and boron (B) on quality hybrid TPS. The TPS-67 (♂) and MF-II (♀) were used as male and female parent, respectively. The experiment consisted of two factors *i.e.*, factor-A; nitrogen splitting (4 levels): SN_0= 2 split (conventional), SN_1= 3 split, SN_2= 4 split and SN_3= 5 split (SN); and factor-B; boron (4 levels): B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1} and B_3= 8 kg B ha^{-1}. The experiment was laid out in a split-plot design with three replications, whereas SN and B were treated as main plot and sub-plot, respectively. The nitrogen splitting and/or boron had significant effect on most of the parameters studied in this experiment. Results revealed that most of the growth, flowering, berry, TPS and quality traits significantly increased with increasing split application of N up to SN_3 which was statistically similar to SN_2. Similar trends of above mentioned parameters were also found in B application. Among the 16 treatment combinations, significantly the highest yield of berries (t ha^{-1}) found in SN_2B_0 (14.83 t) and the lowest from SN_0B_0. The maximum yield of TPS was found from SN_1B_3 (172.81 kg ha^{-1}) and the minimum from SN_0B_0. The maximum weight of 100-TPS was found from SN_3B_3 (86.87 mg); whereas, the minimum from SN_0B_0. True potato seed produced from SN_3B_3 contained maximum protein (11.01 %), lipid (21.95 %) and also performed maximum germination (98.11 %), whereas the SN_0B_0 exhibited worst one. Though, the combination of SN_1B_3 (3 split applications of N and 8 kg B ha^{-1}) produced the maximum TPS yield (172.81 kg ha^{-1}) but, on the basis of quality parameters; 100-TPS weight (mg), protein (%), lipid (%) and (%) germination (%); SN_3B_3, SN_2B_3 and SN_2B_2 combinations showed statistical similar results. In conclusion, the combination of SN_2B_2 (4 split applications of N and 6 kg B ha^{-1}) is the best for producing quality TPS from potato mother plant under prevailing climatic condition of Bangladesh.

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LIST OF ACCRONYMS AND ABBREVIATIONS

ACCRONYM	ABBREVAITION
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
Annu.	Annual
Appl.	Applied
B	Boron
Biol.	Biology
Chem.	Chemistry
cm	Centi-meter
CV	Coefficient of Variance
DAP	Days After Planting
Dev.	Development
Ecol.	Ecology
Environ.	Environmental
et al	et alii, And others
Exptl.	Experimental
g	Gram (s)
Hortc.	Hotriculture
i.e.	*id est* (L), that is
J.	Journal
kg	Kilogram (s)
LSD	Least Significant Difference
M.S.	Master of Science
m^2	Meter squares
mg	Milligram
Nutr.	Nutrition
Physiol.	Physiological
Progress.	Progressive
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
SN	Nitrogen splitting
Soc.	Society
SRDI	Soil Resource Development Institute
t ha^{-1}	Ton per hectare
UNDP	United Nations Development Programme
viz	*videlicet* (L.), Namely
%	Percentage
@	At the rate of

CHAPTER 1
INTRODUCTION

Potato (*Solanum tuberosum*) is the 4th world crop after wheat, rice and maize. Bangladesh is the 7th potato production country in the world (FAOSTAT, 2014). In Bangladesh, it ranks 2nd after rice in production. The national average yield and total production in Bangladesh are 19.03 t ha^{-1} and 9435150.00 metric tons, respectively (FAOSTAT, 2014). Total production is increasing day by day as such consumption also rapidly increasing in Bangladesh (Appendix VII). But, the yield of potato is very low (Appendix VI) in Bangladesh compared to other potato growing countries like New Zealand (47.74 t ha^{-1}), Netherlands (45.66 t ha^{-1}), USA (47.15 t ha^{-1}), Japan (30.65 t ha^{-1}), and even in India (22.92 t ha^{-1}) (FAOSTAT, 2014). This low yield of potato might be due to lack of quality seeds, high cost of quality seed, unavailability and uneven distribution of certified seeds, and use of indigenous cultivars having low yield potential are noticeable (Accatino and Malagamba, 1983; Wiersema, 1984). Resource poor farmers of Bangladesh cannot afford to purchase the expensive seed. The seed potato utilization trend is increasing day by day in Bangladesh (Appendix VIII) and the total requirement of seed potatoes in Bangladesh is about 743,685 metric tons considering the seed rate of 1.5 t ha^{-1} (FAOSTAT, 2014). The amount of quality seed potatoes supplied by the public sectors is about 5-9 % of the total requirement (Siddique *et al*., 2015). The rest 91 to 95 % of the required seed is covered by the poor quality farmers own seed potatoes, the quality of which is not known. Therefore, the high cost and inadequate availability of healthy tuber seed are the major constraints in the production and productivity of potato in the country (Siddique and Rashid, 2000).

To overcome this, an alternative technology of true potato seed (TPS) or use of botanical seed or true seed for commercial potato production has shown great promise for producing both disease-free and cheaper seed and thereby, reducing the cost of cultivation and help farmers to be less dependent on conventional seed sources (Umaerus, 1987; Malagamba, 1988; Pallais, 1994; Renia and Hest, 1998; Roy *et al*., 1999).

However, the success of potato production using TPS largely depends on the productivity of quality TPS (Upadhya *et al*., 2003). The formation and development of seeds strongly depend on both genotypic and environmental factors such as, temperature, water, light and the type and quantity of mineral nutrients available in the soil (Delouche, 1980). Nutrient conditions in the mother plants directly affect the production of quality TPS through the flowering and subsequent reproductive growth, including the formation of the gametophytes (Pallais *et al*., 1987). Among various fertilizers, application of a higher level of Nitrogen (N) than that required for the production of maximum tuber yield increases shoot biomass and enhances the bloom of potato mother plants (Krauss, 1978; Pallais *et al*., 1984). Soil N application levels higher than those required for crop production have long been recognized by seed physiologists to improve seed yield and vigour (Delouche, 1980; Gray and Thomas, 1982; Van Staden *et al*., 1982; Gentry and Below, 1991). Application of N also affects TPS weight (Pallais, 1987), which is an important criterion for selecting high-yielding progenies (Dayal *et al*., 1984). Improvement in nitrogen use efficiency is a key issue for sustainable and profitable nitrogen use in high-input agriculture (Ahrens *et al.*, 2010). To “split apply” nitrogen, growers make two or more fertilizer applications during the growing season rather than providing all of the crop N requirements with a single treatment prior to, or at, planting. When all of the nitrogen is supplied ahead of crop growth, more of the nitrogen is susceptible to denitrification, leaching, or volatilization (Grant *et al.*, 2012).

Split application of nitrogen is one of the methods to improve nitrogen use by the crop while reducing the nutrient loss through leaching and volatilization (Tolessa *et al*., 1994). Most of the investigations on nitrogen fertilizer application management are in favor of split-applications to synchronize timing of fertilization according to the crop demand and increase grain yield (Gehl *et al*., 2005). However, continuous supply of N to plants promotes shoot and root growth, and prevents tuberisation (Ivins and Bremner, 1969; Gunasena and Harris, 1971). With supplemental application, excessive N supply have been reported to increase flower production and pollen germination and is effective in the production of vigorous and high quality TPS (Pallais *et al.,* 1984; Pallais *et al.,* 1987; Pallais, 1991; Maingi *et al.,* 1994).

The pollen tube growth and anther development are also sensitive to boron deprivation (Rawson, 1996). In the absence of boron, pollen tubes may burst possibly due to the primary boron functions in the cell wall structure of the pollen tubes (Brown *et al*., 2002). In addition to male sterility, pistil sterility is another alteration of reproductive system due to boron deficiency (Agarwala *et al*., 1981), although boron requirement is minor than in the male organs (Rerkasem *et al*., 1997). In tomato, boron fertilizations have greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of flowers and fruits, which might have increased number and weight of fruits (Davis *et al*., 2003; Lalit *et al*., 2004; Naga *et al*., 2013 and Basavarajeswari *et al*., 2008). Boron influence the IAA metabolism which increases number of flowers (Day, 2000) and stimulates the phosphorus uptake by roots of plants that in turn promoted development of flower clusters and had favorable effect on retention of flowers (Smit and Combrink, 2005). It also influences the fruit formation (Nonnecke, 1989), fruit development and seed development (Phookan *et al.,* 1991).

Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley *et al*., 1995). Bangladesh imports basic seed tubers mostly from the Netherlands, which is really costly for the small and marginal farmers. The agro-ecological conditions of Bangladesh favor (Siddique *et al*., 2015) the use of TPS technology as a supplemental to the traditional use of seed tubers in potato production.

However, the nutritional requirements of potato mother plants for the production of quality TPS have not been investigated well, especially under conditions in which the most promising parental lines (♀ MF-II and ♂ TPS-67) in Bangladesh were grown for TPS production. In the present study, therefore, an attempt has been made-

i) to determine the optimum level of nitrogen splitting for quality hybrid TPS production,

ii) to determine the optimum dose of B for quality hybrid TPS production and

iii) to find out the most promising combination from split applications of N and B for quality hybrid TPS production.

CHAPTER 2

REVIEW OF LITARETURE

The TPS thinking is not far old but it has some drawbacks for its breeding program and nutritional management. This technology has little recent work done by different major potato growing countries and in Bangladesh the quality TPS production is not so good and research work is not very frequent. So, the present study was aimed to impart a better management thinking for quality true potato seed production in aspects of prevailing climatic condition of Bangladesh and to impart a better thinking for reducing the seed problem of potato through experiments on nutritional influences which did not fully supported from the government of Bangladesh. In this chapter some important research works have been reviewed related to present study for quality hybrid TPS production.

2.1 Effect of nitrogen splitting

Masome (2013) evaluated the effects on growth and yield of tomato against urea levels at 0, 50, 100, 150 and 200 mg per kg of soil. Number of flowers and fruit yield, vitamin C, total acidity, TSS, plant height, average fruit size, number of days to flowering, plant dry weight and chlorophyll index were significantly influenced. He mentioned that, highest number of flower from the plant treated with 100 mg of urea nitrogen per kilogram of soil and minimum control level. The results of this study also concluded that urea nitrogen and growth factors are more effective reproductive factors on the growth of tomato plants will have the desired effect.

Raj (2013) reported that, application of nitrogen (150 kg ha^{-1}) when applied with 3-way or 4-way splitting produced the highest grain yields of canola.

Josue *et al*. (2011) conducted a study on tomato with 3 rates of UAN 32 (nitrogenous fertilizer) fertilizer with six (6) split applications.

They also found that, there was a slight decrease in the chlorophyll contents in leaves as the tomatoes progressed from immature green to full red stage (harvest).

Kirimi *et al*. (2011) investigated the effects of nitrogen and spacing on fruit yield of tomato where nitrogen rates 0, 40, 80 and 120 kg N ha^{-1} applied in two equal splits and spacing was 40 x 30, 40 x 40, 50 x 30 and 50 x 40 cm in two consecutive seosons. They reported that, nitrogen of 80 kg ha^{-1} and spacing of 40 x 30 cm had the highest mean fruit numbers in season two and nitrogen of 80 kg N ha^{-1} and spacing of 50 x 30 cm had the highest fruit yield in season one.

Narits, (2011) reported that, the highest protein content was obtained from the variant of three times split-N.

Malakouti *et al.* (2009) conducted an experiment for two consecutive growing seasons to evaluate the response of different split doses of nitrogen on wheat. Six (6) treatments (T_1= Control, T_2= 150 kg ha^{-1} of N as urea in 3-split applications, T_3= 1/3 N as SCU as the base fertilizer + 2-split urea applications, T_4= 150 kg ha^{-1} N as SCU as the base fertilizer, T_5=150 kg ha^{-1} of N as urea in 2-split applications and T_6=1/3 N as complete fertilizer as the base fertilizer +2-split urea applications) in the first year. Then seven (7) treatments (T_1= Control T_2= 180 kg ha^{-1} of N as urea in 2-split applications T_3= 180 kg ha^{-1} of N as urea in 3-split applications T_4= 180 kg ha^{-1} N in 5-split urea applications T_5 = pre-plant urea + 4-split urea applications T_6= 1/3 N as SCU as the base fertilizer +4-split urea applications and T_7=1/3 N as complete fertilizer as the base fertilizer +4-split urea applications) in the second year with 3 replications. The results of first and second year revealed that the higher yield, NUE and NARF were obtained from T_2 and T_6 treatment due to higher N rates and more N split applications.

Khalil *et al.* (2001) who reported that application of nitrogen fertilizer on Nigella sativa increased total lipid content of the seed.

Naik *et al.* (1996) studied the effect of N (100, 150 and 200 kg ha^{-1}) applied in split doses at (0 + 30 days), (0 + 30 + 60 days) and (0 + 30 + 60 + 90 days) on the growth of brinjal cultivars and observed that fruit yield 7.32 q ha^{-1} was found following application of 200 kg N ha^{-1} and that splitting application of N dose had no beneficial effects on growth and seed yield.

Asare and Scarisbrick (1995) noticed that protein content increased with the increase of N fertilizer rate.

Maingi *et al.* (1994) mentioned that, excessive N supply have been reported to increase flower production and pollen germination and is effective in the production of vigorous and high quality TPS.

Hassan *et al*. (1993) carried out a field experiment on growth and yield of green papers by following rates of N were applied: 112, 224, 336 and 448 kg ha^{-1}. As N rates increased, plants exhibited poor early growth and produced lower early and total fruit yields. Doubling the N rate from 112 to 224 kg ha^{-1} resulted in a 21 % increase in flower buds, but the percentage of fruit set decreased as N rates increased.

Almekinders and Wiersema (1991) evaluated the flowering and true seed production from different order inflorescences in potato (*Solanum tuberosum* L.). The number of flowers per inflorescence, berry set, berry weight, number of seeds per berry and seed weight generally decreased from primary inflorescences to tertiary inflorescences and inflorescences on lateral stems.

Rexen (1976) reported that, the protein contents of tubers significantly increased with increasing nitrogen dose. Protein contents of dry tubers were 9.7%, 10.6%, and 10.9% after applying 0, 120 and 240 kg N ha^{-1}, respectively.

2.2 Effects of boron

Hossain *et al*. (2015) carried out an experiment on the effect of boron on photosynthesis and antioxidant response to rapeseed yield with five boron levels (*viz*. 0, 4.5, 9.0, 13.5 and 18.0 kg ha^{-1}). The rate of photosynthesis increased with increasing boron level up to 9.0 kg ha^{-1} with simultaneous increase in photosynthetically active radiation, rate of transpiration and stomatal conductance and decrease in intercellular CO_2 concentration. Dry matter translocation increased with increasing B level up to 9.0 kg ha^{-1} that resulted in highest seed yield.

Bellaloui *et al*. (2013) carried out a greenhouse experiment to show the effects of foliar application (FB) of boron twice at the rate of 1.1 kg ha^{-1} on seed composition of soybean (protein, oil, fatty acids and sugar). They hypothesized that, since B involved in nitrogen and carbon metabolism, it may impact on seed composition. Mysteriously they found that, FB increased B accumulation in leaves and seed, and altered seed composition indicating a possible involvement of B in seed protein, oleic acid and linolenic acid.

Gurmani *et al*. (2012) carried out a pot experiment in glasshouse on two tomato cultivars to access the effects of four levels of soil application of B (0, 0.5, 1.0 and 1.5 mg kg^{-1} soil) in the form of borax on plant growth, biochemical content, antioxidant activity and fruit yield. They reported that, higher plant growth and fruit in both cultivars were achieved by the B at the rate of 1.0 and 1.5 mg kg^{-1}. They also reported that, application of B at the rate of 1.0 and 1.5 mg kg^{-1} significantly increased the chlorophyll, sugar and protein content in both cultivars.

Naz *et al*. (2012) conducted an experiment to study the effect of boron (B) on the growth and yield of Rio Grand and Rio Figue cultivar of tomato. Different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0 kg ha^{-1}) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100 and 60 kg ha^{-1}, respectively.

They reported that, 2 kg B ha^{-1} resulted in maximum number of flower clusters per plant, fruit set percentage, total yield, fruit weight loss and total soluble solid.

Haque *et al*. (2011) conducted an experiment to study the effects of nitrogen and boron on growth and yield of tomato. Four levels of each of Nitrogen (N_0 = 0, N_1 = 60, N_2 = 120 and N_3 = 180 kg N ha^{-1}) and 3 levels of Boron (B_0= 0, B_1= 0.4 and B_2= 0.6 kg B ha^{-1}). Application of N @ 120 kg ha^{-1} gave the highest plant height, flower clusters $plant^{-1}$, flowers $cluster^{-1}$, fruits $cluster^{-1}$, fruits $plant^{-1}$, fruit weight $plant^{-1,}$ fruit weight $plot^{-1}$ and fruit yield. In interaction, N @ 120 kg ha^{-1} along with B @ 0.6 kg ha^{-1} produced the highest plant height, flower clusters $plant^{-1}$, flowers $cluster^{-1}$, fruits $cluster^{-1}$, fruits $plant^{-1}$, fruit weight $plant^{-1}$, fruit weight $plot^{-1}$ and fruit yield.

Salam *et al.* (2010) carried out an experiment to investigate the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. There were twelve treatment combinations which comprised four levels of boron and zinc *viz.*, i) 0 kg B + 0 kg Zn ha^{-1}, ii) 1.5 kg B + 2.0 kg Zn ha^{-1}, iii) 2.0 kg B + 4.0 kg Zn ha^{-1} , iv) 2.5 kg B + 6.0 kg Zn ha^{-1} and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50% <RD), ii) Recommended NPK fertilizer dose (RD), iii) 50% more than the recommended NPK fertilizer dose (50% >RD). The highest pulp weight , dry matter content, chlorophyll-a and chlorophyll-b were recorded with the combination of 2.5 kg B+ 6 kg Zn ha^{-1} and recommended dose of NPK fertilizers (N = 253, P = 90, and K = 125 kg ha^{-1}).

Jyolsna (2008) conducted a pot culture experiment to study the effects of 0, 0.5, 1.0, and 1.5 kg B ha^{-1} with recommended doses of chemical fertilizers (75: 40: 25 kg N, P_2O_5, and K_2O ha^{-1}; RDF) and RDF+ farmyard manure (FYM; 25 t ha^{-1}) on growth, yield, and quality of tomato. B significantly increased plant height and number of primary branches. It also reduced the days to flowering and increased fruit set (12.5 to 20% more at the highest level) both with and without FYM.

Naresh (2002) showed that foliar application of B at rates 50, 100, 150, 200, 250 and 300 ppm on tomato had a positive effect on plant height, number of branches, number of fruits per plant and total tomato yield.

Stanley *et al*. (1995) reported that, the absence of B affect the translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins.

Phookan *et al.* (1991) noticed that, boron influences greatly the flowering, fruit set, fruit development and seed development.

Gupta and Pal (1989) reported that, N plays important roles in the production of high quality seed; attempts to increase flowering, berry setting and TPS quality without N application may be of little significance.

Dear and Lipsett (1987) conducted a little research on the boron (B) status of subterranean clover. They observed that, reproductive growth especially flowering, fruiting, seed set and seed yield is more sensitive to B deficiency than vegetative growth.

Finally it may be taken that, the application of nitrogen as split may provide more nutrition than that of conventional application for better quality TPS. Boron may act as better reproductive nutrient for pollen and sigma for better quality TPS.

CHAPTER 3

MATERIALS AND METHODS

The materials and methods of present research work have been described in this chapter including study area, experimental materials, climate and weather, land preparation, experimental design, layout, intercultural operations, crop sampling, data collection and statistical package etc. within a period. Overall discussion about different levels of nitrogen splitting and B fertilizer has been mentioned for quality TPS production from potato mother plant. The details of experiments and methods have been described under the following headings:

3.1 Study area

The present research work was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2013 to April, 2014. The experimental area is located at 23.41^0 N latitude and 90.22^0 E longitudes and at an altitude of 8.6 m from the sea level. The site and land type used under present study have been shown in Appendix (I-II).

3.1.1 Soil

The soil of the experimental area was to the general soil type series of shallow red brown terrace soils under Tejgaon series. Upper level soils were clay loam in texture, olive-gray through common fine to medium distinct dark yellowish brown mottles under the Agro-ecological Zone (AEZ-28) and belonged to the Madhupur Tract (UNDP, 1988). The selected plot was above flood level and sufficient sunshine was available having available irrigation and drainage system during the experimental period.

3.1.2 Climate and weather

The experimental area is situated in the sub-tropical climatic zone and heavy rainfall during pre-moonsoon (March to May-*Kharif-I*), monsoon period (June to September-*Kharif-II* season) and scanty rainfall during the rest period of the year (Roy, 2013). The Rabi season (October to March) is characterized by comparatively low temperature and plenty of sunshine from November to February (SRDI, 1991). The detailed meteorological data in respect of air temperature, relative humidity, total rainfall collected from the Meteorological station of Sher-e-Bangla Agricultural University, Dhaka during the period of study have been presented in Appendix (IV-V).

3.2 Crop: Potato mother plant (*Solanum tuberosum* L.)

The tubers of both parental line, TPS-67 (as male parent, ♂) and MF-II (as female parent, ♀) were collected from BADC farm, Domar, Dinajpur. The female line MF II is *tuberosum* and male line TPS 67 is *andigena* based (Thakur and Upadhya, 1996). Afterward, no promising line had been released. So, these two promising parental lines were used for their good combining ability for selfing to produce quality TPS (Moniruzzaman, 2000).

3.3 Experimental treatment used under study:

The experimental treatment consisted of two factors *i.e.*, Nitrogen Splitting (SN) and Boron (B) which are presented as follows:

Factor A: Nitrogen Splitting (SN), level-4 (four)

SN_0: 50 kg N ha^{-1} as basal + 125 kg N ha^{-1} as 1^{st} split at 30 DAP + 125 kg N ha^{-1} as 2^{nd} split at 40 DAP.

SN_1: 50 kg N ha^{-1} as basal + 83.3 kg N ha^{-1} as 1^{st} split at 30 DAP + 83.3 kg N ha^{-1} as 2^{nd} split at 40 DAP + 83.3 kg N ha^{-1} as 3^{rd} split at 50 DAP.

SN_2: 50 kg N ha^{-1} as basal + 62.5 kg N ha^{-1} as 1st split at 30 DAP + 62.5 kg N ha^{-1} as 2nd split at 40 DAP + 62.5 kg N ha^{-1} as 3rd split at 50 DAP + 62.5 kg N ha^{-1} as 4th split at 60 DAP.

SN_3: 50 kg N ha^{-1} as basal + 50 kg N ha^{-1} as 1st split at 30 DAP + 50 kg N ha^{-1} as 2nd split at 40 DAP + 50 kg N ha^{-1} as 3rd split at 50 DAP + 50 kg N ha^{-1} as 4th split at 60 DAP + 50 kg N ha^{-1} as 5th split at 70 DAP.

Factor B: Boron (B), level-4 (four)

B_0: 0 kg B ha^{-1}

B_1: 4 kg B ha^{-1}

B_2: 6 kg B ha^{-1}

B_3: 8 kg B ha^{-1}

3.3.1 Treatment Combination

There were 16 treatment combinations under present study are as follows:

SN_0 B_0 = 50 kg N ha^{-1} as basal + 125 kg N ha^{-1} as 1st split at 30 DAP +125 kg N ha^{-1} as 2nd split at 40 DAP and 0 kg B ha^{-1} as basal.

SN_0 B_1 = 50 kg N ha^{-1} as basal + 125 kg N ha^{-1} as 1st split at 30 DAP +125 kg N ha^{-1} as 2nd split at 40 DAP and 4 kg B ha^{-1} as basal.

SN_0 B_2 = 50 kg N ha^{-1} as basal + 125 kg N ha^{-1} as 1st split at 30 DAP +125 kg N ha^{-1} as 2nd split at 40 DAP and 6 kg B ha^{-1} as basal.

SN_0 B_3 = 50 kg N ha^{-1} as basal + 125 kg N ha^{-1} as 1st split at 30 DAP +125 kg N ha^{-1} as 2nd split at 40 DAP and 8 kg B ha^{-1} as basal.

SN_1 B_0 = 50 kg N ha^{-1} as basal + 83.3 kg N ha^{-1} as 1st split at 30 DAP + 83.3 kg N ha^{-1} as 2nd split at 40 DAP + 83.3 kg N ha^{-1} as 3rd split at 50 DAP and 0 kg B ha^{-1} as basal.

SN_1 B_1 = 50 kg N ha^{-1} as basal + 83.3 kg N ha^{-1} as 1st split at 30 DAP + 83.3 kg N ha^{-1} as 2nd split at 40 DAP + 83.3 kg N ha^{-1} as 3rd split at 50 DAP and 4 kg B ha^{-1} as basal.

SN_1 B_2 = 50 kg N ha^{-1} as basal + 83.3 kg N ha^{-1} as 1st split at 30 DAP + 83.3 kg N ha^{-1} as 2nd split at 40 DAP + 83.3 kg N ha^{-1} as 3rd split at 50 DAP and 6 kg B ha^{-1} as basal.

SN_1 B_3 = 50 kg N ha^{-1} as basal + 83.3 kg N ha^{-1} as 1st split at 30 DAP + 83.3 kg N ha^{-1} as 2nd split at 40 DAP + 83.3 kg N ha^{-1} as 3rd split at 50 DAP and 8 kg B ha^{-1} as basal.

SN_2 B_0 = 50 kg N ha^{-1} as basal + 62.5 kg N ha^{-1} as 1st split at 30 DAP + 62.5 kg N ha^{-1} as 2nd split at 40 DAP + 62.5 kg N ha^{-1} as 3rd split at 50 DAP + 62.5 kg N ha^{-1} as 4th split at 60 DAP and 0 kg B ha^{-1} as basal.

SN_2 B_1 = 50 kg N ha^{-1} as basal + 62.5 kg N ha^{-1} as 1st split at 30 DAP + 62.5 kg N ha^{-1} as 2nd split at 40 DAP + 62.5 kg N ha^{-1} as 3rd split at 50 DAP + 62.5 kg N ha^{-1} as 4th split at 60 DAP and 4 kg B ha^{-1} as basal.

SN_2 B_2 = 50 kg N ha^{-1} as basal + 62.5 kg N ha^{-1} as 1st split at 30 DAP + 62.5 kg N ha^{-1} as 2nd split at 40 DAP + 62.5 kg N ha^{-1} as 3rd split at 50 DAP + 62.5 kg N ha^{-1} as 4th split at 60 DAP and 6 kg B ha^{-1} as basal.

SN_2 B_3 = 50 kg N ha^{-1} as basal + 62.5 kg N ha^{-1} as 1st split at 30 DAP + 62.5 kg N ha^{-1} as 2nd split at 40 DAP + 62.5 kg N ha^{-1} as 3rd split at 50 DAP + 62.5 kg N ha^{-1} as 4th split at 60 DAP and 8 kg B ha^{-1} as basal.

SN_3 B_0 = 50 kg N ha^{-1} as basal + 50 kg N ha^{-1} as 1st split at 30 DAP + 50 kg N ha^{-1} as 2nd split at 40 DAP + 50 kg N ha^{-1} as 3rd split at 50 DAP + 50 kg N ha^{-1} as 4th split at 60 DAP + 50 kg N ha^{-1} as 5th split at 70 DAP and 0 kg B ha^{-1} as basal.

SN_3 B_1 = 50 kg N ha^{-1} as basal + 50 kg N ha^{-1} as 1st split at 30 DAP + 50 kg N ha^{-1} as 2nd split at 40 DAP + 50 kg N ha^{-1} as 3rd split at 50 DAP + 50 kg N ha^{-1} as 4th split at 60 DAP + 50 kg N ha^{-1} as 5th split at 70 DAP and 4 kg B ha^{-1} as basal.

SN_3 B_2 = 50 kg N ha^{-1} as basal + 50 kg N ha^{-1} as 1st split at 30 DAP + 50 kg N ha^{-1} as 2nd split at 40 DAP + 50 kg N ha^{-1} as 3rd split at 50 DAP + 50 kg N ha^{-1} as 4th split at 60 DAP + 50 kg N ha^{-1} as 5th split at 70 DAP and 6 kg B ha^{-1} as basal.

SN_3 B_3 = 50 kg N ha^{-1} as basal + 50 kg N ha^{-1} as 1st split at 30 DAP + 50 kg N ha^{-1} as 2nd split at 40 DAP + 50 kg N ha^{-1} as 3rd split at 50 DAP + 50 kg N ha^{-1} as 4th split at 60 DAP + 50 kg N ha^{-1} as 5th split at 70 DAP and 8 kg B ha^{-1} as basal.

3.4 Experimental design and layout

The experiment was laid out in split-plot design with three replications. Nitrogen splitting and boron levels were assigned to main and sub-plot, respectively (Gomez and Gomez, 1984). The size of unit plot was 1.5 m × 1.0 m, where replication to replication and plot to plot distance was 1.0 and 1.0 m, respectively. So, the total numbers of plot were 48, whose layout was sketched in Appendix (III).

