EFFECT OF PLANT SPACING AND NUMBER OF TPS PER HILL ON GROWTH, YIELD AND ECONOMIC RETURN OF SEEDLING TUBER DERIVED FROM TRUE POTATO SEED

BY

SONIA SARMIN

Reg. No.: 09-03600

A Thesis

Submitted to the Institute of Seed Technology
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

SEED TECHNOLOGY

SEMESTER: JANUARY- JUNE, 2015

Approved by:

....
Prof. Dr. Tuhin Suvra Roy
Department of Agronomy
SAU, Dhaka-1207
Supervisor

....
Prof. Dr. Md. Shahidur Rashid Bhuiyan
Department of Genetics and Plant Breeding
SAU, Dhaka-1207
Co-supervisor

....
(Prof. Dr. Mohammed Ali)
Chairman
Examination Committee

INSTITUTE OF SEED TECHNOLOGY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Memo No: SAU/IST/...... Dated: ....

CERTIFICATE

This is to certify that the thesis entitled, **"Effect of plant spacing and number of TPS per hill on growth, yield and economic return of seedling tuber derived from true potato seed"** submitted to the **INSTITUTE OF SEED TECHNOLOGY**, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) IN SEED TECHNOLOGY,** embodies the result of a piece of *bona fide* research work carried out by **SONIA SARMIN,** Registration No. **09-03600** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. I further certify that such help or source of information, as has been availed of during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated- June, 2015
Dhaka, Bangladesh

(Prof. Dr. Tuhin Suvra Roy)
Supervisor
Sher-e-Bangla Agricultural University
Dhaka, Bangladesh-1207

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

DEDICATED TO

MY **Beloved Parents**

ACKNOWLEDGEMENTS

All praises are due to Almighty Allah, the Great, Gracious and Merciful, Whose blessings enabled the author to complete this research work successfully.

The author like to express her deepest sense of gratitude, sincere appreciation to her respected Supervisor ***Prof.Dr. TuhinSuvra Roy****, Institute of Seed Technology, Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh, for his scholastic guidance, support, encouragement and invaluable suggestions and constructive criticism throughout the study period and gratuitous labor in conducting and successfully completing the research work and in the preparation of the manuscript.*

The author also expresses her gratefulness and best regards to respected Co-Supervisor, ***Prof. Dr. Md. Shahidur Rashid Bhuiyan****, Institute of Seed Technology, Sher-e Bangla Agricultural University, Dhaka for his scholastic guidance, helpful comments and constant inspiration, inestimatable help, valuable suggestions throughout the research work and preparation of the thesis.*

The author badesher sincere respect to ***Prof. Dr. Mohammad Ali****, Director, Institute of Seed Technology,Sher-e-Bangla Agricultural University, Dhaka for valuable suggestions and cooperation during the study period. The author also expresses heartfelt thanks to all the teachers of Institute of Seed Technology, SAU, for their valuable suggestions, instructions, cordial help and encouragement during the period of the study.*

The author expresses her sincere appreciatio to her brother, sisters, relatives, well wishers and friends for their inspiration, help and encouragement throughout the study period.

The Author

EFFECT OF PLANT SPACING AND NUMBER OF TPS PER HILL ON GROWTH, YIELD AND ECONOMIC RETURN OF SEEDLING TUBER DERIVED FROM TRUE POTATO SEED

ABSTRACT

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from October 2013 to March 2014, to investigate the effect of spacing and number of true potato seed hill $^{-1}$ on growth, yield and economic return of seedling tuber production. The experiment comprised two factors. Factor A: Plant spacing(3); S_1-25cm x 4cm, S_2-25cm x 5cm, S_3-25cm x 6cm and Factor B: number of TPS hill^{-1}(3)viz; P_1-1 TPS hill^{-1}, P_2-2 TPS hill^{-1},P_3-3 TPS hill^{-1}.The experiment was laid oud in a randomized complete block design (RCBD) with three replications. Plant spacing and / or number of TPS hill^{-1} had significant effect on most of the growth and yield contributing characters studied in this experiment. Yield parameters such as number of seedling tuber m^{-2} gradually decreased with increasing spacing on the other hand, average seedling tuber weight increased with increasing plant spacing. In case of yield 25cm x 5 cm spacing exhibited maximum yield (t ha^{-1}). For number of TPS hill^{-1}, 2TPS hill^{-1} performed the best performance for the production of maximum yield (t ha^{-1}). Among the 45 treatment combination though S_2P_1 and S_1P_3 produced the maximum number of seedling tubers m^{-2}(837) and average weight of seedling tuber (9.73gm), respectively but S_2P_2 was the best combination for the production of maximum yield (53.93 t ha $^{-1}$). It may be concluded that Productivity of view Point 2 TPS hill^{-1} at 25cm x 5cm spacing was the best both in terms of maximum yield and highest benefit cost ratio.