3.5 Land preparation

The allotted experimental area was opened by power tiller in the last week of October, 2013. After two cross tillings followed by subsequent harrowing the previous crop residues, weeds and stubbles were cleaned thoroughly. Finally stable bleaching powder (15 kg ha^{-1}) was broadcasted to mix with soil followed by cross tilling with power tiller to protect the plant from bacterial infection.

3.6 Manures and fertilizers application

Fertilizer such as Urea, TSP, MoP, Gypsum, Borax and $ZnSO_4$ were used as a source of N, P, K, S, B and Zn, respectively.

Fertilizers	Dose (ha^{-1})	Quantity ($plot^{-1}$)
Urea	108.5 kg common as basal dose (for 50 kg N)	16.27 g
	271.25 kg (for each time in case of 2 splitting @ 125 kg N)	40.68 g
	180.76 kg (for each time in case of 3 splitting @ 83.3 kg N)	27.11 g
	135.62 kg (for each time in case of 4 splitting @ 62.5 kg N)	20.34 g
	108.5 kg (for each time in case of 5 splitting @ 50 kg N)	16.27 g
TSP	250 kg	37.5 g
MoP	125 kg	18.75 g
Gypsum	100	15 g
Borax	0 kg (for 0 kg B) 20 kg (for 4 kg B) 30 kg (for 6 kg B) 40 kg (for 8 kg B)	0 g 3 g 4.5 g 6 g
$ZnSO_4$	15 kg	2.25 g
Cowdung	7000 kg(7 tons)	1.05 kg

Source: Anon., 2010

At first 108.5 kg urea (for 50 kg N) and full amount of boron were applied as basal as per treatment. Cowdung as a source of manure and others fertilizers were applied to each plot into furrows and incorporated into the soil before 3 days planting of the seed tubers as basal dose as per recommendation, respectively. The remaining quantity of N fertilizer was applied in rows 10 to 15 cm apart from the female plants and at a depth of 4 to 5 cm in different installments at 10 day intervals (Roy *et al.*, 2007a, b) starting from just before blooming (30 days after planting).

3.7 Preparation of parental line

The parental seed tubers were taken out from the cold store 20 days before planting. After keeping in the pre-heating chamber seed tubers were spread in shade at room temperature. After removal from pre-heating chamber of cold store the seed tubers were sprayed with 3 % boric acid. Finally seed tubers were allowed to sprout under diffused light for proper germination, emergence in order to make them ready for good planting.

3.8 Planting of parental line

On 1 November 2013, seed tubers of the female parent with uniform size (60-70 g) were planted with a spacing of 0.5 m x 0.25 m in unit plots of 1.5 m x 1.0 m. In contrast to standard procedures for growing potatoes, these plants were not ridged. Male plants were planted in separate plots at least 7 days earlier than female plants to harmonize their flowering with that of the female plants. Furadan 5G @ 15 kg ha^{-1} was added to soil before planting of seed tubers for the protection from cutworm.

3.9 Intercultural operations

3.9.1 Earthing up

Solanization of potato tubers is very much harmful and facing to direct sunlight will reduce the tuber and decrease the stolon number. So, earthing up reduce such problems. That is why, two earthing up were done at 30 and 50 DAP, respectively.

3.9.2 Removal of weed

The emerging weeds were uprooted within two weeks of planting of seed tubers by hand and again weeding was done 25 days of planting with the hand tools.

3.9.3 Watering

No flood water was applied on experimental plot. TPS production need more water than that of normal tuber production for supplying proper moisture for vigorous growth. Water was applied through watering can as per when needed.

3.9.4 Control of insects and diseases

All possible phytosanitary measures were adopted to keep plants healthy. Dursban @ 7.5 litre ha^{-1} was drenched on both sides of ridges at 30 DAP to control the cutworm. Dimecron 100 EC @ 2% and Admire 200 SL @ 0.5% were applied to control aphid and jassid. At moist condition of weather Ridomil Gold MZ @ 1gm $litre^{-1}$ was applied before incidence of late blight of potato.

3.9.5 Staking of mother plant

Both parental lines usually attain a height of 4 to 5 ft. or more under extended photoperiod. The stems are herbaceous and erect in its early stages of growth and later they become spreading and prostrate. So, the stem of both parental lines was provided with support using dhaincha sticks and jute rope.

3.9.6 Pruning and trimming of stem

Healthy whole tubers attained bushy type having 3-5 stems. Upadhya *et al.* (1984) reported that, a high number of branches per plant increase the competition for nutrients among themselves which adversely affects TPS quality as well as quantity. In order to keep the plants of female parent line erect, help even distribution of light and to facilitate the pollination and intercultural operations, the plants were pruned to 2 stems per hill. In addition, side shoots of individual plants were trimmed regularly.

3.10 Artificial lighting

During winter season of Bangladesh the natural day length ranged from 9 to 11 hrs. In such natural photoperiod potato plants usually do not turns into flowering. So, **t**he extended photoperiod was maintained at 14 h to induce profuse amounts of flowering and berry sets (Almekinders and Struik, 1996; Van der Vossen, 1998). Artificial light was given by 200 watt white florescent bulb to provide a light intensity of 30,000 to 50,000 lux at the plant surface (Plate 2) from 25 DAP and was continued till completion of harvesting of berries and the intensity of light of this range was measured by HDELX-1010B Digital Lux meter. Only 2 uniform stems plant^{-1} were allowed to grow and first and second inflorescences stem^{-1} were also allowed to develop for the pollination because the best quality TPS is produced from primary and secondary inflorescences (Almekinders and Wiersema, 1991).

3.11 Hand pollination of female parent

Both parental lines (MF-II ♀ and TPS-67 ♂) normally starts blooming at 35-45 DAP. The male line TPS-67 blooms (Plate 3) 7-10 days later than the female line MF II (Plate 6). To synchronize the flowering of both male and female lines, the male line was planted 7-10 days earlier in separate plots. During this period the pollen grain (Plate 4 and 5) was collected from male plants and sun dried for 10 minutes and then extracted by shaking the dried anthers by needle placed over a petridish (Thakur *et al.,* 1994) and female parents were hand pollinated (Plate 8) in the morning (9.00-11.00 a.m.) for proper assurance of fertilization. The crossing between the two parental lines and the subsequent production of TPS were the same as described (Roy *et al.,* 2007a).

3.12 Berry harvesting and true seed extraction

Berries were harvested 5 to 6 weeks after pollination, when they just started to ripen. Berries from 5 plants of each plot were collected in net bags and stored for 7 to 10 days at room temperature to induce full ripening.

Well ripened soft berries were crushed mechanically, allowed to ferment for 24 h at room temperature and then washed under running tap water through a 0.5 mm mesh strainer. The collected seeds were treated with 10 % HCl for 20 min with continuous stirring and then washed well with tap water. The seeds were then treated with 0.5 % sodium hypochlorite solution for 10 min and finally washed 3 to 4 times with distilled water. The seeds were dried at room temperature until the moisture content was reduced to about 7 % and then stored in a desiccator for 15 days for further reduction of the moisture content to 4-4.5 %. This method of seeds extraction was described by Roy *et al.* (2007a). Thereafter, the seeds were weighed. The number of True seed or TPS berry^{-1} was counted and 100-TPS weight was recorded.

3.13 Recording of data

The following data were collected during the experimentation.

A. Growth characteristics

i. Plant height (cm) at 70 DAP
ii. Chlorophyll content (SPAD value) at first flowering stage and final berry harvest stage

B. Flowering characteristics

i. Days to inflorescence emergence
ii. Days to first flower open from inflorescence
iii. Number of total inflorescences plant^{-1}
iv. Number of flowers primary^{-1} inflorescence
v. Number of flowers secondary^{-1} inflorescence

C. Berry characteristics

i. Number of total berries plant^{-1}
ii. Number of berries primary^{-1} inflorescence
iii. Number of berries secondary^{-1} inflorescence
iv. Period from setting to maturity of berries (days)
v. Period from 1st to last harvest of berries (days)

vi. Weight of 100-berries (g)

vii. Total yield of berries plant^{-1} (g)

viii. Total yield of berries (t ha^{-1})

D. TPS characteristics

i. Number of TPS berry^{-1} at different berry sizes

ii. Yield of TPS kg^{-1} of berry (g)

iii. Total yield of TPS plant^{-1} (mg)

iv. Total yield of TPS (kg ha^{-1})

v. Weight of 100-TPS (mg)

E. Quality characteristics of TPS

i. Germination (%) of TPS

ii. Seed protein content (%)

iii. Seed lipid content (%)

F. Correlation Coefficient (r)

Between different growths, yield components, yield and quality of hybrid TPS

3.14 Data recording procedures

A brief outline of the data recording procedures on growth, flower, berry, TPS yield and quality traits followed during the study are given below.

A. Growth characteristics

i. Plant height (cm) at 70 DAP

Length of the plant from ground level to the tip of the tallest stem indicates the plant height. It was measured only at 70 DAP because; at this time berry is being ready to give most of the photosynthates towards berry maturation to harvest more or less. It may impact on plants translocate. So, the height of five randomly selected plant of each plot was measured in cm with the help of a meter scale and mean was calculated.

ii. Chlorophyll content (SPAD value) at first flowering stage and final berry harvest stage

The instrument which is currently used mostly is SPAD-502 manufactured by Minolta Camera Co., Ltd, Osaka, Japan. (1989). SPAD-502 is portable and non-destructive (Duce *et al.,* 1997).The value determined by the instrument provides an indication of the relative amount of chlorophyll present in plant leaves, by measuring the light transmittance of a leaf at two wavelength regions (peaks: approx. 650 and 940 nm). The first one matches with the peak absorbance area of chlorophyll where absorbance is unaffected by carotenoids. The second one is a reference wavelength where the absorbance of chlorophyll is extremely low. Five leaves (third matured leaf from the top of the plant) from five randomly selected plants were measured all time. During measurement, the light transmitted by a leaf is converted into electrical signals, amplified and converted into digital signals. Then the ratio of the intensities of the transmitted light is obtained and processed to calculate the SPAD value. There was a significant linear relationship between chlorophyll meter units and total nitrogen concentration in potato leaves (Vos and Born, 1993), as well as for many other species, including apple (Campbell *et al.,* 1990), bean (Madeira *et al.,* 2000), cabbages (Yadava, 1986; Marquard and Tipton, 1987), citrus (Duce *et al.,* 1997).

B. Flowering characteristics

i. Days to inflorescence emergence

Regularly, all the plants were keenly observed at morning till emergence of inflorescence from the female parent and then days from planting time was deducted to calculate the days to inflorescence emergence.

ii. Days to first flower open from inflorescence

After emergence of inflorescence all the plants were observed to see the first flower open from female plant and then required days were calculated by deducting the observing dates from days of planting.

iii. Number of total inflorescences plant^{-1}

Since, under present study only primary and secondary inflorescence were considered for growing up so, total number was found from five randomly selected plants and then mean was calculated.

iv. Number of flowers primary^{-1} inflorescence

Primary inflorescence is that, which emerged from top of the main stem. From the five randomly selected plants the number of flowers open from primary inflorescence was counted and then mean was calculated.

v. Number of flowers secondary^{-1} inflorescence

Secondary inflorescence is that, which emerged from branched shoots of main stem. From the five randomly selected plants the number of flowers open from secondary inflorescence was counted and then mean was calculated.

C. Berry characteristics

i. Period from setting to maturity of berries (days)

After hand pollination of female parents always all the plants were keenly observed to see the berries and then waited for maturation of berries. The required days were calculated by deducting the days of observation from days of planting.

ii. Period from 1st to last harvest of berries (days)

Berry harvesting was start normally from 5 to 6 weeks after days of planting. When the berries looked as dull greenish in color then it was harvested for seed extraction. The duration of first to last harvest of berries was calculated by deducting the required days of final berry harvest from days of planting.

iii. Number of total berries plant^{-1}

The potato plant bears greenish type of fruit as like as green tomato after successful pollination and fertilization of MF II.

From the five randomly selected plants the total number of berries was counted and then mean was taken in case of both primary and secondary inflorescences.

iv. Number of berries primary^{-1} inflorescence

After pollination of flowers of primary inflorescence turn into berry. The number of berries was counted from five randomly selected plants and then mean was taken.

v. Number of berries secondary^{-1} inflorescence

After pollination of flowers of secondary inflorescence turn into berry. The number of berries was counted from five randomly selected plants and then mean was taken.

vi. Weight of 100-berries (g)

All berries from each plot collected separately in separate packet and then the weight of hundred berries was counted in terms of gram unit.

vii. Total yield of berries plant^{-1} (g)

The total yield of berries per plants was counted in terms of gram from both of primary and secondary inflorescences.

viii. Total yield of berries (t ha^{-1})

The yield of berries per plant was converted to per plot then finally converted to per hectare.

D. TPS characteristics

i. Number of TPS berry^{-1}

The collected berries were packed separately for each plot and then extraction of true seeds was done properly and then seeds were counted against each berry of different sizes.

ii. Yield of TPS kg^{-1} of berry (g)

One kilogram berry was separately extracted per plot and then the yield of true seeds was weighted from one kilogram berry in terms of gram unit.

iii. Total yield of TPS $plant^{-1}$ (mg)

From five randomly selected plants the means were taken to weigh the yield of true seed in terms of milligram unit.

iv. Total yield of TPS (kg ha^{-1})

The yield of true seed per plant was converted to per plot then finally converted to per hectare.

v. Weight of 100-TPS (mg)

Hundred numbers of true seed were taken in milligram balance to weigh against each plot in terms of milligram unit.

E. Quality characteristics of TPS

i. Germination (%) of TPS

The well extracted seeds were placed for germination test in agronomy laboratory and number of germinated seeds was keenly seen at 7 days after placing on petridish with whatmen filter no. 42. Twenty five seeds were placed for germination test. Finally the percent of germination was calculated on the basis of the number of the normal seedlings.

% Germination = $N/T \times 100$

Where, N= No. of normal seedling

T = Total no. of seeds kept for germination

ii. Seed protein content ((%) and

iii. Seed lipid content ((%)

The extracted true seeds were separately packed and labeled for each plot and then sent to Bangladesh Council of Scientific and Industrial Research, Science Laboratory, Dhaka, to determine the seed protein and lipid content. Micro-kjeldhal method was used for nitrogen determination and then nitrogen percentage was multiplied by 6.25 (Ma and Zuazaga, 1942) to determine the percent of crude protein. Total lipid content was measured following the method described by Folch *et al.* (1957).

F. Correlation Co-efficient (r)

Correlation co-efficient was calculated between different growths, yield components, yield and quality of hybrid TPS by using MS excel sheet.

3.15 Statistical package used

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using Statistix 10 (2013) computer program and the treatment means were compared by Least Significant Different (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER 4

RESULTS AND DISCUSSION

The present investigation was attempted to evaluate the response of nitrogen splitting and boron on different characteristics of potato mother plant. In this chapter; figures, tables and appendices have been used to present, discuss and compare the findings obtained from the present study. The ANOVA (analysis of variance) of data in aspects of all the quantitative and qualitative characteristics have been presented in Appendix (IX-XVII). The revelation and all possible interpretations were given under the following headings:

4.1 Growth characteristics

4.1.1 Plant height (cm) at 70 DAP

4.1.1.1 Effect of nitrogen splitting

Profound significant ($p \leq 0.01$) variation was observed in respect of the plant height as to the effect of nitrogen splitting (Figure 1 and Appendix IX). The height of potato mother plant increased with the increasing of split doses of N. Results revealed that, the tallest plant was found from SN_3 (121.34 cm) followed by SN_2 (119.92 cm) and the smallest plant from SN_0 (81.14 cm). The finding also supported by Marschner (1990). He told that, application of high rates of N to potatoes, depending on the variety, generally delays tuber initiation and promotes vegetative growth.

4.1.1.2 Effect of boron

Remarkable variation ($p \leq 0.05$) was noted among the boron doses regarding plant height (Figure 1 and Appendix IX). With the increasing of boron doses the height of potato mother plant was increased. The tallest plant was found from B_3 (112.03 cm) which was statistically similar to B_2 (105.26 cm) and the smallest plant from B_0 (99.0 cm). Jyolsna (2008) noticed that, B significantly increased plant height which supports the present result.

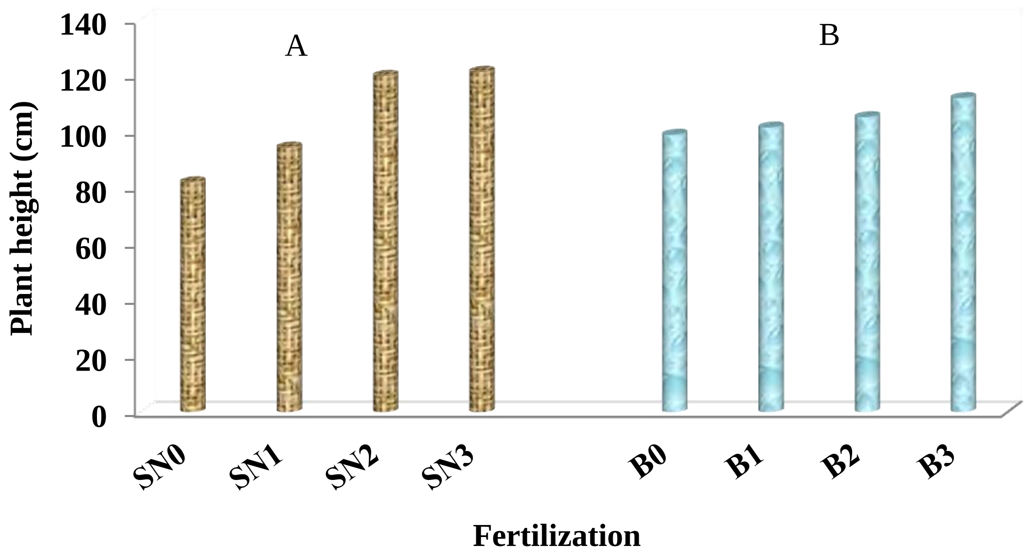


Figure 1: Effect of nitrogen splitting (A) and boron (B) on height (cm) of potato mother plant (LSD value 0.55 and 8.89 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.1.1.3 Combined effect of nitrogen splitting and boron

No significant effect of the nitrogen splitting and boron on the height of potato mother plants was found in the experiment (Table 1 and Appendix IX).

4.1.2 Chlorophyll content (SPAD value) at first flowering stage

4.1.2.1 Effect of nitrogen splitting

Remarkable variation ($p \leq 0.01$) was noted among the split doses of N regarding chlorophyll content (SPAD value) at first flowering stage (Figure 2 and Appendix IX). The leaf chlorophyll content was increased with the increasing split doses of N. The highest SPAD value was found from SN_3 (44.36) followed by SN_2 (44.02) and the lowest from SN_0 (34.11). Leaves exhibit a structural and functional acclimation of the photosynthetic apparatus to the light intensity experienced during their growth (Prioul *et al.,* 1980). Nitrogen supply has large effect on leaf growth because it increases the leaf area of plants and, on that way, it influences on photosynthesis.

Photosynthetic proteins represent a large proportion to total leaf N (Evans, 1989; Field and Mooney, 1986). Chlorophyll content is approximately proportional to leaf nitrogen content, too (Evans, 1983). So, the result of present study was supported from above citation.

4.1.2.2 Effect of boron

No significant effect of the boron on chlorophyll content (SPAD value) at first flowering stage of potato mother plants was found in the experiment (Figure 2 and Appendix IX).

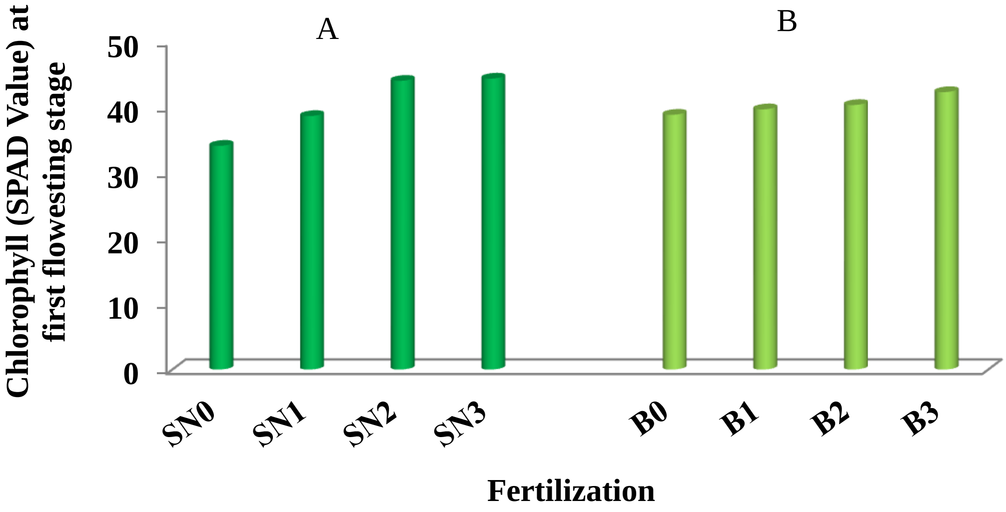


Figure 2: Effect of nitrogen splitting (A) and boron (B) on chlorophyll content at first flowering stage of potato mother plant (LSD value 0.07 and 3.10 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.1.2.3 Combined effect of nitrogen splitting and boron

No significant effect of the split doses of nitrogen and boron on chlorophyll content (SPAD value) at first flowering stage of potato mother plants was found in the experiment (Table 1 and Appendix IX).

4.1.3 Chlorophyll content (SPAD value) at final berry harvest stage

4.1.3.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted on chlorophyll content (SPAD value) at final berry harvest stage (Figure 3 and Appendix IX) against split doses of N. There was an increasing trend of leaf chlorophyll content with the increasing of split application of N. The highest SPAD value was found from SN_3 (21.24) followed by SN_2 (20.74) and the lowest from SN_0 (13.64) at final berry harvest stage. During berry maturation and harvest, the chlorophyll content of the green leaf of plant may be utilized by the plant more or less. So, the trend of chlorophyll content decreased from earlier vegetative stages and flowering stage. Chlorophyll content is approximately proportional to leaf nitrogen content, too (Evans, 1983). Josue *et al*. (2011) has been supported the present findings. Because, they told there was a slight decrease in the chlorophyll contents in leaves as the tomatoes progressed from immature green to full red stage (at harvest).

4.1.3.2Effect of boron

Profound significant ($p \leq 0.01$) variation was observed in respect of the chlorophyll content of leaf at final berry harvesting stage as to the effect of boron (Figure 3 and Appendix IX). A gradual increasing trend was found with the increasing of the boron dose. The SPAD value was highest in B_3 (20.47) followed by B_2 (19.18) and the lowest was in B_0 (15.45).

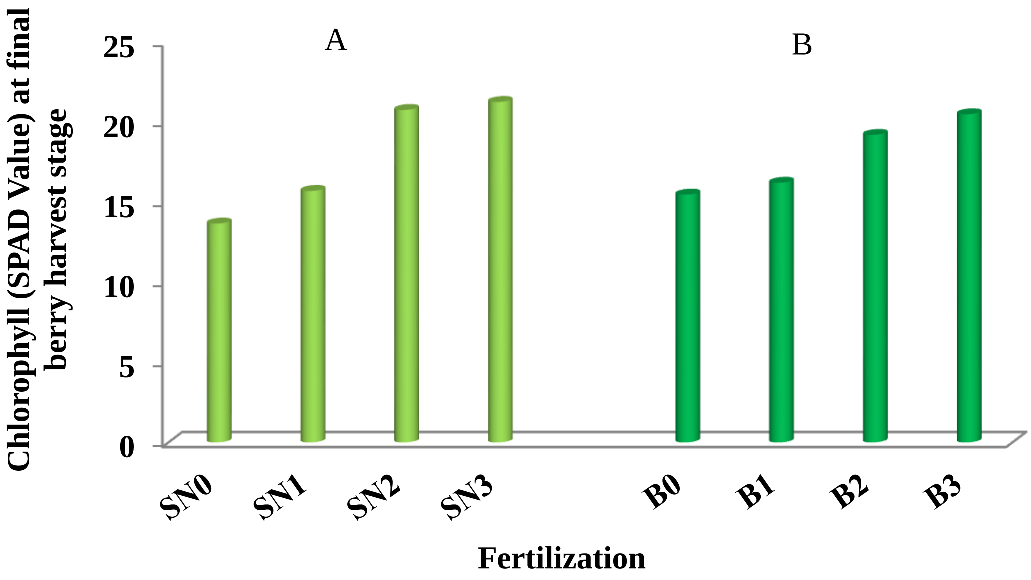


Figure 3: Effect of nitrogen splitting (A) and boron (B) on chlorophyll content at final berry harvest stage of potato mother plant (LSD value 0.03 and 1.19 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.1.3.3 Combined effect of nitrogen splitting and boron

Remarkable significant variation was noted in ($p \leq 0.01$) in respect of chlorophyll content (SPAD value) at final berry harvest stage as to the combined effect of nitrogen splitting and boron application (Table 1 and Appendix IX). The highest SPAD value was found from SN_3B_3 (25.62) which was statistically similar to SN_2B_3 (24.78) and SN_2B_2 (23.98) and the lowest value from SN_0B_0 (12.27).

Table 1: Combined effect of nitrogen splitting and boron on height, chlorophyll at first flowering stage and chlorophyll at final berry harvest stage of potato mother plant

Nitrogen Splitting × Boron	Plant height at 70 DAP (cm)	Chlorophyll at first flowering stage	Chlorophyll at final berry harvest stage
SN_0B_0	79.46	32.92	12.27 h
SN_0B_1	81.93	34.60	13.67 gh
SN_0B_2	82.40	33.77	13.91 fgh
SN_0B_3	84.75	35.17	14.74 efg
SN_1B_0	87.82	37.80	13.75 fgh
SN_1B_1	88.30	37.65	16.30 de
SN_1B_2	93.70	38.90	15.90 def
SN_1B_3	108.14	40.25	16.77 cde
SN_2B_0	112.20	42.20	17.30 cd
SN_2B_1	117.81	43.10	16.90 cd
SN_2B_2	122.76	44.93	23.98 ab
SN_2B_3	126.90	45.87	24.78 ab
SN_3B_0	116.50	42.44	18.50 c
SN_3B_1	118.37	43.34	17.90 cd
SN_3B_2	122.17	43.75	22.96 b
SN_3B_3	128.33	47.93	25.62 a
CV (%)	10.10	9.16	7.98
LSD (0.05)	-	-	2.07
F test	NS	NS	**

Means followed by different letters in the same column differ significantly according to LSD test

**, indicates F test significant at $p \leq 0.01$

NS, not-significant

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2 Flowering characteristics

4.2.1 Days to inflorescence emergence

4.2.1.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of days to inflorescence emergence (Figure 4 and Appendix X) from potato mother plant against split doses of N.

There was a decreasing trend of days to inflorescence emergence with the increasing of split application of N. The maximum (44.25 days) was required for the plant produced from SN_0 followed by SN_1 (41.90 days) and the minimum (35.25 days) was required for the plant produced from SN_3.

4.2.1.2 Effect of boron

No significant effect of the boron on days to inflorescence emergence from potato mother plants was found in the experiment (Figure 4 and Appendix X).

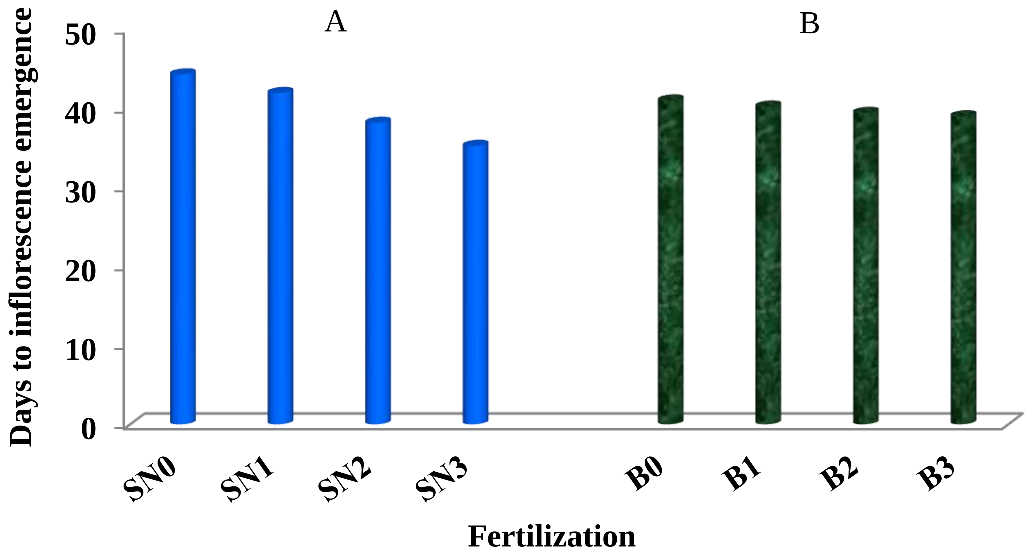


Figure 4: Effect of nitrogen splitting (A) and boron (B) on days to inflorescence emergence from potato mother plant (LSD value 1.54 and 2.56 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.1.3 Combined effect of nitrogen splitting and boron

No significant effect of the split doses of nitrogen and boron on days to inflorescence emergence from potato mother plants was found in the experiment (Table 2 and Appendix X).

4.2.2 Days to first flower open from inflorescence

4.2.2.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of days to first flower open from inflorescence (Figure 5 and Appendix X) of potato mother plant against split doses of N. There was a decreasing trend of days to first flower open from inflorescence with the increasing of split application of N. The maximum (52.39 days) was required for the plant produced from SN_0 followed by SN_1 (47.34 days) and the minimum (41.54 days) was required for the plant produced from SN_3. Results are supported by Masome (2013). He told that, number of days to flowering of tomato influenced significantly by urea nitrogen fertilizer with increasing doses.

4.2.2.2 Effect of boron

No significant effect of the boron on of days to first flower open from inflorescence of potato mother plants was found in the experiment (Figure 5 and Appendix X).

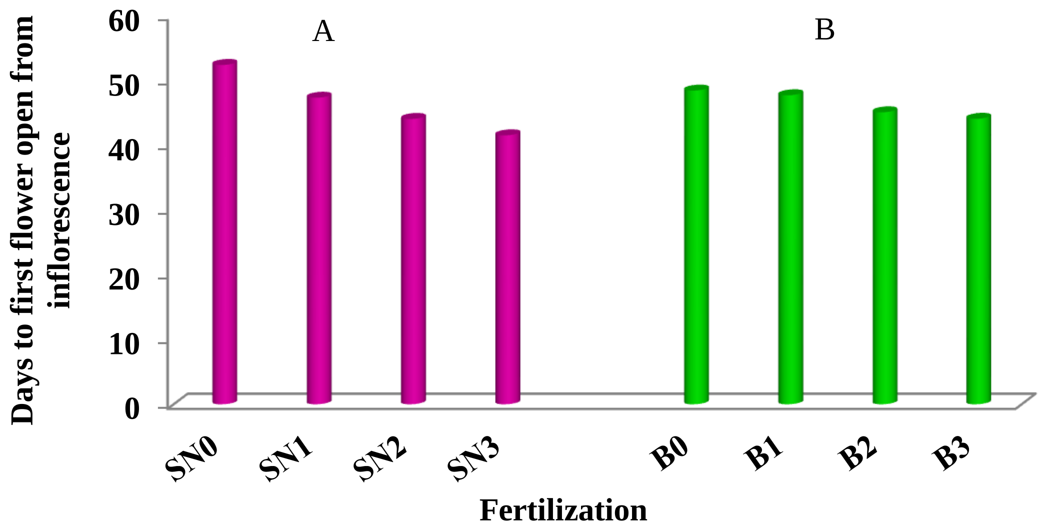


Figure 5: Effect of nitrogen splitting (A) and boron (B) on days to first flower open from inflorescence of potato mother plant (LSD value 0.09 and 3.82 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.2.3 Combined effect of nitrogen splitting and boron

No significant combined effect of the split doses of nitrogen and boron on of days to first flower open from inflorescence of potato mother plants was found in the experiment (Table 2 and Appendix X).

Table 2: Combined effect of nitrogen splitting and boron on days to inflorescence emergence and days to first flower open from inflorescence of potato mother plant

Nitrogen Splitting × Boron	Days to inflorescence emergence	Days to first flower open from inflorescence
SN_0B_0	44.90	55.79
SN_0B_1	43.80	52.09
SN_0B_2	44.20	51.49
SN_0B_3	44.10	50.19
SN_1B_0	43.30	49.69
SN_1B_1	42.50	48.09
SN_1B_2	41.20	45.39
SN_1B_3	40.60	46.19
SN_2B_0	40.10	47.09
SN_2B_1	39.60	46.89
SN_2B_2	36.80	41.59
SN_2B_3	36.10	40.69
SN_3B_0	35.60	41.19
SN_3B_1	34.90	43.79
SN_3B_2	35.40	41.89
SN_3B_3	35.10	39.29
CV (%)	7.64	6.63
LSD (0.05)	-	-
F test	NS	NS

NS, not-significant

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.3 Number of total inflorescences plant^{-1}

4.2.3.1 Effect of nitrogen splitting

Pronounced significant variation ($p \leq 0.01$) was noted in respects number of total inflorescences plant^{-1} (Figure 6 and Appendix XI) of potato mother plant against split doses of N.

There was a gradual increasing trend to number of total inflorescences plant^{-1} with the increasing of split application of N. The highest number of inflorescence was found from SN_3 (7.05) treatment followed by SN_2 (6.98) and the lowest number of inflorescence produced from SN_0 (4.52) treatment. Similar trend was reported by Hassan *et al*. (1993). They mentioned that, doubling the N rate from 112 to 224 kg ha^{-1} resulted in increase in flower buds.

4.2.3.2 Effect of boron

Pronounced significant variation ($p \leq 0.01$) was noted in respects number of total inflorescences plant^{-1} (Figure 6 and Appendix XI) of potato mother plant doses of boron. There was a gradual increasing trend to number of total inflorescences plant^{-1} with the increasing of boron doses. The highest number of inflorescence was found from B_3 (6.80) followed by B_2 (6.17) and the lowest number of inflorescence produced from B_0 (5.46).

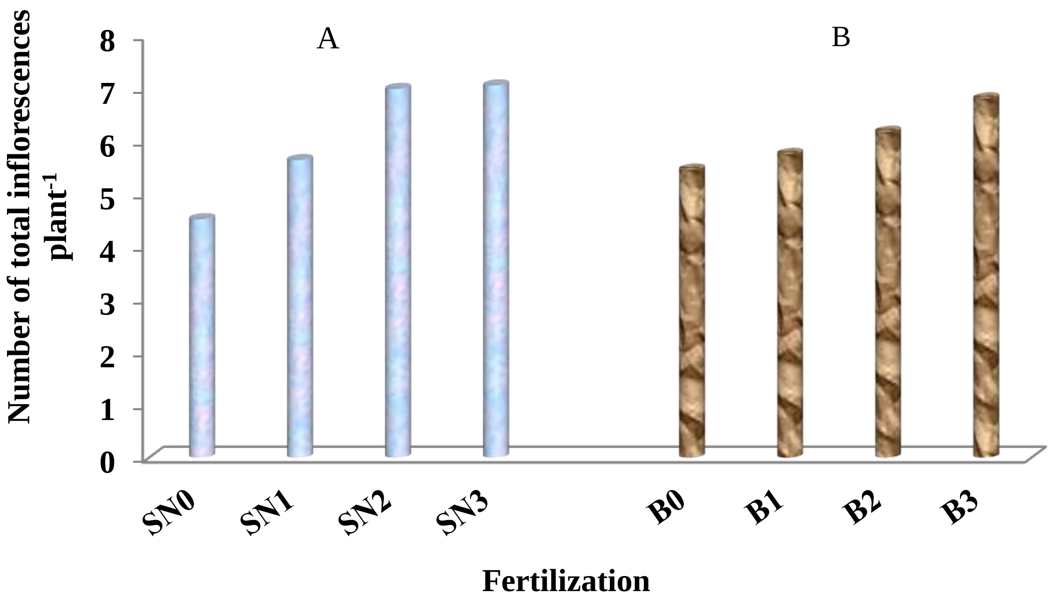


Figure 6: Effect of nitrogen splitting (A) and boron (B) on number of total inflorescences plant^{-1} in potato (LSD value 0.03 and 0.44 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.3.3 Combined effect of nitrogen splitting and boron

Remarkable significant variation was noted in ($p \leq 0.05$) in respect of number of total inflorescences plant^{-1} as to the combined effect of nitrogen splitting and boron (Table 3 and Appendix XI). The highest inflorescence number was found from SN_3B_3 (8.51) which was statistically similar to SN_2B_3 (8.02) and the lowest from SN_0B_0 (4.00).

4.2.4 Number of flowers primary^{-1} inflorescence

4.2.4.1 Effect of nitrogen splitting

Notable significant variation ($p \leq 0.01$) was noted in respects of number of flowers primary^{-1} inflorescence (Figure 7 and Appendix XI) of potato mother plant against split doses of N. There was a gradual increasing trend to number of flowers primary^{-1} inflorescence with the increasing of split application of N. The highest number of flower was found from SN_3 (21.71) followed by SN_2 (20.82) and the lowest number of flower produced from SN_0 (14.49). Upadhya *et al*. (1984) noticed that, the number of flowers per inflorescence varies from 6 to 26. So, the rage of flowers number partially supports the results from present study against N splitting. Results also supported by Maingi *et al.* (1994). They mentioned that, excessive N supply as split increase flower production.

4.2.4.2 Effect of boron

Pronounced significant variation ($p \leq 0.01$) was noted in respects of number of flowers primary^{-1} inflorescence (Figure 7 and Appendix XI) of potato mother plant against doses of boron. There was a gradual increasing trend to number of flowers primary^{-1} inflorescence with the increasing of boron doses. The highest number of flower was found from B_3 (20.45) which was statistically similar to B_2 (19.39) and the lowest number of flower produced from statistically similar B_1 (17.05) and B_0 (16.66).

Results supported by Bergmann (1984); Oyewole and Aduayi (1992). They told that, a positive relation present between increasing B in plant and numbers of flowers, the proportion of flowers not aborted.

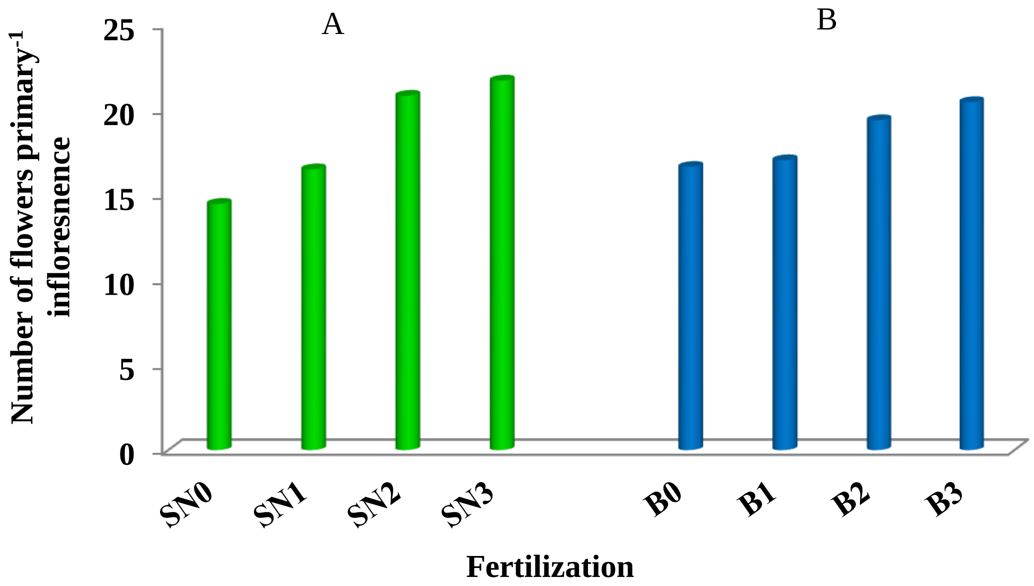


Figure 7: Effect of nitrogen splitting (A) and boron (B) on number of flowers primary^{-1} inflorescence in potato mother plant (LSD value 0.01 and 1.68 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.4.3 Combined effect of nitrogen splitting and boron

Remarkable significant variation ($p \leq 0.05$) was noted in respect of number of flowers primary^{-1} inflorescence as to the combined effect of nitrogen splitting and boron (Table 3 and Appendix XI). The highest flower number was found from SN_3B_3 (25.49) which was statistically similar to SN_3B_2 (23.28), SN_2B_3 (24.23) and SN_2B_2 (23.00) and the lowest number from SN_0B_0 (13.10).

4.2.5 Number of flowers secondary^{-1} inflorescence

4.2.5.1 Effect of nitrogen splitting

Profound significant variation ($p \leq 0.01$) was noted in respects of number of flowers secondary^{-1} inflorescence (Figure 8 and Appendix XI) against split doses of N. There was a gradual increasing trend to number of flowers secondary^{-1} inflorescence with the increasing of split application of N. The highest number of flower was found from SN_3 (16.54) followed by SN_2 (16.17) and the lowest number of flower produced from SN_0 (10.04).|

4.2.5.2 Effect of boron

Remarkable significant variation ($p \leq 0.01$) was noted in respects of number of flowers secondary^{-1} inflorescence (Figure 8 and Appendix XI) of potato mother plant doses of boron. There was a gradual increasing trend to number of flowers secondary^{-1} inflorescence with the increasing of boron doses. The highest number of flower was found from B_3 (15.49) which was statistically similar to B_2 (14.54) and the lowest number of flower produced from statistically similar B_1 (12.67) and B_0 (11.92).

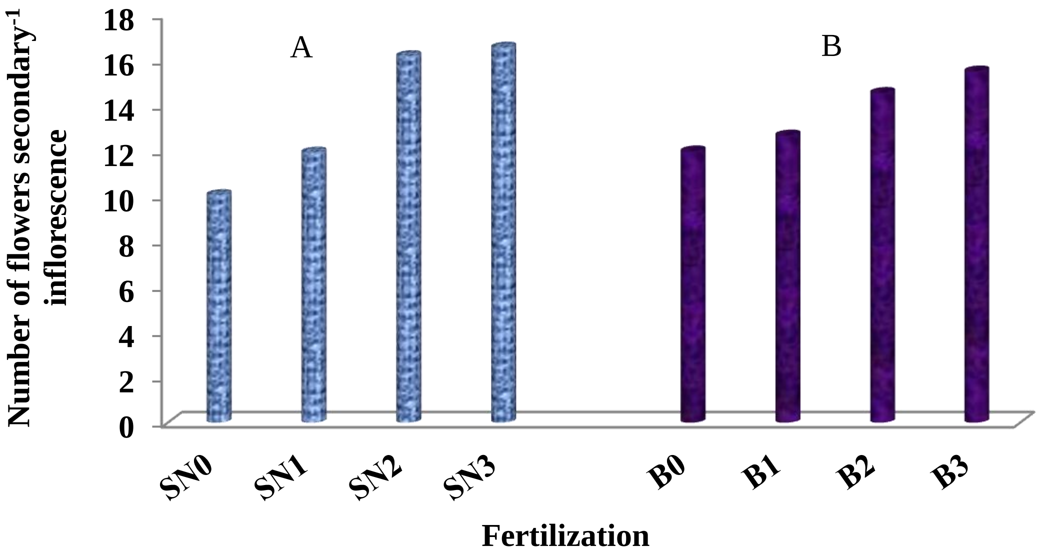


Figure 8: Effect of nitrogen splitting (A) and boron (B) on number of flowers secondary^{-1} inflorescence in potato mother plant (LSD value 0.04 and 1.0 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.2.5.3 Combined effect of nitrogen splitting and boron

Remarkable significant variation ($p \leq 0.01$) was noted in respect of number of flowers secondary^{-1} inflorescence as to the combined effect of nitrogen splitting and boron (Table 3 and Appendix XI). The highest flower number was found from SN_3B_3 (19.49) which was statistically similar to SN_2B_3 (18.89) and SN_2B_2 (18.49) and the lowest number from SN_0B_0 (8.19).

Table 3: Combined effect of nitrogen splitting and boron on number of total inflorescences plant^{-1}, number of flowers primary^{-1} inflorescence and number of flowers secondary^{-1} inflorescence in potato mother plant

Nitrogen Splitting × Boron	Number of total inflorescences plant^{-1}	Number of flowers primary^{-1} inflorescence	Number of flowers secondary^{-1} inflorescence
SN_0B_0	4.00 i	13.10 f	8.19 j
SN_0B_1	4.73 hi	14.49 ef	9.99 ij
SN_0B_2	4.43 hi	14.99 ef	10.89 hi
SN_0B_3	4.91 h	15.39 d-f	11.09 hi
SN_1B_0	5.16 gh	15.99 c-f	11.69 g-i
SN_1B_1	5.70 fg	17.09 b-e	11.49 g-i
SN_1B_2	5.92 e-g	16.29 c-e	11.99 gh
SN_1B_3	5.77 fg	16.69 b-e	12.49 f-h
SN_2B_0	6.07 ef	17.99 b-d	13.19 e-g
SN_2B_1	6.38 d-f	18.07 b-d	14.09 d-f
SN_2B_2	7.46 bc	23.00 a	18.49 ab
SN_2B_3	8.02 ab	24.23 a	18.89 a
SN_3B_0	6.60 de	19.54 b	14.79 c-e
SN_3B_1	6.20 d-f	18.54 bc	15.09 cd
SN_3B_2	6.88 cd	23.28 a	16.79 bc
SN_3B_3	8.51a	25.49 a	19.49 a
CV (%)	8.71	10.86	8.71
LSD (0.05)	0.76	2.91	1.73
F test	*	*	**

Means followed by different letters in the same column differ significantly according to LSD test

*, ** indicate F test significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3 Berry characteristics

4.3.1 Number of total berries plant^{-1}

4.3.1.1 Effect of nitrogen splitting

Profound significant variation ($p \leq 0.01$) was noted in respects of number of total berries plant^{-1} (Figure 9 and Appendix XII) of potato mother plant against split doses of N. There was a gradual deceasing trend to number of total berries plant^{-1} with the increasing of split application of N. The highest number of berries were found from SN_0 (19.84) followed by SN_1 (16.32) and the lowest number of berries produced from SN_3 (12.65). Finding of present study supported by Hassan *et al*. (1993). They reported that, percentage of fruit set decreased as N rates increased.

4.3.1.2 Effect of boron

Remarkable significant variation ($p \leq 0.05$) was noted in respects of number of total berries plant^{-1} (Figure 9 and Appendix XII) of potato mother plant doses of boron. There was a gradual decreasing trend to number of total berries plant^{-1} with the increasing of boron doses. The highest number of berries was found from B_0 (16.83) treatment which was statistically similar to B_1 (15.73) and the lowest number of berries produced from statistically similar B_2 (15.18) and B_3 (14.79). Fruit set was completely inhibited at the highest boron treatment (Goldberg *et al*., 2003), which supported the present findings.

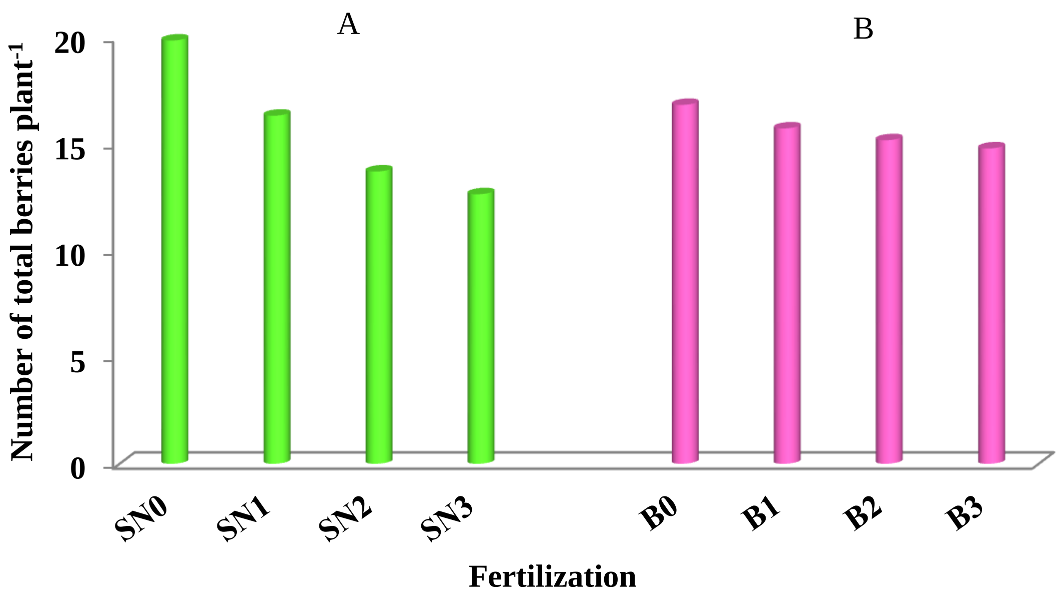


Figure 9: Effect of nitrogen splitting (A) and boron (B) on Number of total berries plant^{-1} in potato (LSD value 0.08 and 1.35 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.1.3 Combined effect of nitrogen splitting and boron

No significant combined effect of the split doses of nitrogen and boron on number of total berries plant^{-1} of potato was found in the experiment (Table 4 and Appendix XII).

4.3.2 Number of berries primary^{-1} inflorescence

4.3.2.1 Effect of nitrogen splitting

Profound significant variation ($p \leq 0.01$) was noted in respects of number of berries primary^{-1} inflorescence (Figure 10 and Appendix XII) of potato mother plant against split doses of N. There was a gradual deceasing trend to number of berries primary^{-1} inflorescence with the increasing of split application of N. The highest number of berries were found from SN_0 (14.33) followed by SN_1 (11.53) and the lowest number of berries produced from SN_3 (9.12).

4.3.2.2 Effect of boron

Remarkable significant variation ($p \leq 0.01$) was noted in respects of number of berries primary^{-1} inflorescence (Figure 10 and Appendix XII) of potato mother plant doses of boron. There was a gradual decreasing trend to number of berries primary^{-1} inflorescence with the increasing of boron doses. The highest number of berries was found from B_0 (12.16) and the lowest number of berries produced from statistically similar B_1 (11.20), B_2 (10.84) and B_3 (10.66).

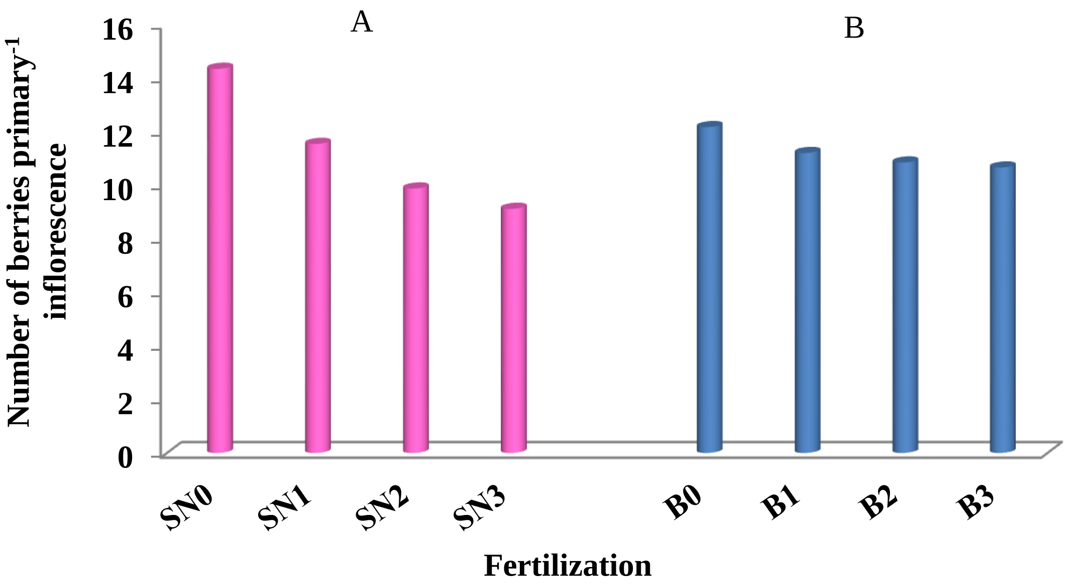


Figure 10: Effect of nitrogen splitting (A) and boron (B) on number of berries primary^{-1} inflorescence in potato mother plant (LSD value 0.06 and 0.87 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.2.3 Combined effect of nitrogen splitting and boron

No significant combined effect of the split doses of N and boron on number of berries primary^{-1} inflorescence of potato was found in the experiment (Table 4 and Appendix XII).

4.3.3 Number of berries secondary^{-1} inflorescence

4.3.3.1 Effect of nitrogen splitting

Profound significant variation ($p \leq 0.01$) was noted in respects of number of berries secondary^{-1} inflorescence (Figure 11 and Appendix XII) of potato mother plant against split doses of N. There was a gradual deceasing trend to number of berries secondary^{-1} inflorescence with the increasing of split application of nitrogen. The highest number of berries were found from SN_0 (5.04) followed by SN_1 (4.24) and the lowest number of berries produced from SN_3 (3.22).

4.3.3.2 Effect of boron

Remarkable significant variation ($p \leq 0.01$) was noted in respects of number of berries secondary^{-1} inflorescence (Figure 11 and Appendix XII) of potato mother plant doses of boron. There was a gradual decreasing trend to number of berries secondary^{-1} inflorescence with the increasing of boron doses. The highest number of berries was found from B_0 (4.26) which was statistically similar to B_1 (4.07) and the lowest number of berries produced from B_3 (3.75).

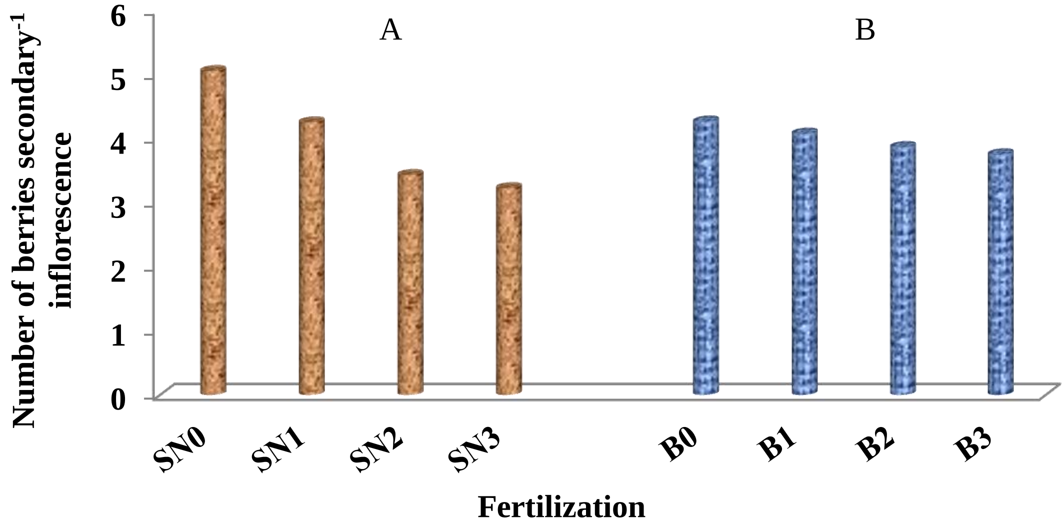


Figure 11: Effect of nitrogen splitting (A) and boron (B) on number of berries secondary^{-1} inflorescence in potato mother plant (LSD value 0.02 and 0.29 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.3.3 Combined effect of nitrogen splitting and boron

No significant combined effect of the split doses of N and B on number of berries secondary^{-1} inflorescence of potato was found in the experiment (Table 4 and Appendix XII).

Table 4: Combined effect of nitrogen splitting and boron on number of total berries plant^{-1}, number of berries primary^{-1} inflorescence and number of berries secondary^{-1} inflorescence in potato mother plant

Nitrogen Splitting × Boron	Number of total berries plant^{-1}	Number of berries primary^{-1} inflorescence	Number of berries secondary^{-1} inflorescence
SN_0B_0	22.32	16.25	5.21
SN_0B_1	19.68	14.19	5.19
SN_0B_2	19.18	13.80	5.04
SN_0B_3	18.16	13.09	4.74
SN_1B_0	17.95	12.94	4.63
SN_1B_1	16.12	11.10	4.24
SN_1B_2	15.86	11.04	4.10
SN_1B_3	15.36	11.05	3.99
SN_2B_0	14.20	10.21	3.69
SN_2B_1	14.07	10.11	3.65
SN_2B_2	13.50	9.74	3.20
SN_2B_3	13.08	9.44	3.16
SN_3B_0	12.84	9.25	3.49
SN_3B_1	13.04	9.39	3.20
SN_3B_2	12.16	8.78	3.10
SN_3B_3	12.56	9.05	3.10
CV (%)	10.30	9.22	8.73
LSD (0.05)	-	-	-
F test	NS	NS	NS

NS, not-significant

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.4 Period from setting to maturity of berries (days)

4.3.4.1 Effect of nitrogen splitting

Profound significant variation ($p \leq 0.01$) was noted in respects of period from setting to maturity of berries (days) on potato mother plant against split doses of N (Figure 12 and Appendix XIII). There was a gradual increasing trend for period from setting to maturity of berries (days) with the increasing of split application of N. The berries of potato mother plant got the longest time (days) for their maturation those are produced from SN_2 (53.27) followed by SN_3 (52.71) and the berries produced from SN_0 (48.83) got shortest time to mature. Simmonds (1963) reported that, at least 6 weeks is required for berry maturation in order to get good germination of TPS. Pallais (1987) indicated that berry ripening is highly dependent on environment, and varies from 4 to 11 weeks. These citations supported the present results.

4.3.4.2 Effect of boron

Remarkable significant variation ($p \leq 0.01$) was noted in respects of period from setting to maturity of berries (days) on potato mother plant against boron doses (Figure 12 and Appendix XIII). The application of boron showed that, the berries found from B_0 (50.37) to B_2 (50.77) got the shortest time for maturation, whereas the berries were found from B_3 (55.6) treatment got the longest time to mature.

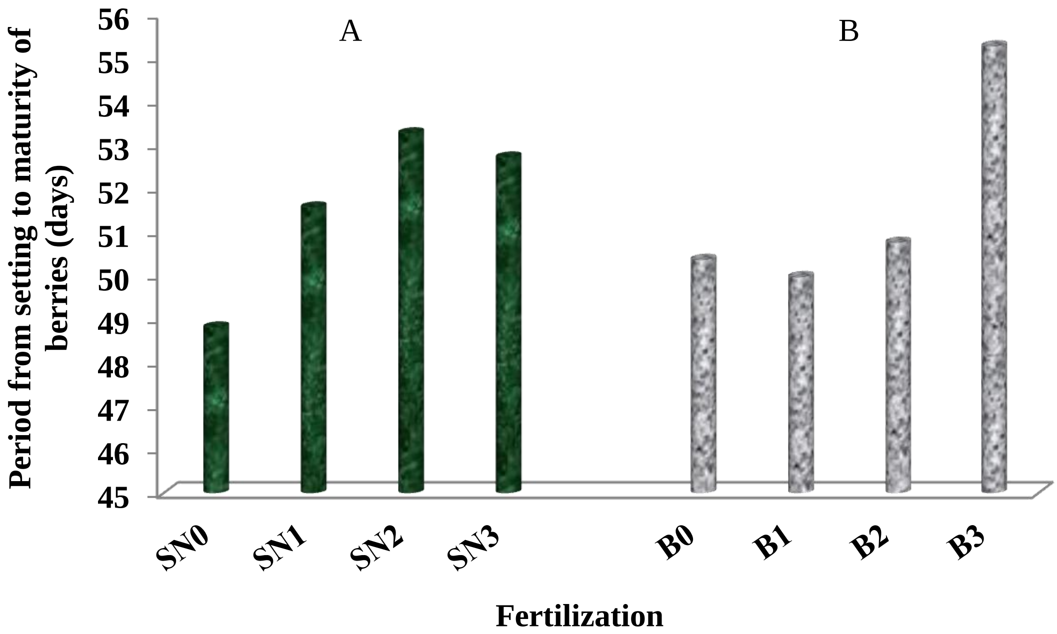


Figure 12: Effect of nitrogen splitting (A) and boron (B) on period from setting to maturity of berries (days) in potato mother plant (LSD value 0.19 and 3.07 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.4.3 Combined effect of nitrogen splitting and boron

Notable significant variation ($p \leq 0.05$) in was noted in respect of period from setting to maturity of berries (days) as to the combined effect of nitrogen splitting and boron application (Table 5 and Appendix XIII). The berries found from SN_3B_3 (60.72) got the longest time for maturation which was statistically similar to SN_2B_3 (57.18) and the shortest time was got by the berries were found from SN_0B_0 (45.86).

4.3.5 Period from 1st to last harvest of berries (days)

4.3.5.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of period from 1st to last harvest of berries (days) from potato mother plant against split doses of N (Figure 13 and Appendix XIII).

A gradual increasing trend was found for period from 1st to last harvest of berries (days) with the increasing of split application of N. The longest duration of berry harvesting was found from SN_2 (39.85) followed by SN_3 (35.03) and the shortest duration was found from SN_0 (31.93). Results of present study supported by Van Staden *et al*. (1982). They noticed, the export of cytokinins from the roots to the shoots enhanced by N application resulting in delayed senescence of the plants. Therefore, berry gets the longer duration for their maturation on potato mother plants and a better chance for high quality seed production.

4.3.5.2 Effect of boron

Profound significant variation ($p \leq 0.01$) was noted in respects of period from 1st to last harvest of berries (days) on potato mother plant against boron doses (Figure 13 and Appendix XIII). The application of boron showed that, the berries found from B_0 (34.24) to B_2 (34.25) was harvestable within short period of time from first harvest of berries; whereas, the berries were found from B_3 (39.09) was harvestable within long period of time.

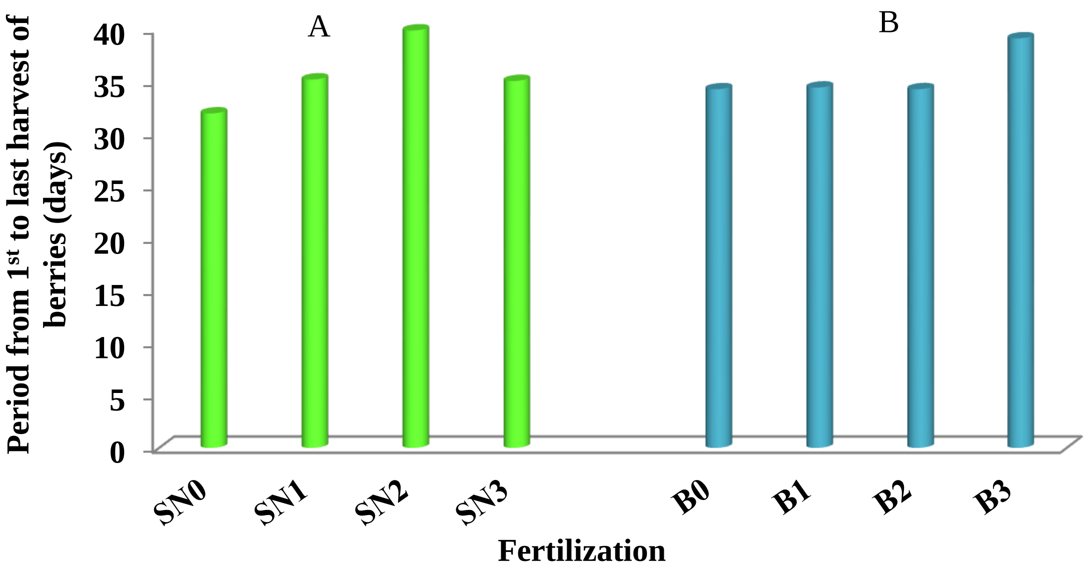


Figure 13: Effect of nitrogen splitting and boron on period from 1st to last harvest of berries (days) in potato mother plant (LSD value 0.26 and 3.04 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.5.3 Combined effect of nitrogen splitting and boron

Notable significant variation ($p \leq 0.05$) was noted in respect of period from 1st to last harvest of berries (days) as to the combined effect of nitrogen splitting and boron application (Table 5 and Appendix XIII). The berries found from SN_3B_3 (40.05) combination was harvestable within longest duration of time from potato mother plant which was statistically similar to SN_2B_3 (42.13) and SN_2B_2 (40.72) combinations. The shortest harvesting duration was found from SN_0B_0 (29.68).

Table 5: Combined effect of nitrogen splitting and boron on period from setting to maturity of berries (days) and period from 1st to last harvest of berries (days) in mother plant

Nitrogen Splitting × Boron	Period from setting to maturity of berries (days)	Period from 1st to last harvest of berries (days)
SN_0B_0	45.86 e	29.68 ef
SN_0B_1	49.03 de	32.12 d-f
SN_0B_2	49.64 de	32.88 d-f
SN_0B_3	50.77 c-e	33.04 c-f
SN_1B_0	51.07 c-e	34.24 c-e
SN_1B_1	51.22 cd	34.15 c-e
SN_1B_2	51.63 cd	35.13 cd
SN_1B_3	52.36 b-d	37.15 b-d
SN_2B_0	52.05 b-d	38.27 bc
SN_2B_1	48.59 de	38.26 bc
SN_2B_2	55.24 bc	40.72 ab
SN_2B_3	57.18 ab	42.13 ab
SN_3B_0	52.51 b-d	34.75 c-e
SN_3B_1	51.07 c-e	33.07 c-f
SN_3B_2	46.55 de	28.23 f
SN_3B_3	60.72 a	44.05 a
CV (%)	7.08	10.20
LSD (0.05)	5.33	5.28
F test	*	*

Means followed by different letters in the same column differ significantly according to LSD test

*, indicates F test significant at $P \leq 0.05$

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.6 Weight of 100-berries (g)

4.3.6.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of weight of 100-berries (g) of potato mother plant against split doses of N (Figure 14 and Appendix XIV). A gradual increasing trend was found for weight of 100-berries (g) with the increasing of split application of N. The highest weight of berries was found from SN_3 (1116.10 g) followed by SN_2 (1019.80 g) and the lowest weight of berries was found from SN_0 (626.50 g).

4.3.6.2 Effect of boron

Profound significant variation ($p \leq 0.05$) was noted in respects of weight of 100-berries (g) of potato mother plant against boron doses (Figure 14 and Appendix XIV). A gradual decreasing trend was seen with the increasing doses of boron. The application of boron showed that, the berries found from B_1 (958.86 g) had highest weight which was statistically similar to B_0 (932.58 g); whereas, the berries were found from B_3 (839.77 g) had lowest weight. Similar results reported by Bergmann (1984); Oyewole and Aduayi (1992). They told that, a positive relation present between B in plant and fruit weight as present results.

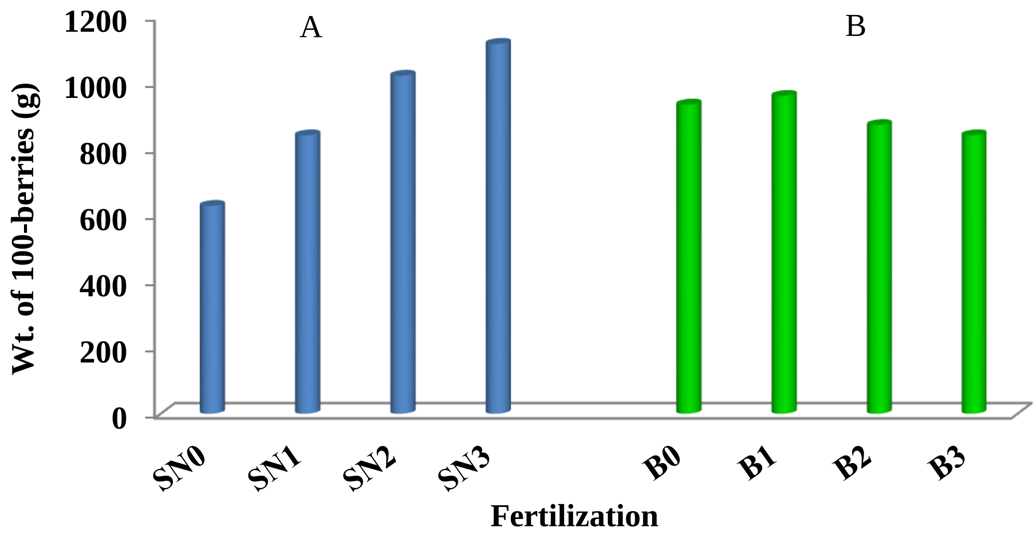


Figure 14: Effect of nitrogen splitting (A) and boron (B) on weight of 100-berries (g) of potato mother plant (LSD value 5.30 and 82.16 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.6.3 Combined effect of nitrogen splitting and boron

Notable significant variation ($p \leq 0.01$) was noted in respect of weight of 100-berries (g) as to the combined effect of nitrogen splitting and boron application (Table 6 and Appendix XIV). The berries found from SN_3B_1 (1337.60 g) combination had highest weight which was statistically similar to SN_3B_0 (1291.90 g); whereas, the lowest weight was found from SN_0B_0 (581.30 g).

4.3.7 Total yield of berries plant^{-1} (g)

4.3.7.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of total yield of berries plant^{-1} (g) of potato against split doses of N (Figure 15 and Appendix XIV). A gradual decreasing trend was found for total yield of berries plant^{-1} (g) with the increasing of split application of N from SN_1 (164.53 g) towards off ahead over conventional, SN_0 (137.92 g); whereas the lowest yield was found from SN_3 (136.54 g).

4.3.7.2 Effect of boron

No profound significant variation of the effect of boron doses in respects of total yield of berries plant^{-1} (g) was found in the experiment (Figure 15 and Appendix XIV).

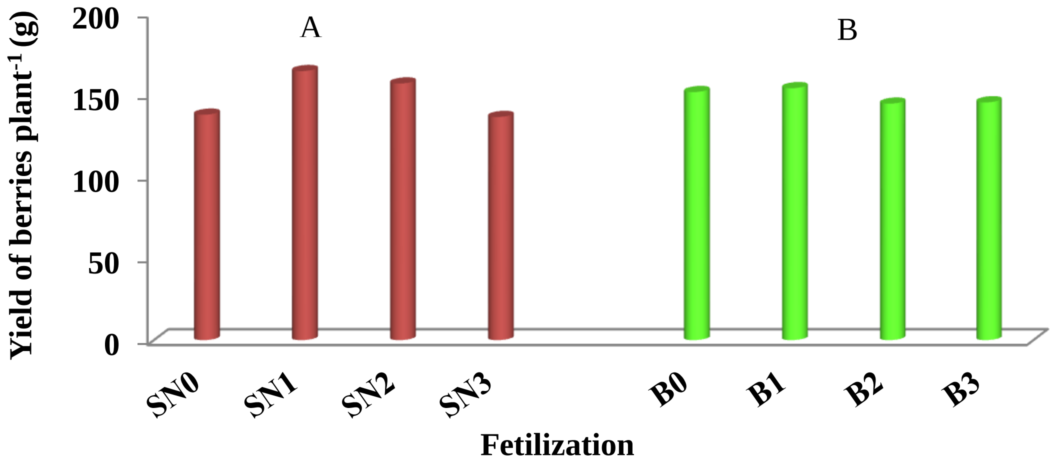


Figure 15: Effect of nitrogen splitting (A) and boron (B) on total yield of berries plant^{-1} (g) of potato (LSD value 0.43 and 11.99 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.7.3 Combined effect of nitrogen splitting and boron

Notable significant variation ($p \leq 0.01$) was noted in respect of total yield of berries plant^{-1} (g) as to the combined effect of nitrogen splitting and boron application (Table 6 and Appendix XIV). The highest yield of berries was found from SN_2B_0 (185.47 g) combination which was statistically similar to SN_2B_1 (180.80 g), SN_1B_3 (178.42 g) and SN_1B_2 (170.84 g); whereas, the lowest yield was found from SN_3B_3 (128.79 g).

4.3.8 Total yield of berries (t ha^{-1})

4.3.8.1 Effect of nitrogen splitting

Remarkable significant variation ($p \leq 0.01$) was noted in respects of total yield of berries (t ha^{-1}) from potato mother plant against SN (Figure 16 and Appendix XIV). A gradual decreasing trend was found for total yield of berries (t ha^{-1}) with the increasing of split application of nitrogen from SN_1 (13.16 t) towards off ahead over conventional, SN_0 (11.03 t); whereas the lowest yield was found from SN_3 (10.92 t). Similar finding was found from Hassan *et al*. (1993). They showed that, as N rates increased, plants exhibited poor early growth and produced lowest early and total fruit yields.

4.3.8.2 Effect of boron

No significant variation of the effect of boron doses in respects of total yield of berries (t ha^{-1}) was found in the experiment (Figure 16 and Appendix XIV).

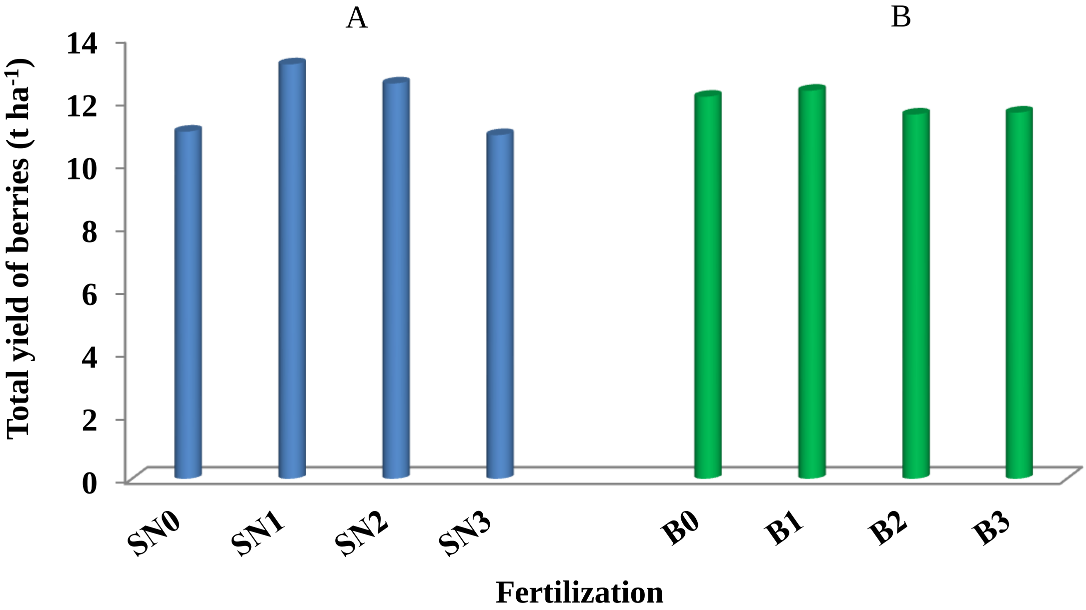


Figure 16: Effect of nitrogen splitting (A) and boron (B) on total yield of berries (t ha^{-1}) of potato (LSD value 0.02 and 0.75 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.3.8.3 Combined effect of nitrogen splitting and boron

Notable significant variation ($p \leq 0.01$) was noted in respect of total yield of berries (t ha^{-1}) as to the combined effect of nitrogen splitting and boron application (Table 6 and Appendix XIV). The highest yield of berries was found from SN_2B_0 (14.83 t) combination which was statistically similar to SN_2B_1 (14.47 t), SN_1B_3 (14.27 t) and SN_1B_2 (13.66 t); whereas, the lowest yield was found from SN_3B_3 (10.30 t) which was statistically more similar with SN_2B_2 (10.51 t), SN_0B_0 (10.43 t) and SN_2B_3 (10.40 t).

Table 6: Combined effect of nitrogen splitting and boron on weight of 100-berries (g), total yield of berries plant^{-1} (g) and total yield of berries (t ha^{-1}) in potato mother plant

Nitrogen Splitting × Boron	Wt. of 100-berries (g)	Total yield of berries plant^{-1} (g)	Total yield of berries (t ha^{-1})
SN_0B_0	581.3 h	130.45 ef	10.43 e
SN_0B_1	609.0 h	135.45 ef	10.83 de
SN_0B_2	650.8 gh	141.23 d-f	11.29 de
SN_0B_3	664.7 gh	144.56 d-f	11.56 c-e
SN_1B_0	705.1 gh	150.41 c-e	12.03 cd
SN_1B_1	788.3 fg	158.45 b-d	12.67 bc
SN_1B_2	905.4 ef	170.84 a-c	13.66 ab
SN_1B_3	959.5 de	178.42 ab	14.27 a
SN_2B_0	1152.0 bc	185.47 a	14.83 a
SN_2B_1	1100.5 cd	180.89 a	14.47 a
SN_2B_2	947.8 de	131.43 ef	10.51 e
SN_2B_3	879.1 ef	130.07 ef	10.40 e
SN_3B_0	1291.9 ab	140.58 d-f	11.24 de
SN_3B_1	1337.6 a	141.58 d-f	11.32 de
SN_3B_2	978.8 de	135.21 ef	10.81 de
SN_3B_3	855.8 ef	128.79 f	10.30 e
CV (%)	10.83	9.56	7.50
LSD (0.05)	142.42	20.78	1.30
F test	**	**	**

Means followed by different letters in the same column differ significantly according to LSD test

**, indicates F test significant at $P \leq 0.01$

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4 TPS characteristics

4.4.1 Number of TPS berry^{-1} at different berry sizes

4.4.1.1 Effect of nitrogen splitting

Profoundly significant ($p \leq 0.01$) variation was noted on different split application of N in respects of number of TPS berry^{-1} at different berry sizes (Figure 17 and Appendix XV). In case of TPS in small sized berry, the maximum number was found from SN_1 (71.49) and thereafter decreased the seed number per berry with the increasing rates of nitrogen splitting and the minimum number per berry was found from SN_3 (52.74).

In case of TPS in medium sized berry, there was a gradual increasing trend in the number of seed per berry with the increasing of split application of N up to SN_2 treatment. The maximum number of TPS per berry was found from SN_2 (226.25) followed by SN_3 (218.00) and the minimum from SN_0 (160.75). In case of TPS in large sized berry, there was a gradual increasing trend in the number of seed per berry with the increasing of split application of N up to SN_2 treatment. The maximum number of TPS per berry was found from SN_2 (280.25) followed by SN_3 (267.50) and the minimum from SN_0 (229.25).

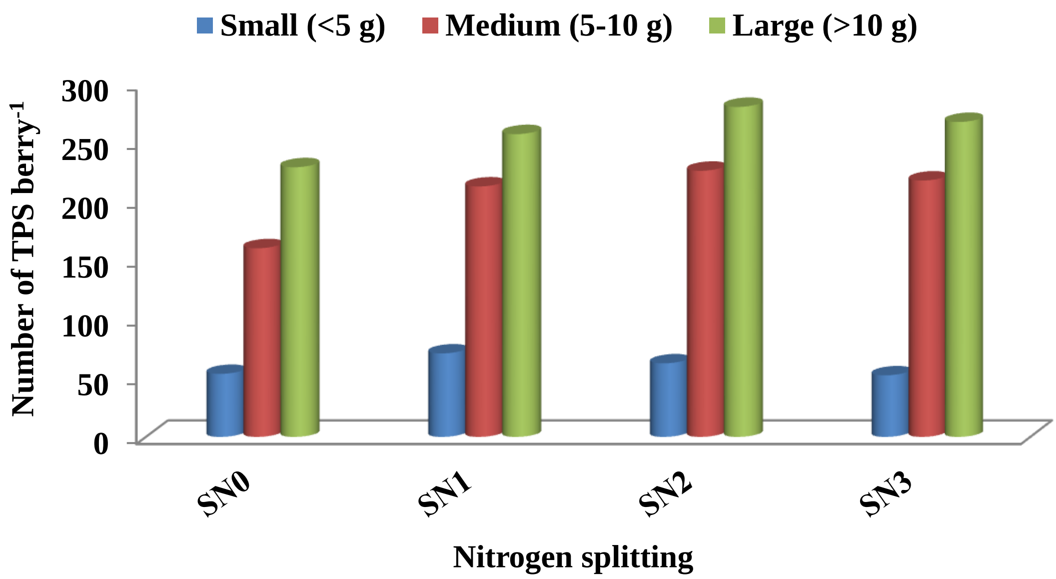


Figure 17: Effect of nitrogen splitting on number of TPS berry^{-1} at different berry sizes in potato mother plant (LSD value 0.35, 1.93 and 0.96 for TPS in small, medium and large sized berry, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

4.4.1.2 Effect of boron

In case of TPS in small sized berry, no significant effect of the boron on number of TPS berry^{-1} was found in the experiment (Figure 18 and Appendix XV). In case of TPS in medium sized berry, there was a significant ($p \leq 0.05$) variation was noted in gradual increasing trend of the number of seed per berry with the increasing of boron (Figure 18 and Appendix XV).

The maximum number of TPS per berry was found from B_3 (220.50) which was statistically similar to B_2 (207.50) and the minimum from B_0 (194.50). In case of TPS in large sized berry, there was a significant ($p \leq 0.01$) variation was noted in gradual increasing trend of the number of seed per berry with the increasing of boron (Figure 18 and Appendix XV). The maximum number of TPS per berry was found from B_3 (279.50) followed by B_2 (261.50) and the minimum from B_0 (245.50).

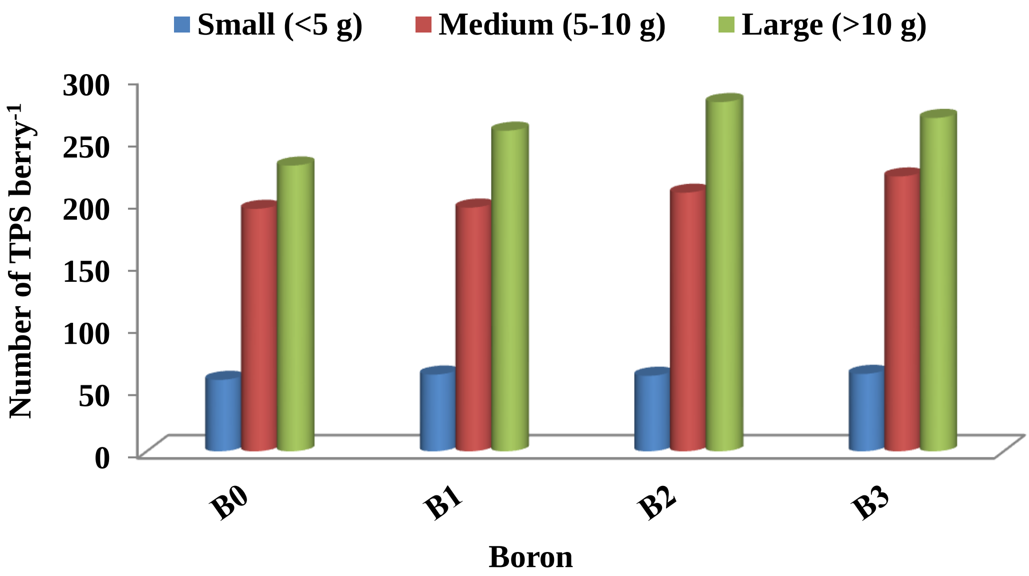


Figure 18: Effect of boron on number of TPS berry^{-1} at different berry sizes in potato mother plant (LSD value 4.63, 19.10 and 14.78 for TPS in small, medium and large sized berry, respectively)

Note: B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.1.3 Combined effect of nitrogen splitting and boron

Profoundly significant ($p \leq 0.01$ and $p \leq 0.05$) variation was noted on different combinations of split application of N and boron in respects of number of TPS berry^{-1} at different berry sizes (Table 7 and Appendix XV). In case of TPS in small sized berry, maximum number of TPS per berry was found from SN_1B_2 (77.99) which was statistically similar to SN_1B_3 (76.99), SN_2B_0 (72.99) and SN_1B_1 (68.99).

Minimum number was found from SN_3B_2 (50.00). In case of TPS in medium sized berry, maximum number of TPS per berry was found from SN_3B_3 (249.00) which was statistically similar to SN_1B_2 (243.00), SN_2B_3 (240.00), SN_2B_3 (238.00), SN_3B_1 (221.00) and SN_3B_0 (220.00). Minimum number was found SN_0B_0 (143.00). In case of TPS in large sized berry, maximum number of TPS per berry was found from SN_3B_3 (316.00) which was statistically similar to SN_2B_3 (297.00) and SN_2B_2 (295.00). Minimum number was found SN_0B_0 (213.00).

Table 7: Combined effect of nitrogen splitting and boron on number of TPS berry^{-1} at different berry sizes in potato mother plant

Nitrogen Splitting × Boron	Number of TPS berry^{-1} at different berry sizes		
	Small (<5 g)	Medium (5-10 g)	Large (>10 g)
SN_0B_0	40.00 h	143.00 i	213.00 g
SN_0B_1	53.99 d-g	155.00 hi	229.00 fg
SN_0B_2	58.99 d-f	167.00 g-i	235.00 e-g
SN_0B_3	62.99 cd	178.00 f-i	240.00 d-g
SN_1B_0	61.99 c-e	193.00 d-g	245.00 c-f
SN_1B_1	68.97 a-c	201.00 d-f	251.00 c-f
SN_1B_2	77.99 a	243.00 ab	268.00 c
SN_1B_3	76.99 a	215.00 b-e	265.00 cd
SN_2B_0	72.99 ab	222.00 a-d	270.00 bc
SN_2B_1	67.99 bc	205.00 c-f	259.00 c-e
SN_2B_2	55.00 d-g	238.00 a-c	295.00 ab
SN_2B_3	55.99 d-g	240.00 a-c	297.00 ab
SN_3B_0	53.99 e-g	220.00 a-e	254.00 c-f
SN_3B_1	55.00 d-g	221.00 a-d	252.00 c-f
SN_3B_2	50.00 g	182.00 e-h	248.00 c-f
SN_3B_3	51.99 fg	249.00 a	316.00 a
CV (%)	9.13	11.09	6.78
LSD (0.05)	8.04	33.14	25.61
F test	**	*	*

Means followed by different letters in the same column differ significantly according to LSD test

*, ** indicate F test significant at $P \leq 0.05$ and $P \leq 0.01$, respectively

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.2 Yield of TPS kg^{-1} berry (g)

4.4.2.1 Effect of nitrogen splitting

Profound significant ($p \leq 0.01$) variation was noted on nitrogen splitting in respects of yield of TPS kg^{-1} berry (g) in (Figure 19 and Appendix XVI). The yield was increased with the increasing of splitting of N up to SN_2 treatment and thereafter slightly decreased with increasing rate of split. The maximum TPS yield was found from SN_2 (23.49 g) followed by SN_3 (22.53 g) and the minimum from SN_0 (17.15 g).

4.4.2.2 Effect of boron

Profound significant ($p \leq 0.01$) variation was noted on boron doses in respects of yield of TPS kg^{-1} berry (g) in (Figure 19 and Appendix XVI).The yield was increased with the increasing of splitting of N. The maximum TPS yield was found from B_3 (24.07 g) followed by B_2 (20.49 g), B_1 (19.64 g) and the minimum from B_0 (18.87 g).

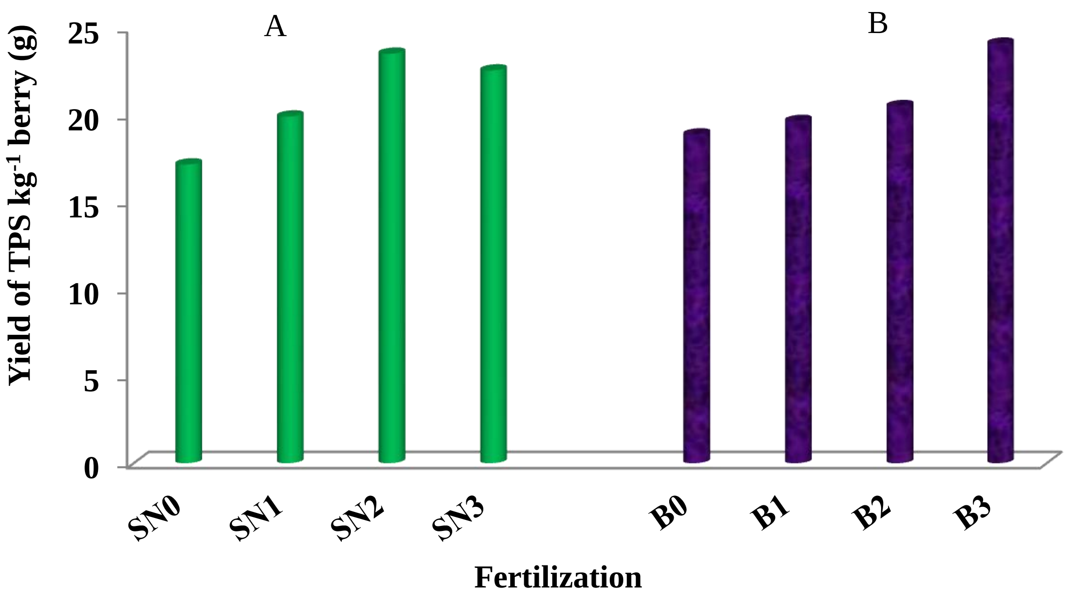


Figure 19: Effect of nitrogen splitting (A) and boron (B) on yield of TPS kg^{-1} berry (g) of potato mother plant (LSD value 0.15 and 1.68 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.2.3 Combined effect of nitrogen splitting and boron

Profoundly significant ($p \leq 0.01$) variation was noted on different combinations of split application of N and boron in respects of yield of TPS kg^{-1} berry (g) in (Table 8 and Appendix XVI). The maximum yield of TPS was found from SN_3B_3 (29.09 g) combination which was statistically similar to SN_2B_3 (27.86) combination and the minimum number was found SN_0B_0 (14.81).

4.4.3 Total yield of TPS plant^{-1} (mg)

4.4.3.1 Effect of nitrogen splitting

Profound significant ($p \leq 0.01$) variation was noted in respect of total yield of TPS $plant^{-1}$ (mg) as to the effect of split application of N (Figure 20 and Appendix XVI). A gradual decreasing trend was seen with the increasing split doses of N from SN_1 towards ahead of splitting. The maximum TPS yield was found from SN_1 (1838.6 mg) followed by SN_2 (1594.9 mg) and the minimum from SN_0 (1340.0 mg).

4.4.3.2 Effect of boron

Remarkable significant ($p \leq 0.05$) variation was noted in respect of total yield of TPS $plant^{-1}$ (mg) as to the effect of boron application (Figure 20 and Appendix XVI). A gradual increasing trend was seen with the increasing boron doses. The maximum TPS yield was found from B_3 (1648.3 mg) which was statistically similar to B_2 (1549.4 mg), B_1 (1524.6 mg) and the minimum from B_0 (1456.6 mg).

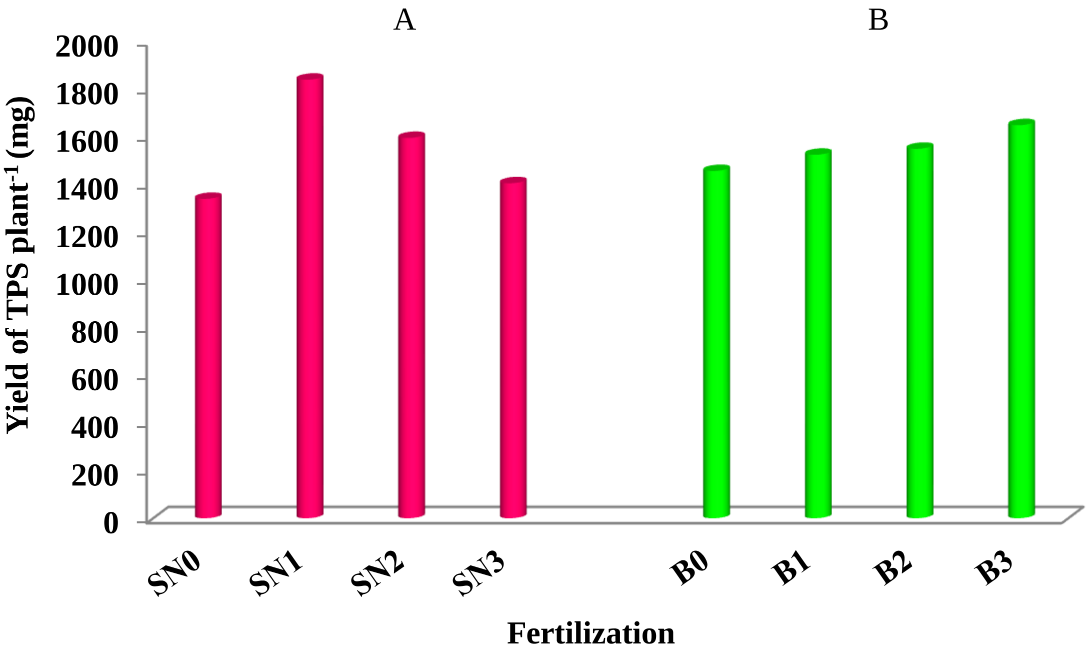


Figure 20: Effect of nitrogen splitting (A) and boron (B) on total yield of TPS plant^{-1} (mg) of potato mother plant (LSD value 10.13 and 129.31 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.3.3 Combined effect of nitrogen splitting and boron

Profoundly significant ($p \leq 0.01$) variation was noted on different combinations of split application of N and boron in respects of total yield of TPS plant^{-1} (mg) in (Table 8 and Appendix XVI). The maximum yield of TPS was found from SN_1B_3 (2160.1 mg) and the minimum yield was found from SN_0B_0 (1001.8 mg).

4.4.4 Total yield of TPS (kg ha^{-1})

4.4.4.1 Effect of nitrogen splitting

Profound significant ($p \leq 0.01$) variation was noted in respect of total yield of TPS (kg ha^{-1}) as to the effect of split application of N (Figure 21 and Appendix XVI).

A gradual decreasing trend was seen with the increasing split doses of N. The maximum TPS yield (kg ha^{-1}) was found from SN_1 (147.09 kg) followed by SN_2 (127.59 kg) and the minimum from SN_0 (107.20 kg). Raj (2013) reported that, application of nitrogen (150 kg ha^{-1}) when applied with 3-way or 4-way splitting produced the highest grain yields of canola. The report was correlated to present results.

4.4.4.2 Effect of boron

Remarkable significant ($p \leq 0.05$) variation was noted in respect of total yield of TPS (kg ha^{-1}) as to the effect of boron (Figure 21 and Appendix XVI). A gradual increasing trend was seen with the increasing boron levels. The maximum TPS yield was found from B_3 (131.87 kg) which was statistically similar to B_2 (123.95 kg), B_1 (121.97 kg) and the minimum from B_0 (116.53 kg). Dordas (2006) reported that, boron requirement is highest for seed than for forage production in alfalfa plants, which correlated to results of present study.

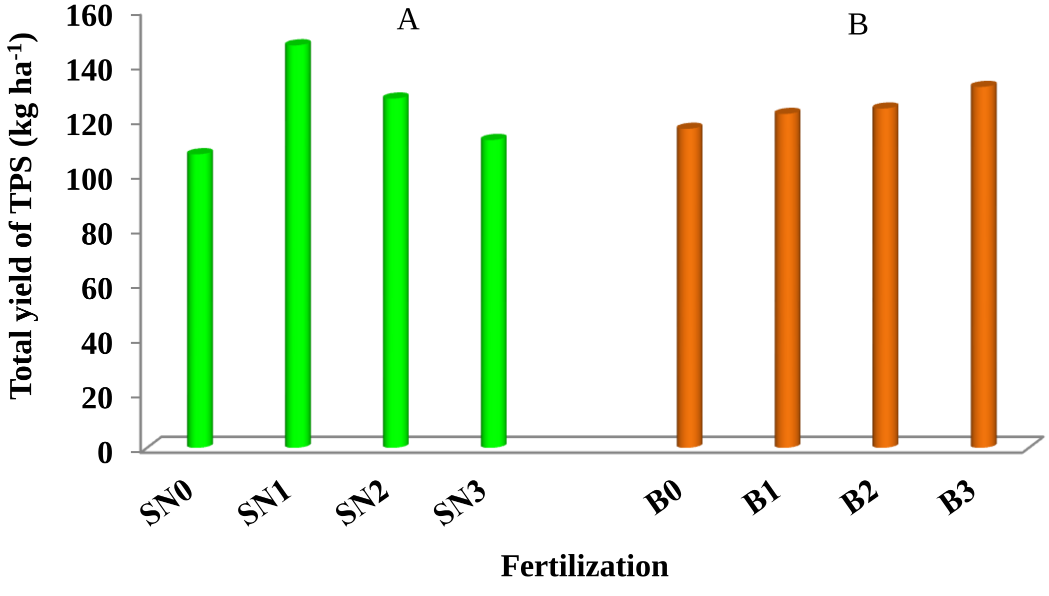


Figure 21: Effect of nitrogen splitting (A) and boron (B) on total yield of TPS (kg ha^{-1}) of potato mother plant (LSD value 0.81 and 10.34 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.4.3 Combined effect of nitrogen splitting and boron

Profoundly significant ($p \leq 0.01$) variation was noted on different combinations of split application of N and boron in respects of total yield of TPS (kg ha^{-1}) in (Table 8 and Appendix XVI). The maximum yield of TPS was found from SN_1B_3 (172.81 kg) and the minimum yield was found from SN_0B_0 (80.14 kg).

Table 8: Combined effect of nitrogen splitting and boron on yield of TPS kg^{-1} berry (g), total yield of TPS $plant^{-1}$ (mg) and total yield of TPS (kg ha^{-1}) in potato mother plant

Nitrogen Splitting × Boron	Yield of TPS kg^{-1} berry (g)	Total yield of TPS $plant^{-1}$ (mg)	Total yield of TPS (kg ha^{-1})
SN_0B_0	14.81 f	1001.80 g	80.14 g
SN_0B_1	17.08 ef	1324.30 f	105.94 f
SN_0B_2	18.16 d-f	1473.70 d-f	117.90 d-f
SN_0B_3	18.56 c-e	1560.20 c-f	124.82 c-f
SN_1B_0	19.03 c-e	1630.20 b-e	130.42 b-e
SN_1B_1	19.77 c-e	1680.20 b-d	134.42 b-d
SN_1B_2	20.01 cd	1883.80 b	150.70 b
SN_1B_3	20.77 cd	2160.10 a	172.81 a
SN_2B_0	21.08 bc	1733.50 bc	138.68 bc
SN_2B_1	20.88 b-d	1660.90 b-d	132.87 b-d
SN_2B_2	24.14 b	1501.50 c-f	120.12 c-f
SN_2B_3	27.86 a	1483.80 c-f	118.70 c-f
SN_3B_0	20.56 cd	1460.80 d-f	116.87 d-f
SN_3B_1	20.84 cd	1433.20 ef	114.66 ef
SN_3B_2	19.65 c-e	1338.50 f	107.08 f
SN_3B_3	29.08 a	1389.10 f	111.13 f
CV (%)	9.61	9.93	9.93
LSD (0.05)	2.91	224.19	17.93
F test	**	**	**

Means followed by different letters in the same column differ significantly according to LSD test

**, indicates F test significant at $P \leq 0.01$

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.5 Weight of 100-TPS (mg)

4.4.5.1 Effect of nitrogen splitting

Pronounced significant ($p \leq 0.01$) variation was noted in respect of weight of 100-TPS (mg) of potato mother plant as to the effect of splitting of N (Figure 22 and Appendix XVI). A gradual increasing trend was seen with the increasing split doses of N up to SN_3. The maximum TPS weight was found from SN_3 (80.38 mg) followed by SN_2 (79.26 mg) and the minimum from SN_0 (68.45 mg). Singh *et al*. (1990) indicated that seeds bigger than 75 mg 100-TPS showed good quality for raising seedling tuber production from TPS. So, nitrogen should be applied at SN_2 and SN_3 which partially supported the present findings.

4.4.5.2 Effect of boron

Profound significant ($p \leq 0.01$) variation was noted on boron doses in respects of weight of 100-TPS (mg) in (Figure 22 and Appendix XVI).The weight was increased with the increasing of boron application. The maximum TPS weight was found from B_3 (80.72 mg) which was statistically similar to B_2 (77.16 mg) and the minimum from B_0 (70.98 mg).

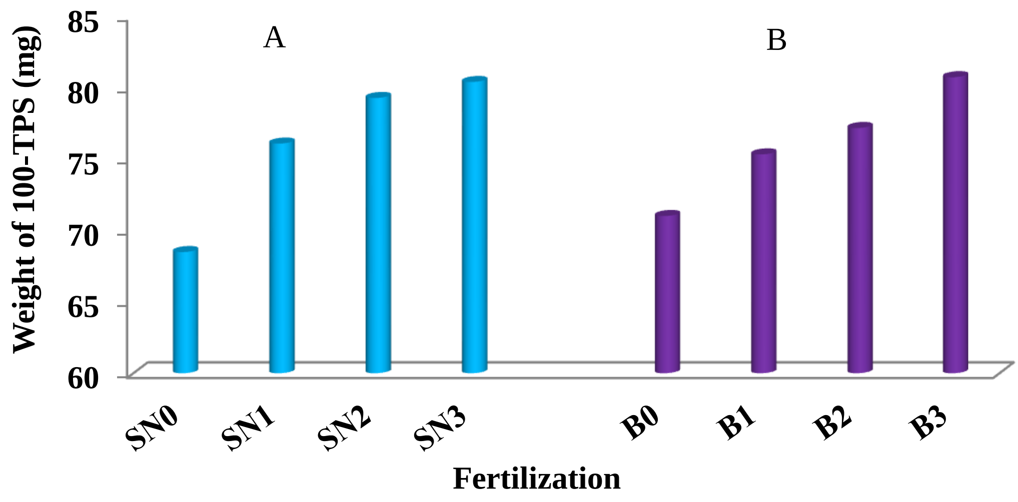


Figure 22: Effect of nitrogen splitting (A) and boron (B) on weight of 100-TPS (mg) of potato mother plant (LSD value 0.31 and 5.01 for SN and B, respectively)

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose
B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.4.5.3 Combined effect of nitrogen splitting and boron

Profoundly significant ($p \leq 0.05$) variation was noted on different combinations of split application of N and boron in respects of weight of 100-TPS (mg) of potato mother plant was found in the experiment (Table 9 and Appendix XVI). The maximum weight of 100-TPS was found from SN_3B_3 (86.87 mg) which was statistically similar to SN_2B_3 (84.24 mg), SN_2B_2 (82.04 mg), SN_3B_1 (79.94 mg) and SN_3B_0 (78.16 mg); whereas, the minimum number was found SN_0B_0 (53.36 mg).

Table 9: Combined effect of nitrogen splitting and boron on weight of 100-TPS (mg) of potato mother plant

Nitrogen Splitting × Boron	Wt. of 100- TPS (mg)
SN_0B_0	53.36 e
SN_0B_1	71.66 d
SN_0B_2	74.04 cd
SN_0B_3	74.75 cd
SN_1B_0	75.18 cd
SN_1B_1	76.07 b-d
SN_1B_2	75.98 b-d
SN_1B_3	77.01 b-d
SN_2B_0	77.22 b-d
SN_2B_1	73.54 cd
SN_2B_2	82.04 a-c
SN_2B_3	84.24 ab
SN_3B_0	78.16 a-d
SN_3B_1	79.94 a-d
SN_3B_2	76.56 b-d
SN_3B_3	86.87 a
CV (%)	7.82
LSD (0.05)	8.68
F test	*

Means followed by different letters in the same column differ significantly according to LSD test

*, indicates F test significant at $P \leq 0.05$

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.5 Quality characteristics of TPS

4.5.1 Seed protein content (%)

4.5.1.1 Effect of nitrogen splitting

Profound significant ($p \leq 0.01$) variation was observed in respect of the seed protein content of TPS as to the effect of nitrogen splitting (Figure 23 and Appendix XVII). Gradual increasing trend was found with the increasing of split application of nitrogen. The highest seed protein content was found from SN_3 (9.52 %) which was statistically similar to SN_2 (9.49 %) and the lowest from SN_0 (6.46 %). The highest plants require larger amount of nitrogen than is any of the mineral nutrients and the absence of an external supply of nitrogen reduced plant growth, root and stem growth also directly reduce photosynthesis, protein synthesis and respiration (Strafford, 1973). Asare and Scarisbrick (1995), noticed that protein content increased with the increase of N fertilizer rate. Narits (2011) said that, the highest protein content was obtained from the variant of three times split-N.

4.5.1.2 Effect of boron

Remarkable significant ($p \leq 0.01$) variation was observed in respect of the seed protein content of TPS as to the effect of boron doses (Figure 23 and Appendix XVII). A gradual increasing trend was seen with the increasing of boron doses. The highest seed protein was found from B_3 (9.36 %) followed by B_2 (8.61 %) and the lowest from B_0 (7.73 %). The absence of optimum amount of boron in soil may reduce the seed quality. Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and turns into decrease protein content of following seeds (Stanley *et al.*, 1995).

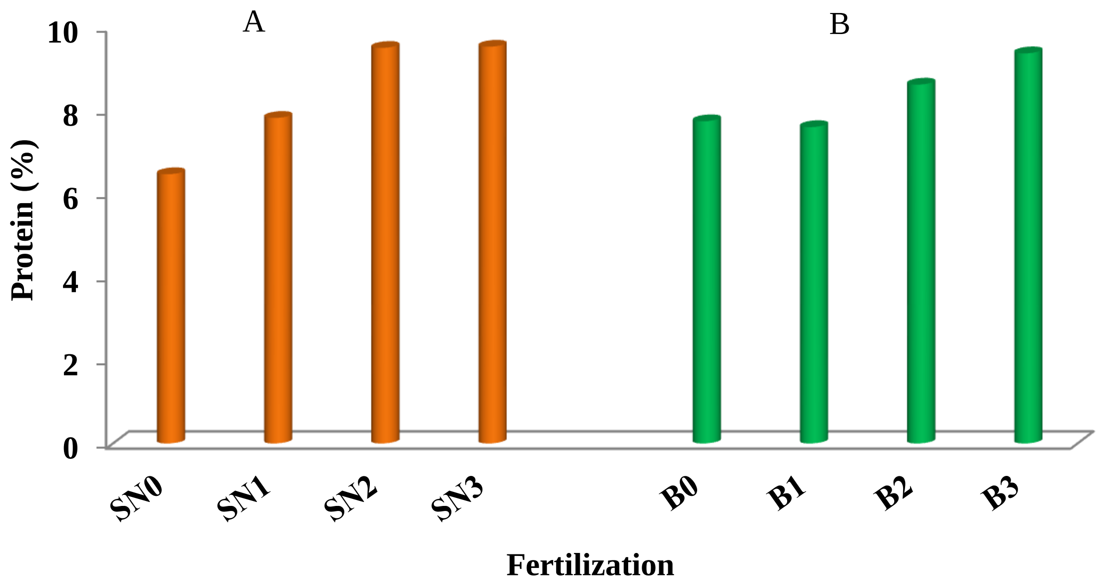


Figure 23: Effect of nitrogen splitting (A) and boron (B) on protein (%) of TPS

(LSD value 0.02 and 0.71 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.5.1.3 Combined effect of nitrogen splitting and boron

Pronounced and significant variation ($p \leq 0.05$) was noted in respect of the protein content of TPS as to the combined effect of split application of N and boron (Table 10 and Appendix XVII). The better combination was SN_3B_3 (11.01 %) in respects of seed protein content which was statistically similar to SN_2B_3 (10.77 %), SN_2B_2 (10.52 %) and SN_3B_0 (9.80 %). Minimum protein of TPS was found from SN_0B_0 (5.21 %).

4.5.2 Seed lipid content (%)

4.5.2.1 Effect of nitrogen splitting

Remarkable significant ($p \leq 0.01$) variation was observed in respect of the seed lipid content of TPS as to the effects of split application of nitrogen (Figure 24 and Appendix XVII). The lipid content was increased with the increasing of nitrogen splitting. But slightly decreased from SN_2 (19.82 %) to SN_3 (18.66 %) and the lowest was found from SN_0 (16.38 %).

Khalil *et al.* (2001), reported that application of nitrogen fertilizer on *Nigella sativa* increased total lipid content of the seed. The citation was correlated to the findings of present study.

4.5.2.2 Effect of boron

The application of boron as different doses had pronounced significant ($p \le 0.01$) effect as to the lipid content of the TPS (Figure 24 and Appendix XVII). Results revealed that, the seed lipid content was not varied with the increasing of boron but statistically similar from B_0 (17.40 %) to B_2 (17.87 %). But a mysterious increase was found in B_3 (19.73 %).

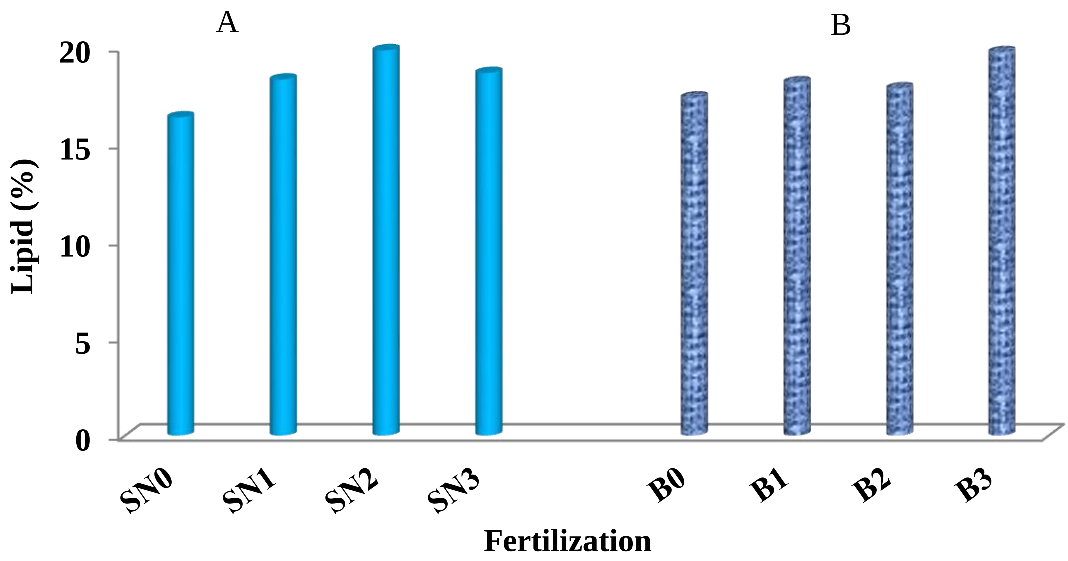


Figure 24: Effect of nitrogen splitting (A) and boron (B) on lipid (%) of TPS

(LSD value 0.21 and 1.23 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.5.2.3 Combined effect of nitrogen splitting and boron

Pronounced and significant variation ($p \le 0.05$) was noted in respect of the lipid content of TPS as to the combined effects of split application of N and boron (Table 10 and Appendix XVII). The better combination was SN_3B_3 (21.95 %) in respects of seed lipid content which was statistically similar with SN_2B_3 (20.90 %) and SN_2B_2 (20.71 %). The minimum lipid of TPS was found from SN_0B_0 (14.67 %).

4.5.3 Germination (%) of TPS

4.5.3.1 Effect of nitrogen splitting

Remarkable significant ($p \leq 0.01$) variation was observed in respect of the percent of germination of TPS against splitting of N (Figure 25 and Appendix XVII). The germination percentage was increased with the increasing of nitrogen splitting. But slightly decreased from SN_2 (92.57 %) to SN_3 (87.69 %) and the lowest was found from SN_0 (84.00 %). The highest 100-TPS weight means it retain highest amount of protein (%) thus it germinate faster (Bhatt, 1989). Present results supported by above citation due to increasing of SN.

4.5.3.2 Effect of boron

Profound significant ($p \leq 0.05$) variation was observed in respect of the germination of TPS as to the effect of boron application (Figure 25 and Appendix XVII). Results revealed that, the germination percent was not varied with increasing boron but statistically similar from B_0 (84.50 %) to B_2 (84.48 %). But a mysterious increase was found in B_3 (91.14 %).

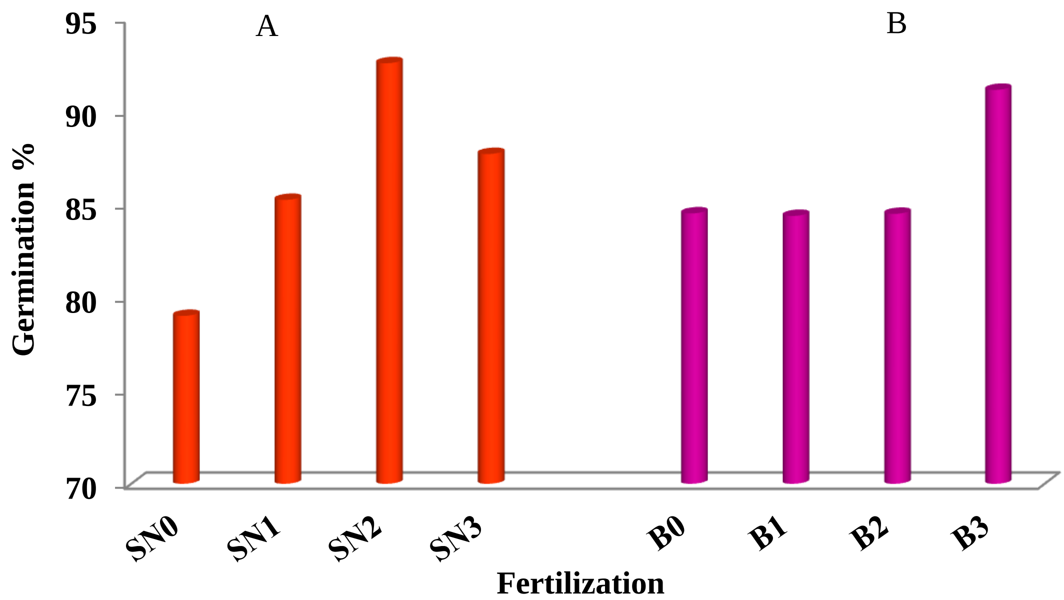


Figure 25: Effect of nitrogen splitting (A) and boron (B) on germination (%) of TPS (LSD value 1.34 and 5.27 for SN and B, respectively**)**

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.5.3.3 Combined effect of nitrogen splitting and boron

Pronounced and significant variation ($p \leq 0.05$) was noted in respect of the germination percent of TPS as to the combined effect of split application of N and boron (Table 10 and Appendix XVII). The SN_3B_3 (98.11 %) combination performed better in respects of germination percent of TPS, which was statistically similar to SN_2B_3 (96.82 %), SN_2B_2 (96.04 %), SN_3B_0 (91.30 %) and SN_2B_0 (89.27 %). The worst percent of germination was found from SN_0B_0 (74.55 %).

Table 10: Combined effect of nitrogen splitting and boron on seed protein content (%), seed lipid content (%) and germination (%) of TPS in potato mother plant

Nitrogen Splitting × Boron	Seed protein content (%)	Seed lipid content (%)	Germination (%) of TPS
SN_0B_0	5.21 g	14.67 e	74.55 g
SN_0B_1	6.07 fg	17.00 c-e	78.32 fg
SN_0B_2	7.08 ef	16.28 de	81.05 e-g
SN_0B_3	7.47 d-f	17.57 cd	82.06 e-g
SN_1B_0	7.80 c-e	18.01 cd	82.88 d-g
SN_1B_1	7.20 ef	18.27 cd	84.54 d-f
SN_1B_2	8.06 c-e	18.52 c	85.93 d-f
SN_1B_3	8.18 c-e	18.48 c	87.55 c-f
SN_2B_0	8.10 c-e	18.60 bc	89.27 a-e
SN_2B_1	8.58 b-d	19.06 bc	88.14 b-e
SN_2B_2	10.52 a	20.71 ab	96.04 a-c
SN_2B_3	10.77 a	20.90 ab	96.82 ab
SN_3B_0	9.80 ab	18.33 cd	91.30 a-d
SN_3B_1	8.50 b-d	18.37 cd	86.47 d-f
SN_3B_2	8.77 bc	15.98 de	74.89 g
SN_3B_3	11.01 a	21.95 a	98.11 a
CV (%)	10.19	8.04	7.27
LSD (0.05)	1.23	2.15	9.23
F test	*	*	*

Means followed by different letters in the same column differ significantly according to LSD test

*, indicates F test significant at $P \leq 0.05$

Note: SN_0= 2 split dose (conventional), SN_1= 3 split dose, SN_2= 4 split dose, SN_3= 5 split dose

B_0= 0 kg B ha^{-1}, B_1= 4 kg B ha^{-1}, B_2= 6 kg B ha^{-1}, B_3= 8 kg B ha^{-1}

4.6. Correlation co-efficient (r)

A strong linear relation (r=0.91 and r=0.90) presents between the leaf chlorophyll content at different stages of growth of potato mother plant and protein content-Figure 26 (a) & 26 (b). These results are understandable, because nitrogen is a structural element of chlorophyll and protein molecules, and thereby affects formation of chloroplasts and accumulation of chlorophyll in them (Tucker, 2004; Daughtry *et al*., 2000). In figure 26 (c), a negative linear relation (r=-0.88) between inflorescence plant^{-1} and number of berries plant^{-1} was present. Under present study, number of berries have not increased with the increasing the fertilization. In figure 26 (d), there was present a relation between weight of 100-berries (g) and yield of berries (t ha^{-1}) but not strong (r=0.32). In figure 26 (e), a strong linear relation (r=0.83) was present between number of TPS berry^{-1} of larger size and 100-TPS weight (mg). Results also reported by Aparna *et al.* (2014) and Almekinders *et al.* (1995), said that, the relationships between 100-TPS weight and number of TPS per beery was possitive. In figure 26 (f), a strong linear relation (r=0.88) was present between number of TPS berry^{-1} of larger size and total yield of TPS (kg ha^{-1}). There was a positive relation (r=0.78) of 100-TPS weight (mg) with germination percentage-Figure 26 (g). This result supported by Borji *et al.* (2007). A strong linear relation (r=0.84) was present between protein (%) and lipid (%) of TPS-Figure 26 (h). Results also supported by, Maralee *et al.* (1991). In figure 26 (i), a strong linear relation (r=0.85) between protein (%) and germination (%) of TPS. Bhatt *et al*. (1989) reported that, high germination percent often correlate with high protein content of seeds. Finding also supported by Morad (2013), carbonylation of storage proteins has positively been reported in dry mature Arabidopsis seeds, and it was suggested that carbonylation of these proteins facilitates their mobilization during germination. Also, in sunflower seeds, breaking of dormancy in the dry state may be associated with preparation for storage protein mobilization. In figure - 26 (j), a strong linear relation (r=0.95) between lipid (%) and germination (%) of TPS.

Result also supported by Antoine *et al.* (2011), the earliness of germination was positively correlated with seed lipid content.

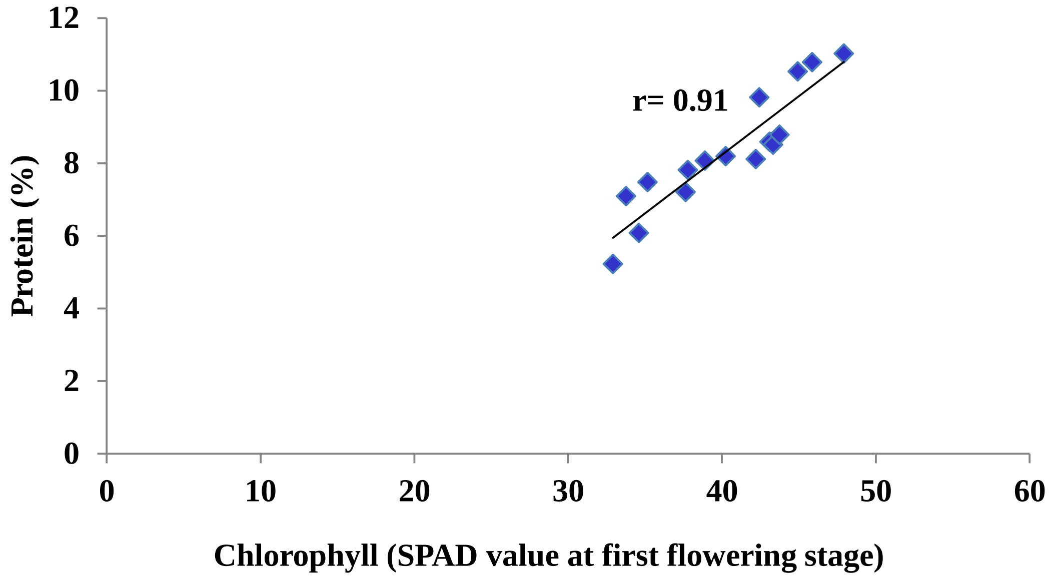


Figure 26 (a): Relation between chlorophyll content at first flowering stage and seed protein (%)

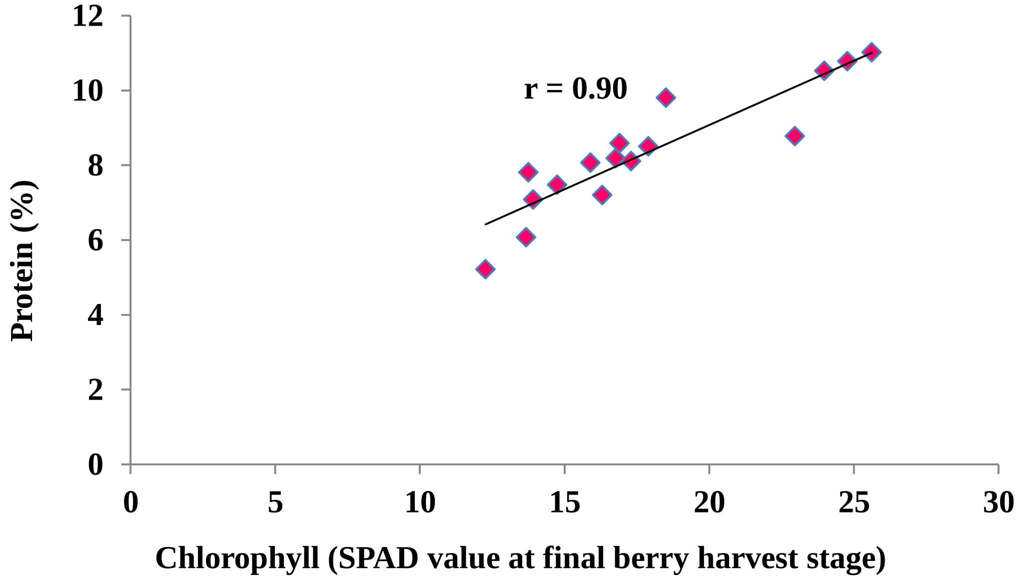


Figure 26 (b): Relation between chlorophyll content at final berry harvest stage and seed protein (%)

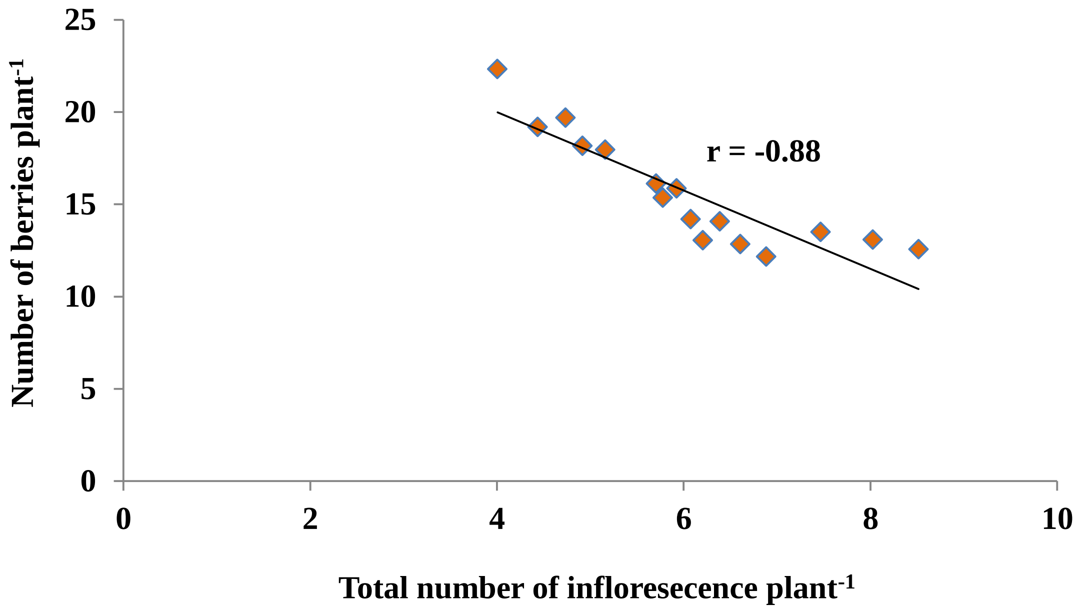


Figure 26 (c): Relation between inflorescence plant^{-1} and number of berries plant^{-1}

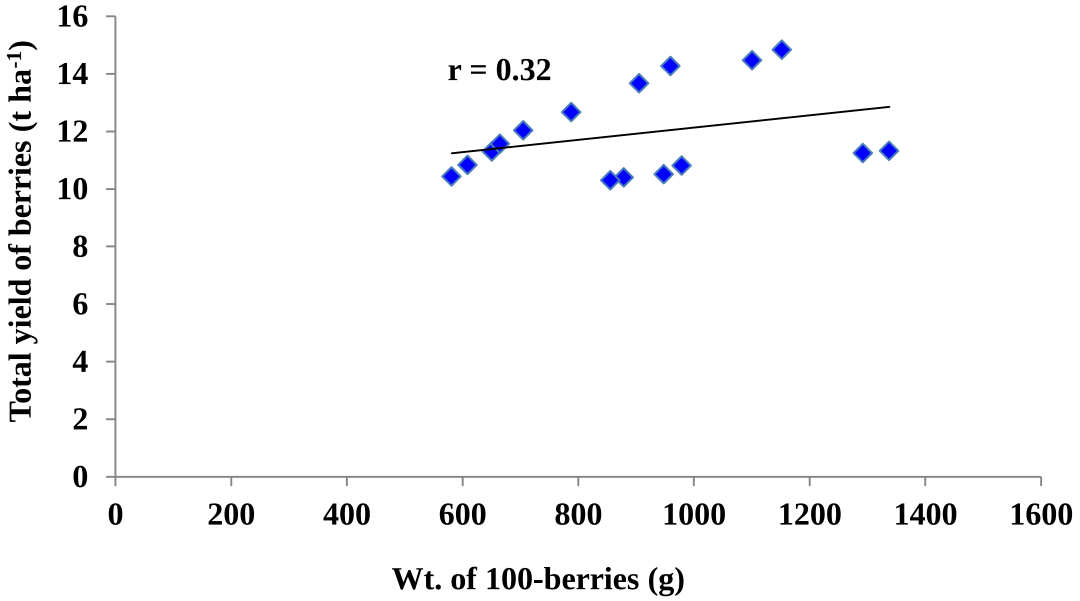


Figure 26 (d): Relation between weight of 100-berries (g) and total yield of berries (t ha^{-1})

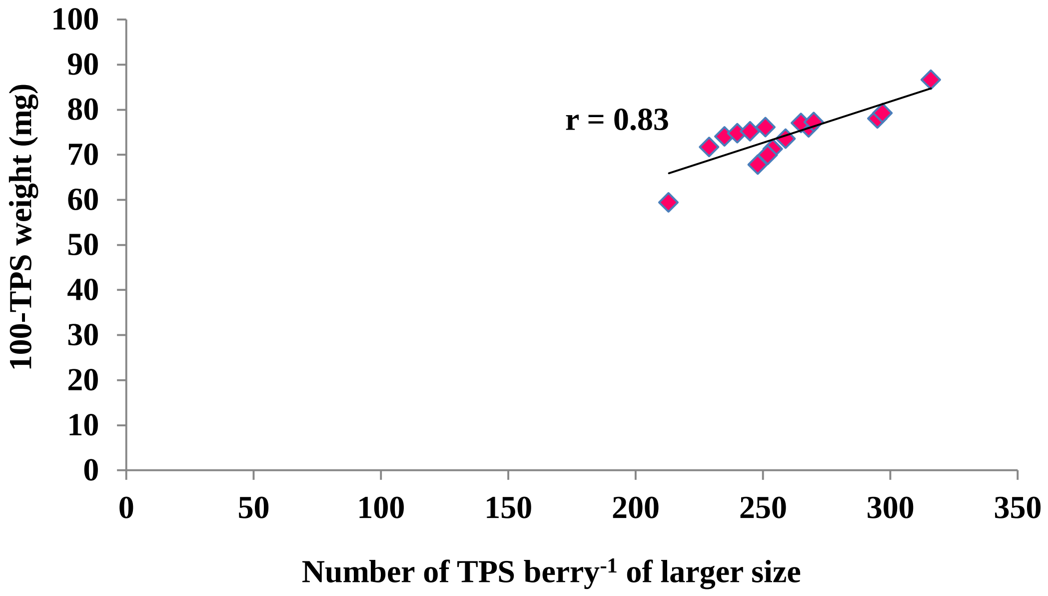


Figure 26 (e): Relation between number of TPS berry^{-1} of larger size and 100-TPS weight (mg)

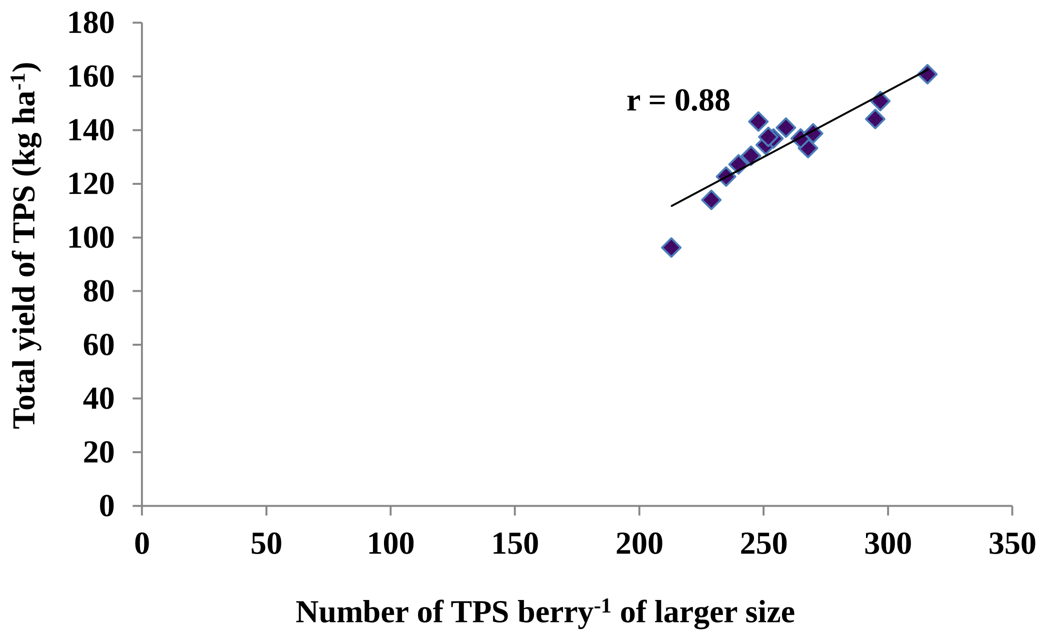


Figure 26 (f): Relation between number of TPS berry^{-1} of larger size and total yield of TPS (kg ha^{-1})

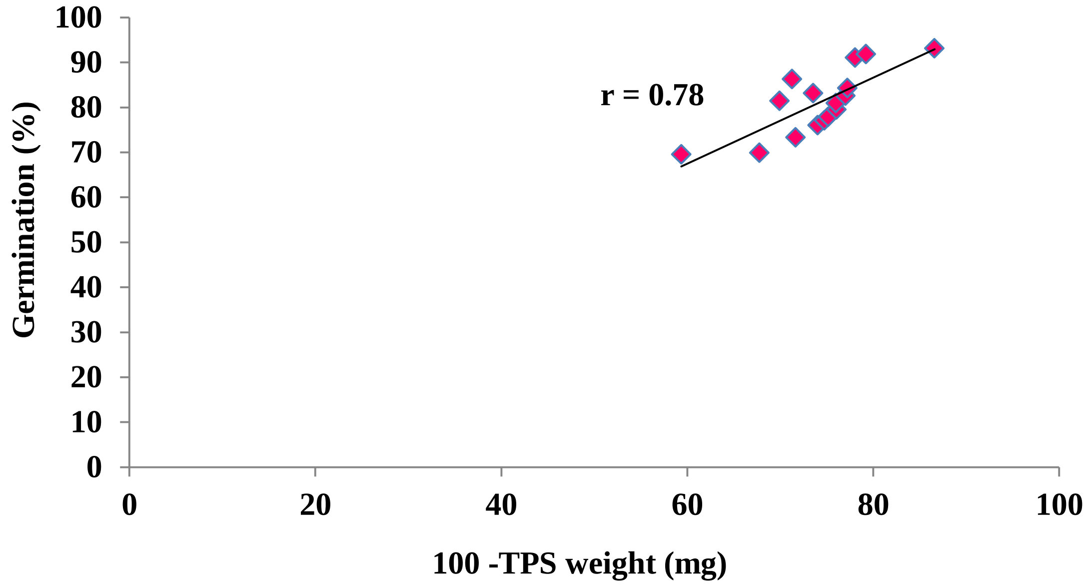


Figure 26 (g): Relation between 100-TPS weight (mg) and germination of TPS (%)

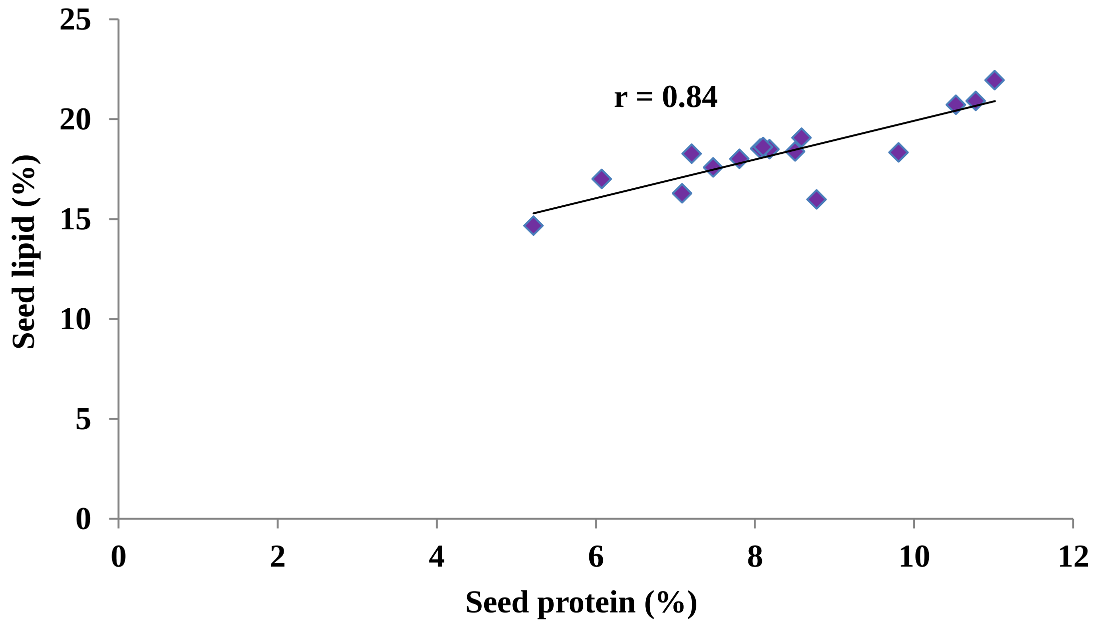


Figure 26 (h): Relation between protein (%) and lipid (%) of TPS

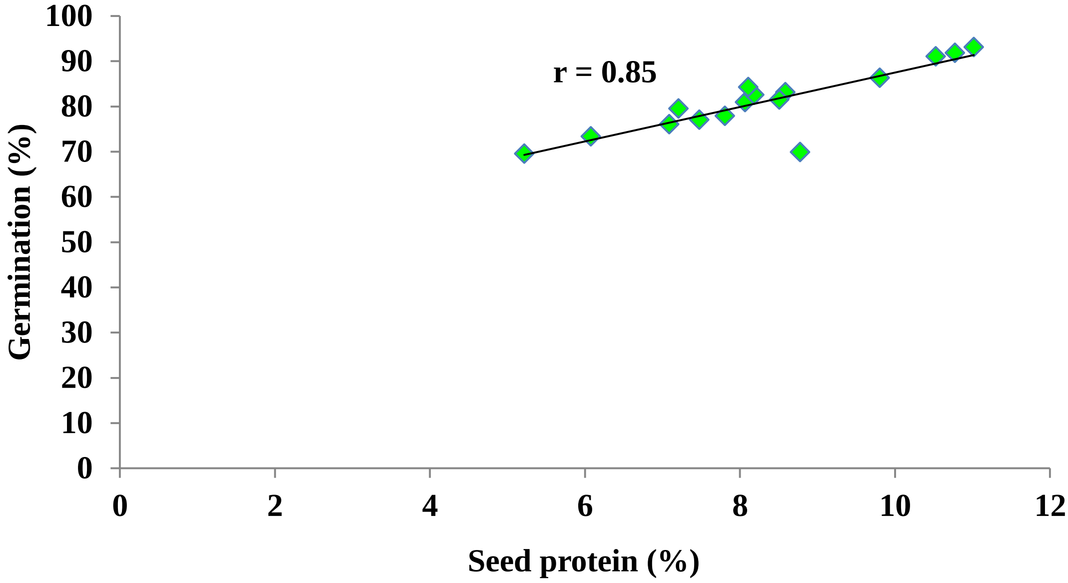


Figure 26 (i): Relation between protein (%) and germination (%) of TPS

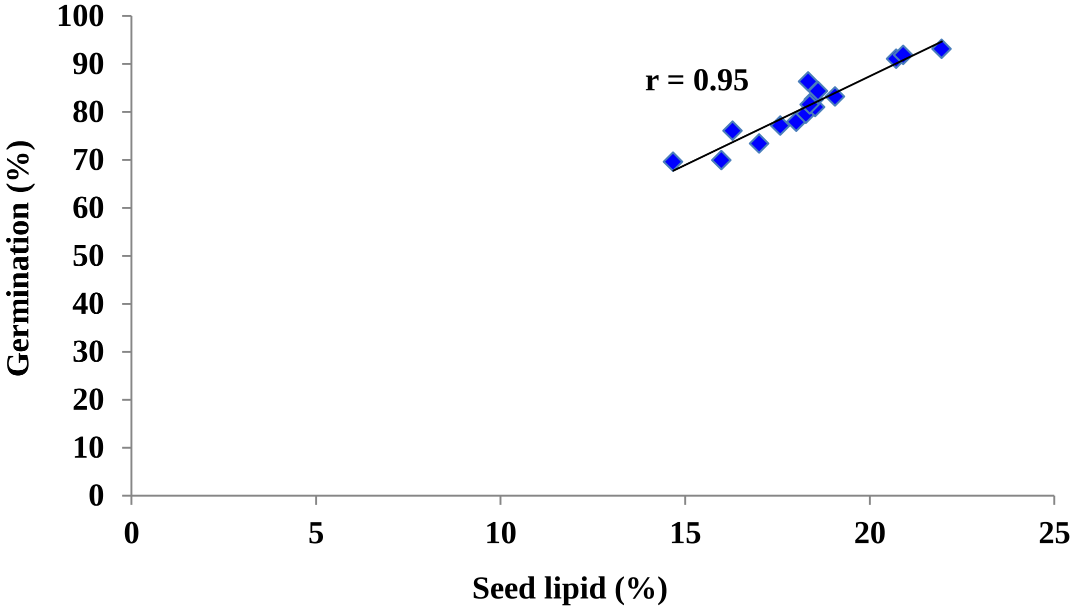


Figure 26 (j): Relation between lipid (%) and germination (%) of TPS

Figure 26 (a-j): Relation between different growths, yield components, yield and quality of hybrid TPS of potato mother plant

CHAPTER 5

SUMMARY AND CONCLUSION

From the perspectives of quality hybrid TPS production under prevailing climatic conditions of Bangladesh, the present experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2013 to April, 2014, located at 23.41^0 N latitude and 90.22 ^{0} E longitudes and at an altitude of 8.6 m from the sea level. The soil of the experimental area was to the general soil type series of shallow red brown terrace soils under Tejgaon series. Upper level soils were clay loam in texture, olive-gray through common fine to medium distinct dark yellowish brown mottles under the Agro-ecological Zone (AEZ-28) and belonged to the Madhupur Tract. The tubers of both parental line, TPS-67 (as male parent ♂) and MF-II (as female parent ♀) were used as a test crop.

The experiment consisted of two factors *i.e.*, factor-A; nitrogen splitting (4 levels): SN_0= 2 split dose (conventional); SN_1= 3 split dose; SN_2= 4 split dose; SN_3= 5 split dose (SN) and factor-B; boron (4 levels): B_0= 0 kg B ha^{-1}; B_1= 4 kg B ha^{-1}; B_2= 6 kg B ha^{-1}; B_3= 8 kg B ha^{-1}. Those were laid out in a split-plot design with three replications, whereas SN and B were treated as main plot and sub-plot, respectively. Sixteen treatment combinations were used. The size of unit plot was 1.5 m × 1.0 m, where replication to replication and plot to plot distance was 1.0 and 1.0 m, respectively. Row to row and plant to plant distances were also 50 and 25 cm, respectively, in each plot. The allotted experimental area was opened by power tiller in the last week of October, 2013. The experimental area was manured with cowdung @ 7 t ha^{-1}. TSP, MoP, Gypsum and $ZnSO_4$ were applied @ 250, 125, 100 and 15 kg ha^{-1} to supply P, K, S and Zn, respectively. Urea and borax was applied as (basal + split) and basal, respectively to supply N and B according to the treatment rates. All the fertilizers, manures and 50 kg N ha^{-1} (108.5 kg urea) applied in furrows as basal dose. Rest N (urea) was applied as per treatment.

On 1 November 2013, seed tubers of the female parent with uniform size (60-70 g) were planted after well preparation from storage chambers. Male plants were planted in separate plots at least 7 days earlier than female plants to harmonize their flowering with that of the female plants. Different Intercultural operations (Earthing up, Removal of weed, Watering, Conventional of insects and diseases and staking of mother plant) was done as per when needed. In order to keep the plants of female parent line erect, help even distribution of light and to facilitate the pollination and intercultural operations, the plants were pruned to 2 stems per hill.

For profuse dynamics of flowering of potato mother plants Artificial light was given to extend the photoperiod by 200 watt white florescent bulb to provide a light intensity of 30,000 to 50,000 lux at the plant surface from 25 DAP and was continued till completion of harvesting of berries and the intensity of light of this range was measured by HDELX-1010B Digital Lux meter. Both parental lines (MF II ♀ and TPS-67 ♂) normally starts blooming at 35-45 DAP.

The female parents were hand pollinated in the morning (9.00-11.00 am) by using the sun dried pollen from male parent for proper assurance of fertilization. Berries were harvested 5 to 6 weeks after pollination, when they just started to ripen. Berries from 5 plants of each plot were collected in net bags and stored for 7 to 10 days at room temperature to induce full ripening. Seeds were extracted successfully. Thereafter, the seeds were weighed. The number of TPS berry^{-1} was counted and 100-TPS weight was recorded. The following data were collected during the experimentation on different traits of potato mother plants *viz.*, growth characteristics: height of plants (cm) at 70 DAP, chlorophyll content (SPAD value) at first flowering stage and final berry harvest stage; flowering characteristics: days to inflorescence emergence, days to first flower open from inflorescence, number of total inflorescences plant-^{1}, number of flowers primary^{-1} inflorescence and number of flowers secondary^{-1} inflorescence.

Berry characteristics: number of total berries plant^{-1}, number of berries primary^{-1} inflorescence, number of berries secondary^{-1} inflorescence, period from setting to maturity of berries (days), period from 1st to last harvest of berries (days), weight of 100-berries (g), total yield of berries plant^{-1} (g) and yield of berries (t ha^{-1}); TPS characteristics: number of TPS berry^{-1} at different berry sizes, yield of TPS kg^{-1} berry (g), total yield of TPS plant^{-1} (mg), total yield of TPS (kg ha^{-1}) and weight of 100-TPS (mg); quality characteristics of TPS: germination (%) of TPS, seed protein content (%) and seed lipid content (%). The statistical computer package, Statistix 10 (2013) was used to analyze the collected data through using ANOVA techniques and mean separation was done by following Least Significant difference (LSD) at 5 % level of probability.

Remarkable variation was found in respects of two factors on different growth, flowering, berry, TPS yield and quality attributes of TPS from potato mother plant. The tallest plant was found from SN_3 (121.34 cm) and the smallest plant from SN_0 (81.14 cm). The tallest plant was found from B_3 (112.03 cm) and the smallest plant from B_0 (99.0 cm). The highest SPAD value was found from SN_3 (44.36) and the lower from SN_0 (34.11) at first flowering stage. B had no effect on this aspect. The highest SPAD value was found from SN_3 (21.24) and the lower from SN_0 (13.64) at final berry harvest stage. The SPAD value was highest in B_3 (20.47) and the lowest was in B_0 (15.45) at final berry harvest stage. The plant height and chlorophyll content was not influenced by the combination of both of them significantly except, highest SPAD value was found from SN_3B_3 (25.62) at final berry harvesting stage. The minimum days was needed to induce inflorescence and flowers by the plant which produced from SN_3 (35.25 and 41.54 days, respectively) and maximum from SN_0 (44.25 and 52.39 days, respectively). Boron and combination of SN with B had no influence on this aspect.

Total number of inflorescence plant^{-1}, flower from both primary and secondary inflorescences found significantly highest from SN_3 (7.05, 21.71 and 16.54, respectively) and lowest from SN_0 (4.52, 14.49 and 10.04, respectively). Total number of inflorescence plant^{-1}, flower from both primary and secondary inflorescences found significantly highest from B_3 (6.80, 20.45 and 15.49, respectively) and lowest from B_0 (5.46, 16.66 and 11.92, respectively). Combindly, SN_3B_3 (8.51, 25.49 and 19.49, respectively) gave the highest number in respects of inflorescence and flower. Total number of total berries plant^{-1}, berry from both primary and secondary inflorescences found significantly highest from SN_0 (19.84, 14.33 and 5.04, respectively) and lowest from SN_3 (12.65, 9.12 and 3.22, respectively). Total number of total berries plant^{-1}, berry from both primary and secondary inflorescences found significantly highest from B_0 (16.83, 12.16 and 4.26, respectively) and lowest from B_3 (14.79, 10.66 and 3.75, respectively). Combindly, there was no effect of SN and B on these aspects. The longest duration for berry maturation and harvesting was found from SN_2 (53.27 and 39.85, respectively) and the shortest duration was found from SN_0 (48.83 and 31.93, respectively). The longest duration for berry maturation and harvesting was found from B_3 (55.6 and 39.09, respectively) and the shortest duration was found from B_0 (50.37 and 34.24, respectively). Combindly, SN_3B_3 (60.72 and 40.04, respectively) gave the longest period of maturation and harvesting and shortest duration from SN_0B_0 (45.86 and 29.68 days, respectively). Hundred berry weights were highest at SN_3B_1 (1337.60 g) which was similar with SN_3B_0 (1291.90 g) and lowest from SN_0B_0 (581.3 g). The highest yield of berries plant^{-1} (g) and yield (t ha^{-1}) was found from SN_2B_0 (185.47 g and 14.83 t, respectively) and the lowest from SN_3B_3 (128.79 g and 10.30 t, respectively). The highest number of TPS was found from both of medium and large sized berry upon SN_3B_3 (249.00 and 316.00) followed SN_2B_3 (240.00 and 297.00), respectively. Except TPS from small sized berry, whereas SN_1B_2 (77.99) combination was better for TPS numbers.

The maximum TPS yield (kg ha^{-1}) was found from SN_1 (147.09 kg) followed by SN_2 (127.59 kg) and the minimum from SN_0 (107.20 kg).Whereas, the maximum TPS yield was found from B_3 (131.87 kg) which was statistically similar to B_2 (123.95 kg), B_1 (121.97 kg) and the minimum from B_0 (116.53 kg). Combindly, the maximum yield of TPS was found from SN_1B_3 (172.81 kg) and the minimum yield was found from SN_0B_0 (80.14 kg). The 100-TPS weight was maximum under SN_3 (80.38 mg) followed by SN_2 (79.26 mg) and the minimum from SN_0 (68.45 mg). Whereas, the maximum 100-true seed weight was found in B_3 (80.72 mg) which was statistically similar to B_2 (77.16 mg) and the minimum from B_0 (70.98 mg). Combindly, the maximum weight of 100-TPS was found from SN_3B_3 (86.87 mg) which was statistically similar to SN_2B_3 (84.24 mg), SN_2B_2 (82.04 mg), SN_3B_1 (79.94 mg) and SN_3B_0 (78.16 mg); whereas, the minimum from SN_0B_0 (53.36 mg). The protein (%), lipid (%) and germination (%) was highest under SN_3 (9.52 %), SN_2 (19.82 %) and SN_2 (92.57 %), respectively. The lowest protein (%), lipid (%) and germination (%) was found from SN_0 (6.46 %), SN_0 (16.38 %) and SN_0 (84.00 %), respectively. The protein (%), lipid (%) and germination (%) was highest under B_3 (9.36, 19.73 and 91.14 %, respectively) and lowest from B_0 (7.73, 17.40 and 84.50 %, respectively). Combindly, highest percent was found from SN_3B_3 (11.01, 21.95 and 98.11 %, respectively) and lowest from SN_0B_0 (5.21, 14.67 and 74.55 %, respectively).

Splitting of nitrogen must be applied for seed production from potato mother plant in order to maximize quality attributes, 100-TPS weight. Since, it’s a main important quality trait of TPS and boron at highest doses to proper retention of flowers, berries and qualities also.

Though, the combination of SN_1B_3 (3 split applications of N and 8 kg B ha^{-1}) produced the maximum TPS yield (172.81 kg ha^{-1}) but, on the basis of quality parameters; 100-TPS weight (mg), protein (%), lipid (%) and (%) germination (%); SN_3B_3 (5 split applications of N and 8 kg B ha^{-1}), SN_2B_3 (4 split applications of N and 8 kg B ha^{-1}) and SN_2B_2 (4 split applications of N and 6 kg B ha^{-1}) combinations showed statistical similar results.

In conclusion, the combination of SN_2B_2 (4 split applications of N and 6 kg B ha^{-1}) is the best for producing quality TPS from potato mother plant under prevailing climatic condition of Bangladesh.

In order to validate these speculations, more research programs should be conducted to assess the combined effect of nitrogen splitting and boron on the basis of findings from present study. The economic benefits from present investigation had not been calculated. So, the further researchers should be drawn attention to impart a better combination of nutritional management with reasonable cost for commercial potato growing under prevailing climatic condition of Bangladesh. The extension and other technology dissemination personnel's should be involved in further attempt to give the message in front of commercial potato growers.

REFERENCES

Accatino, P. and Malagamba, P. (1983). Growing potatoes from TPS. Current agronomic knowledge and future prospects. In: Proc. Int. Congress. 10th Anniversary of International Potato Center, Lima, Peru, p. 61.

Agarwala, S. C., Sharma, P. N., Chatterjee, C. and Sharma, C. P. (1981) Development and enzymatic change during pollen development in boron deficiency maize plants. *J. Plant Nutr*. **3**(1-4): 329-336.

Ahrens, T. D., Lobell, D. B., Ortiz-monasterio, J. I., Li, Y. and Matson, P. A. (2010). Narrowing the agronomic yield gap with improved nitrogen use efficiency: a modeling approach. *Ecol. Appl*. **20**(1): 91-100.

Almekinders, C. J. M. and Struik, P. C. (1996). Shoot development and flowering in potato (*Solanum tuberosum* L.). *Potato Res.* **39**(4)): 581-607.

Almekinders, C. J. M., Neuteboom, J. H. and Struik, P. C. (1995). Relation between berry weight, number of seeds per berry and 100-seed weight in potato inflorescences. *Scientia Hortic*. **61**(3-4): 177-184.

Almekinders, C. J. M, and Wiersema, S. G. (1991). Flowering and true seed production in potato (*Solanum tuberosum* L.). 1. Effects of inflorescence position, nitrogen treatment, and harvest date of berries. *Potato res*. **34**(4): 365-377.

Anonymous (2010). Annual Report. Tuber Crops Research Center, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, p. 67.

Antoine, G., Carolyne, D. and Nathalie, C. (2011). Prediction of germination rates of weed species: Relationships between germination speed parameters and species traits. *Ecol. Model.* **222**(3): 626-636.

Aparna, K., Hash, C. T., Yadav, R. S. and Vadez, V. (2014). Seed number and 100-seed weight of pearl millet (*Pennisetum glaucum* (L.) respond differently to low soil moisture in genotypes contrasting for drought tolerance. *J. Agron. Crop Sci*. **200**(2): 119-131.

Asare, E. and Scarisbrick, D. H. (1995). Rate of nitrogen and sulphur fertilization on yield, yield components and seed quality on oilseed rape (*Brassica napus* L.). *Field Crops Res*. **44**(1): 41-46.

Basavarajeswari, C. P., Hosamni, R. M., Ajjappalavara, P. S., Naik, B. H., Smitha, R. P. and Ukkund (2008). Effect of foliar application of micronutrients on growth, yield components of Tomato (*Lycopersicon esculentum* Mill). *Karnataka J. Agril. Sci*. **21**(3): 428-430.

Bellaloui, N., Hu, Y., Mengistu, A., Kassem, M. A. and Abel, C. A. (2013). Effects of foliar boron application on seed composition, cell wall boron, and seed 15 δ N and 13 δ C isotopes in water-stressed soybean plants. *Front. Plant Sci*. **4**: 1-12.

Bergmann, W. (1984). The significance of the micronutrient boron in agriculture. Symp. held by the Borax Group in the Int., 20 December, Trade Centre of the GDR, Berlin.

Bhatt, A. K., Bhalla, T. C., Agrawal, H. O. and Upadhya, M. D. (1989). Effect of seed size on protein and lipid contents, germination and imbibition in true potato seeds. *Potato Res.* **32**(4): 477-481.

Borji, M., Ghorbanli, M. and Sarlak, M. (2007). Some seed traits and their relationships to seed germination, emergence rate and electrical conductivity in common bean (*Phaseolus vulgaris* L.). *Asian J. Plant Sci.* **6**(5): 781-787.

Brown, P. H., Bellaloui, N., Wimmer, M. A., Bassil, E. S., Ruiz, J., Hu, H., Pfeffer, H., Dannel, F. and Romheld, V. (2002). Boron in plant biology. *Plant Biol*. **4**(2): 205-223.

Campbell, R. J., Mobley, K. N., Marini, R. P. and Pfeiffer, D. G. (1990). Growing conditions alter the relationship between SPAD-501 values and apple leaf chlorophyll. *Hort Sci.* **25**(3): 330-331.

Daughtry, C. S. T., Walthall, C. I., Kim, M. S., Brown De Colstoun, E. and Mcmurtrey, J. E. (2000): Estimating corn leaf chlorophyll concentration from leaf and canopy reflectance. *Rem. Sens. Environ.* **74**(2): 229-239.

Davis, T. M., Sanders, D. C., Nelson, P. V., Lengnick, L. and Sperry, W. J. (2003). Boron improves growth, yield, quality and nutrient content of tomato. *J. American Soc. Hortic. Sci.* **128**(3): 441-446.

Day, S. C. (2000). Tomato crop in vegetable growing. Agrobios, New Dehli, India. pp. 59-61.

Dayal, T. R., Upadhya, M. D. and Chaturvedi, S. N. (1984). Correlation studies on 100-true seed weight, tuber yield and other morphological traits in potato (*Solanum tuberosum* L.). *Potato Res.* **27**(2): 185-188.

Dear, B. S. and Lipsett, J. (1987). The effect of boron supply on the growth and seed production of subterranean clover (*Trifolium subterraneum* L.). *Crop and Pasture Sci.* **38**(3): 537-546.

Delouche, J. C. (1980). Environmental effects on seed development and seed quality. *J. American Soc. Hortic. Sci.* **15**: 775-780.

Dordas, C. (2006). Foliar boron application improves seed set, seed yield, and seed quality of alfalfa. *Agron. J*. **98**(4): 907-913.

Duce, P., Arca, B., Spano, D., Ventura, A. and Usai, I. (1997). A nondestructive instrument to determine chlorophyll content: applicability to Citrus. *Italus Hortus*. **4**(4): 26-31.

Evans, J. R. (1983): Nitrogen and photosynthesis in the flag leaf of wheat (*Triticum aestivum* L.). *Plant Physiol*. **72**(2): 297-302.

Evans, J. R. (1989): Photosynthesis and nitrogen relationship in leaves of C3 plants. *Oecologia*. **78**(1): 9-19.

FAOSTAT (2014). Statistical Database. Food and Agricultural Organization of United Nations, Rome, Italy.

FAOSTAT (2013). Statistical Database. Food and Agricultural Organization of United Nations, Rome, Italy.

Field, C. and Mooney, H. A. (1986): The photosynthesis-nitrogen relationship in wild plants. In: On the economy of plant form. T. J. Givnish, (ed.). Cambridge, University Press. pp. 25-53.

Folch, J., Lee, M. and Solane-Stanley, G. H. (1957). A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.* **226**(1): 497-509.

Gehl, R. J., Schmidt, J. P., Maddux, L. D. and Gordon, W. B. (2005). Corn yield response to nitrogen rate and timing in sandy irrigated soils. *Agron. J.* **97**(4): 1230-1238.

Gentry, L. E. and Below, F. E. (1991). Time of availability influences mixed N-induced increases in yield of maize. *Agron. J.* **217**: 244-248.

Goldberg, S., Shouse, P. J., Lesch, S. M., Grieve, C. M., Poss, J. A., Forster, H. S. and Sua-rez, D. L. (2003). Effect of high boron application on boron content and growth of melons. *Plant Soil*. **256**(2): 403-411.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedure of agricultural research. 2nd Edition. John Willey and Sons, New York, USA. pp. 139-180.

Grant, C. A., Wu, R., Selles, F., Harker, K. N., Clayton, G. W., Bittman, S., Zebarth, B. J. and Lupwayi, N. Z. (2012). Crop yield and nitrogen concentration with controlled release urea and split applications of nitrogen as compared to non-coated urea applied at seeding. *Field Crops Res*. **127**(27): 170-180.

Gray, D. and Thomas, T. H. (1982). Seed germination and seedling emergence as influenced by the position of the development of the seed on and chemical application to the parent plant. In: The physiology and biochemistry of seed development, dormancy and germination. A.A. Khan, (ed.). Elsevier, New York. pp. 81-110.

Gunasena, H. P. and Harris, P. M. (1971). The effect of CCC, nitrogen and potassium on the growth and yield of two varieties of potatoes. *J. Agril. Sci.* **76**(1): 33-52.

Gupta, A. and Pal, K. (1989). Response of potato varieties to nitrogen fertilization under rainfed conditions. *Indian J. Agron.* **34**(4): 478-480.

Gurmani, A. R., Andaleep, R., Khan, S. U., Nawab, N. N. and Zafar, M. (2012). Biochemical attributes, plant growth and yield of tomato as affected by boron application rates. *J. Chem. Soc. Pakistan.* **34**(4): 946-953.

Haque, M. E., Paul, A. K. and Sarker, J. R. (2011). Effect of nitrogen and boron on the growth and yield of tomato (*Lycopersicon esculentum* Mill.). *Int. J. Bio-resource and Stress Manag.* **2**(3): 277-282.

Hassan, S. A., Jm, G. and We, S. (1993). Growth and yield potential of green pepper as affected by nitrogen at transplanting. *Pertanika J. Trop. Agric. Sci.* **16**(2): 101-105.

Hossain, M. F., Shenggang, P., Meiyang, D., Zhaowen, M., Karbo, M. B., Bano, A. and Xiangru, T. (2015). Photosynthesis and antioxidant response to winter rapeseed (*Brassica napus* L.) as affected by boron. *Pakistan J. Bot.* **47**(2): 675-684.

Ivins, J. D. and Bremner, P. M. (1969). Growth, development and yield in the potato. *Outlook on Agril.* **4**(5): 211-217.

Josue, S. M., Navreet, K. M., Dave, G., Florence, C. S. and Caio, D. (2011). Effect of irrigation, surfactant and fertilizer rates on chlorophyll content in tomato leaves. Annuel report. CIT. Department of Plant Science, California State University, Fresno.

Jyolsna, V. K., and Mathew, U. (2008). Boron nutrition of tomato (*Lycopersicon esculentum* L.) grown in the laterite soils of southern Kerala. *J. Trop. Agril.* **46**(1-2): 73-75.

Khalil, M. Y, Hussein, M. S. and El-Sherbeny, S. E. (2001). A comparative study on the effect of some foliar fertilizers on the growth and yield of *Sinapis abla* and *Nigella sativa* plants. *Egyptian J. Hortic.* **28**(3): 371-385.

Kirimi, J. K., Itulya, F. M. and Mwaja, V. N. (2011). Effects of nitrogen and spacing on fruit yield of tomato. *African J. Hortic. Sci.* **5**: 50-60.

Krauss, A. (1978). Tuberization and abscisic acid content in potato (*Solanum tuberosum* L.) as affected by nitrogen nutrition. *Potato Res.* **21**(2): 183-193.

Lalit, B., Srivastava, B. K. and Singh, M. P. (2004). Studies on the effect of foliar application of micronutrients on growth, yield and economics of tomato (*Lycopersicon esculentum* Mill). *Progress. Hortic*. **36**(2): 331-334.

Ma, T. S. and Zuazaga, G. (1942). Micro-Kjeldahl determination of nitrogen- A new inagandicator and an improved rapid method. *Ind. Eng. and Chem. Anal. Educ.* **14**: 280-282.

Madeira, A. C., Mendonca, A., Ferreira, M. E. and Taborda, M. (2000). Relationship between spectroradiometric and chlorophyll measurements in green beans. *Communications in Soil Sci. Plant Anal.* **31**(5-6): 631-643.

Maingi, D. M., Nyabundi, J. O. and Kidane-Mariam, H. M. (1994). The effect of nitrogen fertilizer split application on flowering, berry number and size in true potato (*Solanum tuberosum* L.) seed production. In: Proc. of the 5th symp. ISTRC-Africa Branch, Accra, Ghana, pp. 194-197.

Malagamba, P. (1988). Potato production from true seed in tropical climates. *Hort. Sci*. **23**: 495-500.

Malakouti, M., Babaakbari, M. and Nezami, S. (2009). Improving Grain Yield, Nitrogen Use Efficiency and Nitrogen Recovery in Wheat through Pre-Plant N-Fertilizers. *J. Watet Soil Sci.* **13**(49): 129-138.

Maralee, C. G., Seymour, R. A. and David, J. G. (1991). Hydrolysis of lipid and protein reserves in loblolly pine seeds in relation to protein electrophoretic patterns following imbibition. *Plant Physiol.* **88**(1): 99-106.

Marquard, R. D. and Tipton, J. L. (1987). Relationship between extractable chlorophyll and an in situ method to estimate leaf greenness. *Hort. Sci.* **22**(6): 1327.

Marschner, H. (1990). Functions of mineral nutrients: Macronutrients. In: Mineral nutrition of higher plants. Academic Press, London. pp. 195-219.

Masome, H. (2013). Effects of different levels of urea on the growth and yield of tomato. *J. Nov. Appl. Sci*. **2**(S3): 1031-1035.

Moniruzzaman, A. F. M. (2000). A survey report on response of farmers to potato production from True Potato Seed (TPS). Bangladesh Agricultural Research Institute, Gazipur, Bangladesh. pp. 1-24.

Morad, S. (2013). Biochemical aspects of protein changes in seed physiology and germination. *Intl. J. Adv. Biol.Biomed. Res.* **1**(8): 885-898.

Naga, S. K., Swain, S. K., Sandeep, V. V. and Raju, B. (2013). Effect of foliar application of micronutrients on growth parameters in tomato (*Lycopersicon esculentum* Mill.). *Discourse J. Agril. food sci.* **1**(10): 146-151.

Naik, L. B., Probhakar, M. and Douode, S. D. (1996). Effects of nitrogen on growth, seed yield and quality in brinjal (*Solanum melongena* L.). *Annals Agric. Res.* **17**(4): 419-442.

Naresh, B. (2002). Response of foliar application of boron on vegetative growth, fruit yield and quality of tomato var. Pusa Ruby. *Indian J. Hill Farming*. **15**: 109-112.

Narits, L. (2011). Effect of top-fertilizing of raw protein and glucosinolates content of winter turnip rape. *Agron. Res*. **9**(S2): 451-454.

Naz, R. M. M., Muhammad, S., Hamid, A. and Bibi, F. (2012). Effect of boron on the flowering and fruiting of tomato. *Sarhad J. Agric*. **28**(1): 37-40.

Nonnecke, I. B. L. (1989). Vegetable Production. Avi Book Publishers. New York, USA. pp. 200-229.

Oyewole, O. I., and Aduayi, E. A. (1992). Evaluation of the growth and quality of the "Ife Plum" tomato as affected by boron and calcium fertilization. *J. plant Nutr.* **15**(2): 199-209.

Pallais, N. (1994). True potato seed: A global perspective. *Intl. Potato Cent. Circ*. **20**: 2-3.

Pallais, N. (1991). Changing potato propagation from vegetative to sexual. *Hortic. Sci.* **26**(3): 239-241.

Pallais, N. (1987). True potato seed quality. *Theor. Appl. Genet*. **73**(6): 784-792.

Pallais, N., Villagarcia, S., Fong, N., Tapia, J. and Garcia, R. (1987). Effect of supplemental nitrogen on true potato seed weight. *American Potato J*. **64**(9): 483-491.

Pallais, N., Fong, N. and Berrios, D. (1984). Research on the physiology of potato sexual seed production. In: Innovative methods for propagating potatoes. Report XXVIII, Planning Conf., International Potato Centre, Lima, Peru. pp. 149-168.

Phookan, D. B., Shadeque, A. and Barukah, P. J. (1991). Effect of plant growth regulators on seed yield and quality of tomato. *Vegetable Sci.* **18**: 93-95.

Prioul, J. L., Brangeon, J. and Reyss, A. (1980). Interaction between external and internal conditions in the development of photosynthetic features in a grass leaf I. *Plant Physiol*. **66**(4): 762-769.

Raj, M. (2013). Canola response to split nitrogen applications at Katanning. Annual report. Department of Agriculture and Food, Western Australia, p. 1.

Rawson, H. M. (1996). The developmental stage during which boron limitation causes sterility in wheat genotypes and the recovery of fertility. *Australian J. Plant Physiol*. **23**(6): 709-717.

Renia, H. and Hest, P. V. (1998). Opportunity and challenges for the commercial use of botanical potato hybrid seed. 30 May-5 June, Monte Carlo. p. 1-15.

Rerkasem, B., Lordkaew, S. and Dell, B. (1997). Boron requirement for reproductive development in wheat. *Soil Sci. and Plant Nutr.* **43**: 953-957.

Rexen, B. (1976). Studies of protein of potatoes. *Potato Res.* **13**: 189–202.

Roy, M., and Ghosh, S. (2013). Rainfall variation in Bangladesh: trends, factors and effects. *Manag. Res. Prac*., **5**(3): 56.

Roy, T. S., Nishizawa, T. and Ali, M. H. (2007a). Flower, berry and true potato seed production in potato mother plants (*Solanum tuberosum* L.). 1. Effects of nitrogen and phosphorus fertilizers. *J. Agron*. **6**(1): 106-112.

Roy, T. S., Nishizawa, T. and Ali, M. H. (2007b). Flower, berry and true potato seed production in potato mother plants (*Solanum tuberosum* L.). 2. Effects of nitrogen and potassium fertilizers. *J. Agron***. 6**(1): 88-93.

Roy, T. S., Hossain, M. J., Ali, M. H., Rashid, M. H. and Akhter, S. (1999). A comparative study of 31 hybrid true potato seed progenies. *Bangladesh J. Agril. Res*. **24**: 599-607.

Salam, M. A., Siddique, M. A., Rahim, M. A., Rahman, M. A. and Saha, M. G. (2010). Quality of tomato (*Lycopersicon esculentum* Mill.) as influenced by boron and zinc under different levels of NPK fertilizers. *Bangladesh J. Agril. Res*. **35**(3): 475-488.

Siddique, M. N. A., Sultana, J., Huda, M. S., Abdullah, M. R. and Chowdury M. A. (2015). Potato production and management with preference to seed potato supply chain, certification and sectors involve in Bangladesh. *Intl. J. Business, Manag. Soc. Res.* **1**(1): 1-13.

Siddique, M. A. and Rashid, M. H. (2000). Role of True Potato Seed in potato development. In: Proc. of workshop on potato development in Bangladesh, Dhaka, Bangladesh, pp. 43-48.

Simmonds, N. W. (1963). Experiments on the germination of potato seeds. I. *Potato Res.* **6**(1): 45-60.

Smit, J. N. and Combrink, N. J. J. (2005). Pollination and yield of winter-grown greenhouse tomatoes as affected by boron nutrition, cluster vibration and relative humidity. *South African J. Plant Soil*. **22**(2): 110-115.

Singh, J., Singh, A. N. and Pandey, P. C. (1990). True potato seed for potato production in India. Technical Bulletin No. 24, Central Potato Research Institute, Indian Council for Agricultural Research, India. pp. 13-14.

SRDI. (1991). Land and Soil Resource Utilization Guide. Ministry of Agriculture, Dhaka, Bangladesh. p. 3.

Stanley, D. W., Bourne, M. C., Stone, A. P. and Wismer, W. V. (1995). Low temperature blanching effects of chemistry, firmness and structure of canned green beans and carrots. *Food Sci.* **60**(2): 327-333.

Strafford, G. A. (1973). Essentials of Plant Physiology. 2nd ed. Heinemann Educational Books Ltd., London. p. 78.

Thakur, K. C. and Upadhya, M. D. (1996). Strategies for the transfer of hybrid TPS production technology. In: Production and Utilization of True Potato Seed in Asia. Proc. Inter-Regional Workshop held at the Central Potato Research Station, Modipuram, India, pp. 135-155.

Thakur, K. C., Upadhya, M. D., Bhargava, S. N. and Bhargava, A. (1994). Bulk pollen extraction procedures and the potency of the extracted pollen. *Potato Res.* **37**(3): 245-248.

Tolessa, D, Gemechu, G. and Melakeselam, L. (1994). Response of maize to split application of nitrogen fertilizer at Bako. In: CSSE (Crop Science Society of Ethiopia, 1995, Sebil). Proc. of the Sixth Annu. Conf., 3-4 May, Addis Abeba, Ethiopia, **6**: 6-60.

Tucker, M. (2004). Primary Nutrients and Plant Growth. In: Essential Plant Nutrients. SCRIBD, (ed.). North Carolina Department of Agriculture. p. 89.

Umaerus, M. (1987). True potato seed. In: Proc. of the 10th triennial conf. of the European association for potato research. Aalborg, Denmark, pp. 72-102.

UNDP. (1988). Land Resources Appraisal of Bangladesh for Agricultural Development. Report 2. Agroecological Regions of Bangladesh. United Nations Development Programme and Food and Agriculture Organization. pp. 212–221.

Upadhya, M. D., Cabello, R., Falcon, R. and Chujoy, E. (2003). Effects of location and year of production on hybrid true potato seed quality and performance. *Acta Hortic.* **619**: 371-374.

Upadhya, M. D., Thakur, K. C., Juneja, A. and Kadian, M. S. (1984). True potato seed production, flowering quality and economics. In: Innovative methods for propagating potatoes. International Potato Center Report of the XXVIII Plann. Conf. Lima, Peru, pp. 117-146.

Van der Vossen, H. A. M. (1998). The commercial production of hybrid True Potato Seed (TPS): A description of technologies and practices as applied in India and Bangladesh. International Mimeograph: p. 4.

Van Staden, J., Davey, J. E. and Brown, N. A. C. (1982). Cytokinins in seed development and germination. In: The physiology and biochemistry of seed development, dormancy and germination. A.A. Khan, (ed.). Elsevier, New York. pp. 181-200.

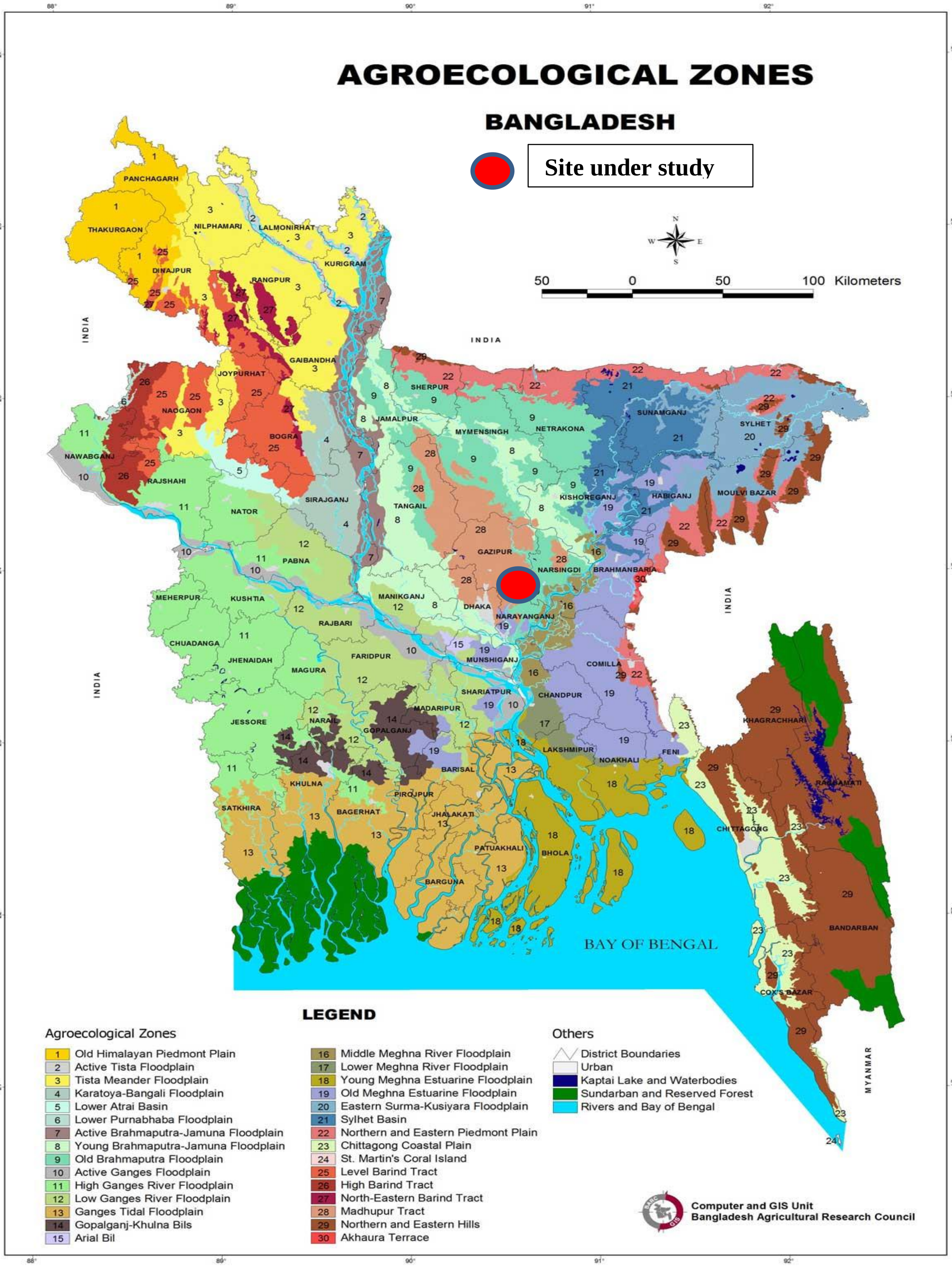
Vos, J. and Born, M. (1993). Hand-held chlorophyll meter: a promising tool to assess the nitrogen status of potato foliage. *Potato Res.* **36**(4): 301-308.

Wiersema, S. G. (1984). The production and utilization of seed tubers derived from true potato seed. Ph.D. Thesis, University of Reading, UK. p. 229.

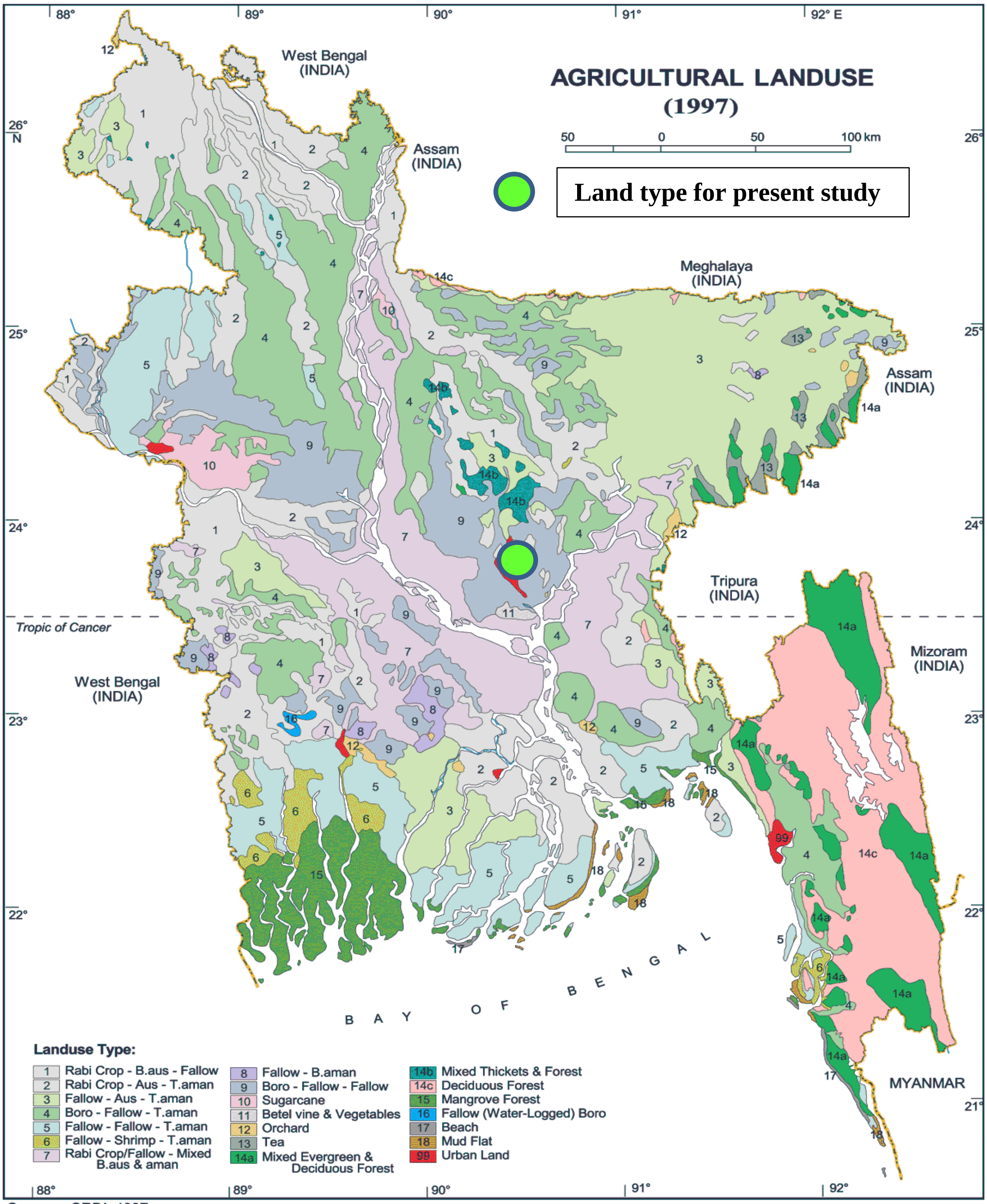
Yadava, U. L. (1986). A rapid nondestructive method to determine chlorophyll in intact leaves. *Hort. Sci.* **21**(6): 1449-1450.

APPENDICES

Appendix I: Map showing the site used for present study

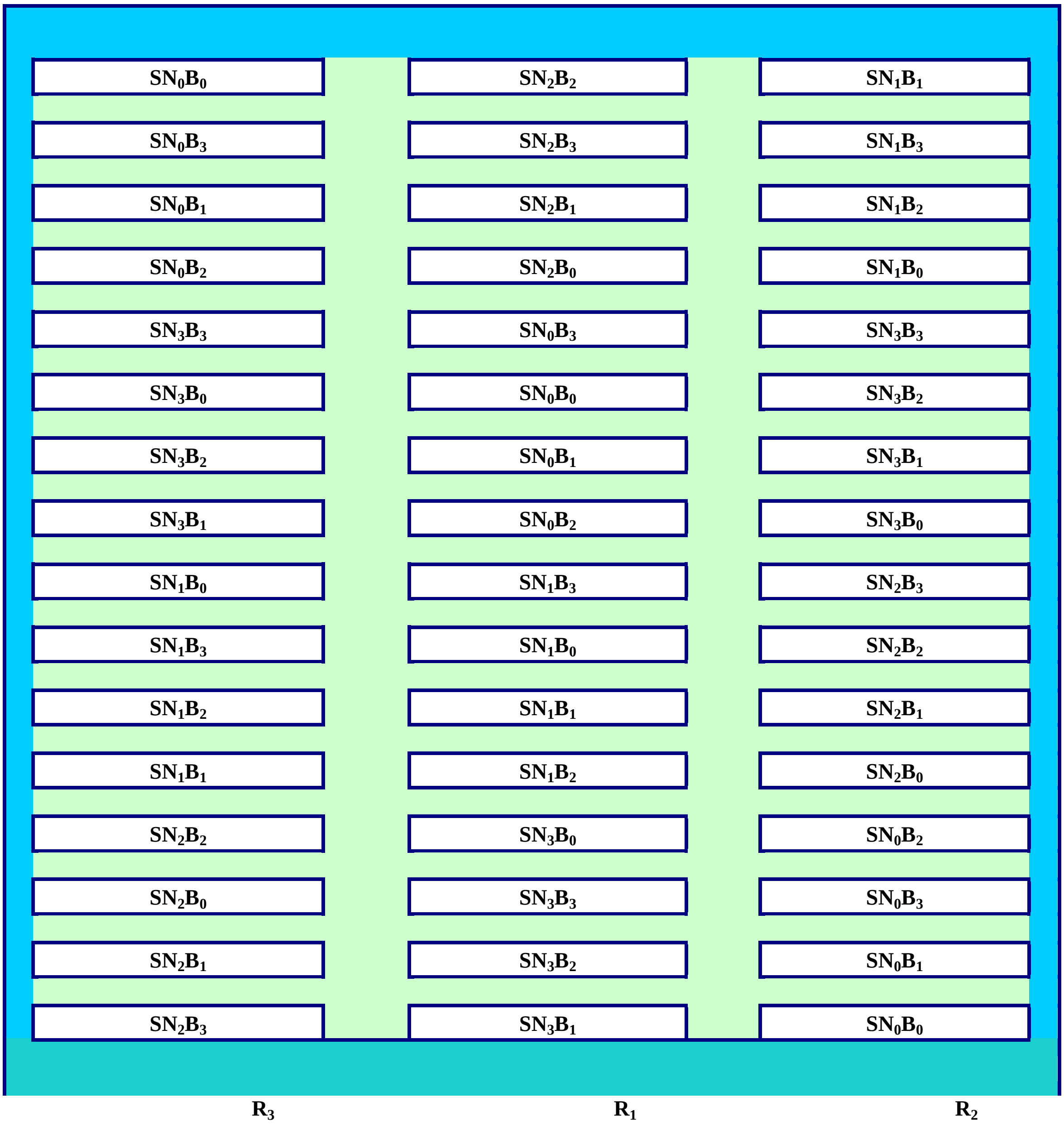


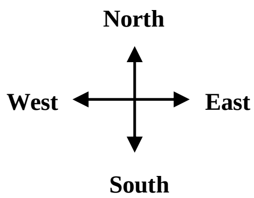
Appendix II: Map showing the type of land used for present study



Source: *SRDI, 1997*

Appendix III: Layout of the experimental plots

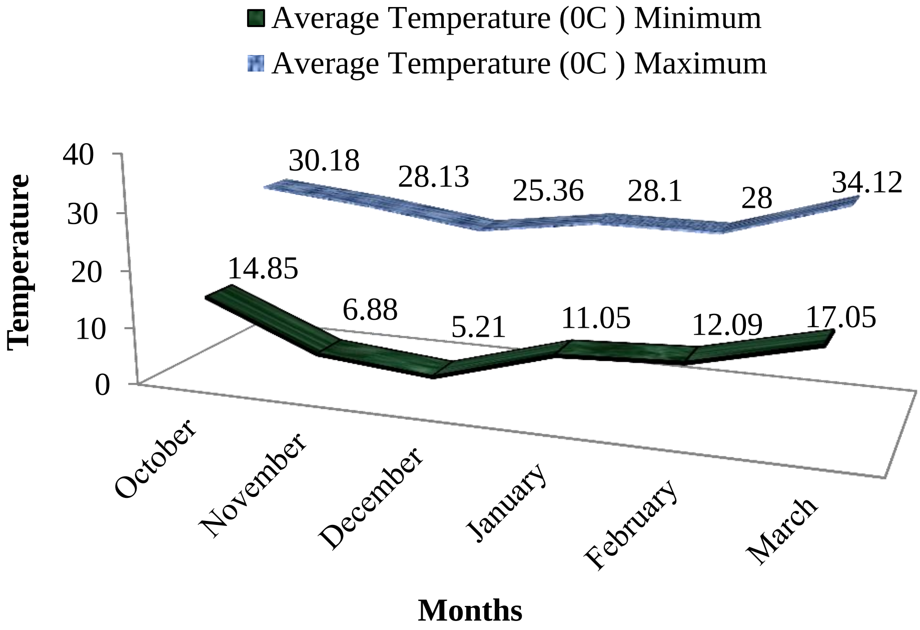




Legends:

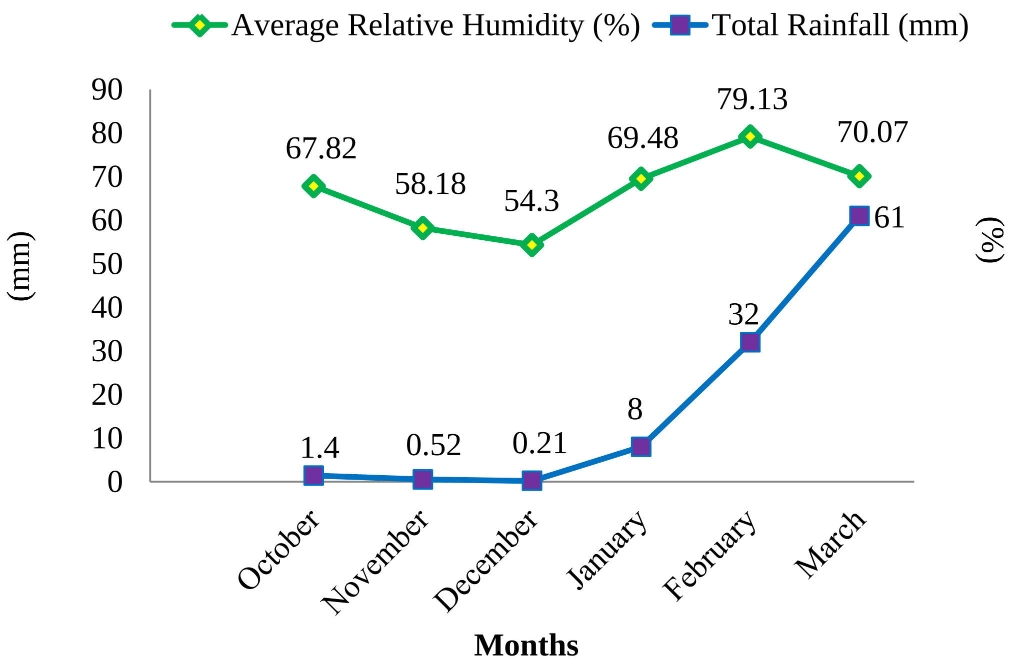
Treatments: 16 (Nitrogen splitting: 4 × Boron: 4); Replication: 3 (Three); Number of plot: 48**.** Length of a plot: 1.5 m; Width of a plot: 1.0 m; Area of a plot: 1.5 m^2. Row to row distance: 0.50 m; plant to plant distance: 0.25 m

Appendix IV. Figure showing the weather data, 2013-2014



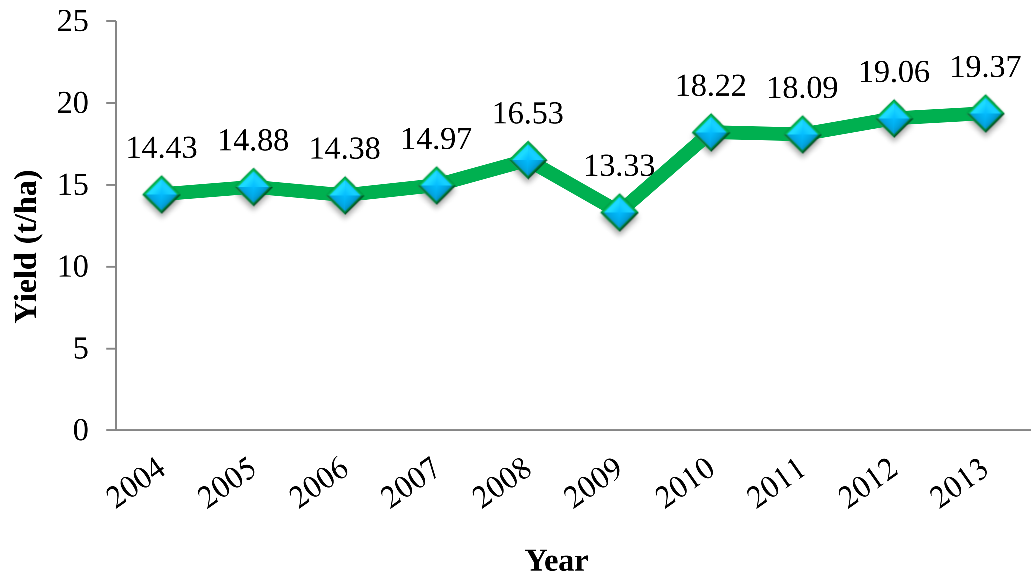
Source: Meteorological station of Sher-e-Bangla Agricultural University, Dhaka-1207

Appendix V. Figure showing the weather data (cont'd), 2013-2014



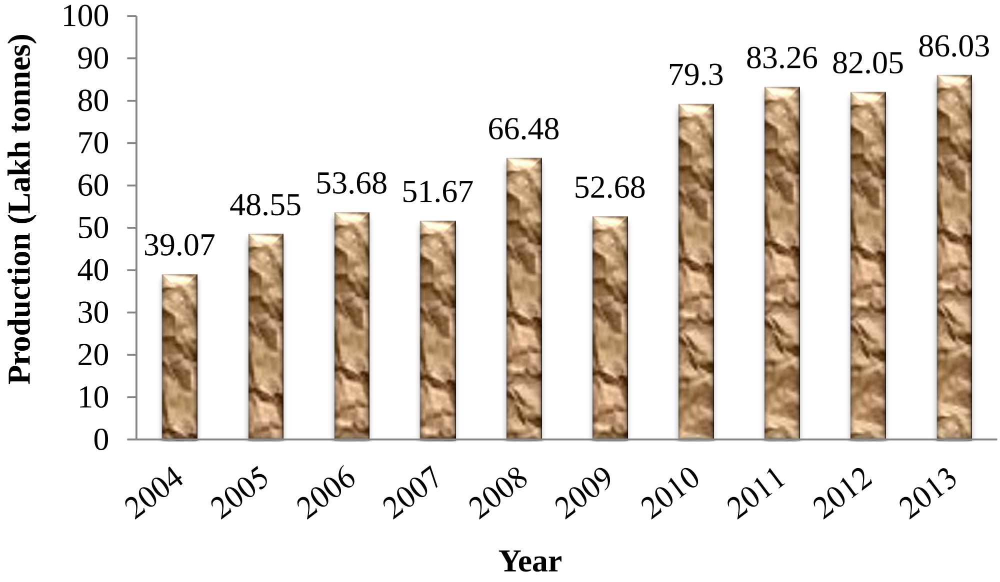
Source: Meteorological station of Sher-e-Bangla Agricultural University, Dhaka-1207

Appendix VI. Figure showing the trend of potato yield in Bangladesh



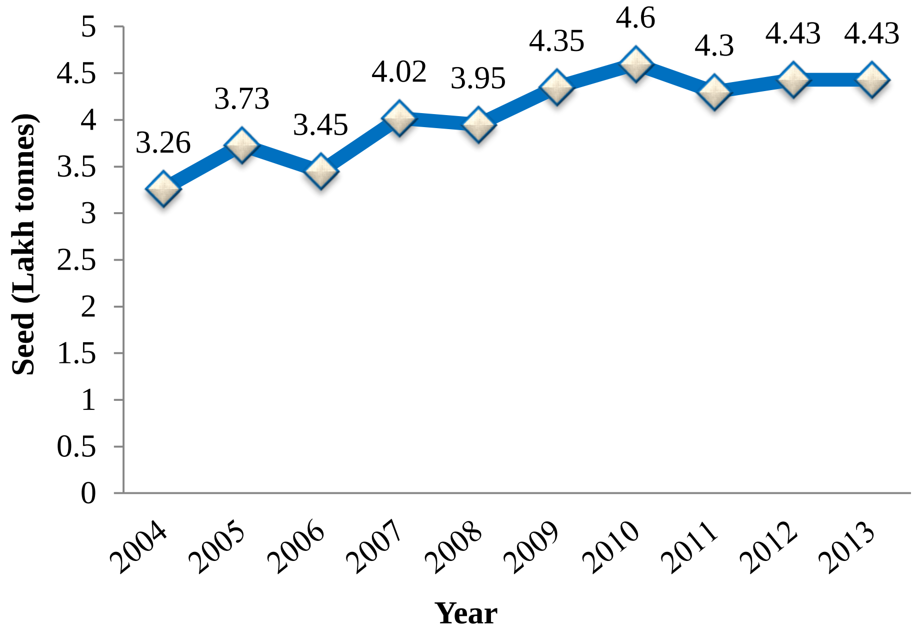
Source: FAOSTAT, 2013

Appendix VII. Figure showing the trends of potato production in Bangladesh



Source: FAOSTAT, 2013

Appendix VIII. Figure showing the trends of seed potato utilization in Bangladesh



Source: FAOSTAT, 2013

Appendix IX. Mean square values for plant height (cm) at 70 DAP, chlorophyll content (SPAD value) at first flowering stage and final berry harvest stage of potato mother plant

Sources of variation	Degrees of freedom	**Mean Square**		
		Plant height (cm) at 70 DAP	Chlorophyll content (SPAD value) at first flowering stage	Chlorophyll content (SPAD value) at final berry harvest stage
Replication	2	0.61	0.050	0.018
Nitrogen splitting (A)	3	4486.89**	285.504**	168.984**
Error (**I**)	6	0.31	0.005	0.002
Boron (B)	3	383.85*	26.185^{NS}	68.696**
Interaction (A×B)	9	34.21^{NS}	2.436^{NS}	11.338**
Error (**II**)	24	111.32	13.606	2.022

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability
NS: Non-significant

Appendix X. Mean square values for days to inflorescence emergence and days to first flower open from inflorescence of potato mother plant

Sources of variation	Degrees of freedom	Mean Square	
		Days to inflorescence emergence	Days to first flower open from inflorescence
Replication	2	2.102	0.020
Nitrogen splitting (A)	3	190.428**	263.272**
Error (**I**)	6	2.403	0.009
Boron (B)	3	9.403^{NS}	51.702^{NS}
Interaction (A×B)	9	2.656^{NS}	7.275^{NS}
Error (**II**)	24	9.296	20.652

**: Significant at 0.01 level of probability NS: Non-significant

Appendix XI. Mean square values for number of total inflorescences plant^{-1}, number of flowers primary^{-1} inflorescence and number of flowers secondary^{-1} inflorescence of potato mother plant

Sources of variation	Degrees of freedom	Mean Square		
		No. of total inflorescences plant^{-1}	No. of flowers primary^{-1} inflorescence	No. of flowers secondary^{-1} inflorescence
Replication	2	0.010	0.017	0.014
Nitrogen splitting (A)	3	17.538**	142.648**	122.875**
Error (**I**)	6	0.001	1.224	0.002
Boron (B)	3	4.091**	40.224**	31.945**
Interaction (A×B)	9	0.768*	8.973*	4.597**
Error (**II**)	24	0.278	3.992	1.419

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability

Appendix XII. Mean square values for number of total berries plant^{-1}, number of berries primary^{-1} inflorescence and number of berries secondary^{-1} inflorescence of potato mother plant

Sources of variation	Degrees of freedom	Mean Square		
		No. of total berries plant^{-1}	No. of berries primary^{-1} inflorescence	No. of berries secondary^{-1} inflorescence
Replication	2	0.017	0.010	0.005
Nitrogen splitting (A)	3	122.875**	64.076**	8.353**
Error (**I**)	6	0.007	0.004	0.001
Boron (B)	3	9.425*	5.383**	0.615**
Interaction (A×B)	9	1.695^{NS}	1.121^{NS}	0.038^{NS}
Error (**II**)	24	2.592	1.069	0.121

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability

NS: Non-significant

Appendix XIII. Mean square values for period from setting to maturity of berries (days) and period from 1st to last harvest of berries (days) of potato mother plant

Sources of variation	Degrees of freedom	Mean Square	
		Period from setting to maturity of berries (days)	Period from 1st to last harvest of berries (days)
Replication	2	0.063	0.197
Nitrogen splitting (A)	3	46.845**	127.839**
Error (**I**)	6	0.036	0.072
Boron (B)	3	72.854**	69.214**
Interaction (A×B)	9	29.607*	28.782*
Error (**II**)	24	13.350	13.099

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability

Appendix XIV. Mean square values for weight of 100-berries (g), total yield of berries plant^{-1} (g) and total yield of berries (t ha^{-1}) of potato mother plant

Sources of variation	Degrees of freedom	Mean Square		
		Wt. of 100-berries (g)	Total yield of berries plant^{-1} (g)	Total yield of berries (t ha^{-1})
Replication	2	0.18063	0.07	0.0003
Nitrogen splitting (A)	3	558075**	2330.34**	14.9089**
Error (**I**)	6	28.2388	0.19	0.0007
Boron (B)	3	36043.6*	258.35^{NS}	1.6522^{NS}
Interaction (A×B)	9	74452.5**	1063.85**	6.8040**
Error (**II**)	24	9509.91	202.68	0.7985

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

NS: Non-significant

Appendix XV. Mean square values for number of TPS berry^{-1} at different berry sizes of potato mother plant

Sources of variation	Degrees of freedom	Mean Square		
		No. of TPS berry^{-1} at different berry sizes		
		Small (<2cm)	Medium (2-3 cm)	Large (>3 cm)
Replication	2	0.200	1.8	1.41
Nitrogen splitting (A)	3	917.563**	10566.8**	5644.49**
Error (**I**)	6	0.129	3.8	0.93
Boron (B)	3	54.678^{NS}	1784.1*	2938.33**
Interaction (A×B)	9	222.974**	1138.5*	683.00*
Error (**II**)	24	30.300	514.0	307.74

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

NS: Non-significant

Appendix XVI. Mean square values for yield of TPS kg^{-1} berry (g), total yield of TPS plant^{-1} (mg), total yield of TPS (kg ha^{-1}) and weight of 100-TPS (mg) of potato mother plant

Sources of variation	Degrees of freedom	Mean Square			
		Yield of TPS kg^{-1} berry (g)	Total yield of TPS plant^{-1} (mg)	Total yield of TPS (kg ha^{-1})	Wt. of 100-TPS(mg)
Replication	2	0.129	201	1.29	0.284
Nitrogen splitting (A)	3	97.427**	600773**	3844.95**	347.185**
Error (**I**)	6	0.023	103	0.66	0.100
Boron (B)	3	63.333**	75703*	484.50*	197.079**
Interaction (A×B)	9	12.257**	110811**	709.19**	81.599*
Error (**II**)	24	3.989	23552	150.73	35.365

**: Significant at 0.01 level of probability *: Significant at 0.05 level of probability

Appendix XVII. Mean square values for germination (%) of TPS, seed protein content (%) and seed lipid content (%) of potato mother plant

Sources of variation	Degrees of freedom	Mean Square		
		Germination (%) of TPS	Seed protein content (%)	Seed lipid content (%)
Replication	2	2.284	0.003	0.019
Nitrogen splitting (A)	3	382.418**	26.175**	24.467**
Error (**I**)	6	1.806	0.007	0.046
Boron (B)	3	134.198*	8.186**	12.128**
Interaction (A×B)	9	86.358*	1.6216*	4.991*
Error (**II**)	24	39.236	0.7204	2.162

**: Significant at 0.01 level of probability   *: Significant at 0.05 level of probability

Plate 1. Experimental signboard

Plate 2. Extended photoperiod through artificial lightening at night (30, 000-50, 000 lux)

Plate 3. Male flowers from TPS-67 (♂)

Plate 4. Male flowers from TPS-67 (♂) with anther to collect pollen grains

Plate 5. Pollen grains of TPS-67 (♂)

Plate 6. Female flowers from MF-II (♀)

a) Flower of SN_0B_0 combination

b) Flower of SN_2B_3 combination

c) Flower of SN_3B_3 combination

Plate 7 (a, b and c). Female flower of different combinations

Plate 8. Artificial pollination of female flowers from MF-II (♀) with pollen grains of TPS-67 (♂)

Plate 9. Newly sets berries with female flowers after fertilization

a) Berry of SN_0B_0 combination

b) Berry of SN_2B_3 combination

c) Berry of SN_3B_3 combination

Plate 10 (a, b and c). Berry of different combinations

Plate 11. Fleshy berries with true potato seed

Plate 12. Extracted true potato seeds from matured berry

Plate 13. Worked on field with potato mother plant

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