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

LIST OF CONTENTS

CONTENTS (cont'd)

LIST OF TABLES

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACCRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Anon.	Anonymous
As	Arsenic
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
BCF	Bio Concentration Factors
cm	Centi-meter
cm^2	Squarecenti-meter
CV	Coefficient of Variance
DAP	Days After Planting
Dev.	Devlopment
DMRT	Duncan's Multiple Range Test
Environ.	Environmental
et al.	And others
Expt.	Experimental
FAO	Food and Agriculture Organization
g	Gram (s)
$hill^{-1}$	Per hill
i.e.	*id est* (L), that is
j.	Journal
kg	Kilogram (s)
mg	Milligram
m^2	Meter squares
M.S	Master of Science
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
SE	Standard Error
$t\ ha^{-1}$	Ton per hectare
TSS	Total Soluble Solids
UNDP	United Nations Development Programme
viz	Namely
WHO	World Health Organization
%	Percentage

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

Chapter I

Introduction

Sher-e-Bangla Agricultural University
Library
Accession No. 39786
Sign. [illegible] Date: 16.11.16

CHAPTER I

INTRODUCTION

Potato (*Solanum tuberosum* L.) popularly known as 'The King of vegetables'. It is a tuber crop belongings to the family Solanaceae. It originated in the central Andean area of South America (Keeps, 1979). It is the 4th world crop after wheat, rice and maize. Bangladesh is the 8th potato producing country in the world. In Bangladesh, it ranks 2nd after rice in production (FAO, 2013). It contributes not only energy but also substantial amount of high quality protein and essential vitamins, minerals and trace elements to the diet (Horton, 1987).

In Bangladesh, it ranks second after rice in terms of production. The total area under potato crop, national average yield and total production in Bangladesh are 4,30,446 hectares, 19.071 t ha^{-1} and 82,05,470 metric tons, respectively. The total production is increasing over time as such consumption also rapidly increasing in Bangladesh (MOA, 2013). It is considered as a vegetable crop and contributes as much 55% of the total vegetable production in Bangladesh (BBS, 2013). The yield is very low in comparison to that of the other leading potato growing countries of the world, 40.16 t ha^{-1} in USA, 42.1t ha^{-1} in Denmark and 40.0 t ha^{-1} in UK (FAO, 2013).

In Bangladesh, potato is grown during the winter season. Nutritionally, the tuber is rich in carbohydrates or starch and is a good source of protein, vitamin C and B, potassium, phosphorus and iron. Potato is one of the most important vegetable crops and having a balanced food containing about 75 to 80% water, 16 to 20 % carbohydrates, 2.5 to 3.2% crude protein, 1.2 to 2.2% true protein, 0.8 to 1.2% mineral water, 0.1 to

0.2% crude fats, 0.6% crude fiber and some vitamins (Sehnini *et al.*, 1999). It is a staple diet in European countries and its utilization both in processed and fresh food form in increasing considerably in Asian countries (Bhuyun, 2003). Being a carbohydrate rich crop, potato can partially substitute rice, which is our main food item. It is grown in almost all countries of the world. In main countries including those Europe, America and Canada, potato is a staple food. In the last 2-3 decades, production of potato in Bangladesh has increased with the cultivation of high yielding varieties. In Bangladesh, potato is mainly used as vegetable and available in the market throughout the year with reasonable price as compared to other vegetables. According to Kadly (1972), among crops, the potato ranks first in protein production per gram per day. Biological value, which is an index of the protein of absorbed nitrogen retained in body for growth or maintenance or both, is 73 for potato compared to 54 for maize and 53 for wheat flour.

Potato has acquired great importance in rural economy in Bangladesh. It is not only a cash crop but also an alternative of food crop against rice and wheat. Bangladesh has a great agro-ecological potential of growing potato. The area and production of potato in Bangladesh has been increasing during the last decades but the yield per unit area remains more or less static. The reasons for such a low yield of potato in Bangladesh are imbalanced fertilizer application, use of low quality seed and use of sub-optimal production practices. Available reports indicated that potato production in Bangladesh can be increased by improving cultural practices among which optimization of manure and fertilizer, planting time, spacing and use of optimal sized seed are important which influences the yield of potato (Divis and Barta, 2001).

Among the various means for reducing the cost of production of potato, the use of true potato seed (TPS) would be an important individual approach. TPS are the botanical seeds obtained from berries produced by the potato plants. Tubers produced from TPS are termed as seedling tubers. Use of TPS as an alternative or supplemental planting materials has many advantages over the traditional method of potato production. The cost of seed tubers, which generally accounts for 35-55% (Kadian *et al.*, 1992; Elias *et al.*, 1997; Singh, 1999) of the total input cost for potato production in the traditional methods can be reduced significantly by the use of TPS. Use of TPS not only saves the seed cost but also reduces the transmission of virus and tuber borne diseases (Jones, 1982). Private companies of Bangladesh adoption of TPS seedling tuber production technology under Bangladesh conditions.

Development of true potato seed (TPS) technology has opened a new era in potato cultivation. Studies conducted at Tuber Crop Research Centre BARI showed that a good TPS progeny can produce 500 to 800 small tubers (called seedling tuber) in a meter of land when planted at 10 cm × 10 cm spacing (TCRC, 2004). These seedling tubers can be planted as good quality seed tubers for ware potato production (Wiersema, 1984). Wiersema (1984) stated that these seedling tubers have higher yield potentiality and the yields from these seedling tubers can be as high as that of large seed tubers when an optimum plant spacing is used.

The number of TPS production per unit area is an important factor, because these are the planting materials to produce either seed potato or ware potato in the subsequent years. Seedling tuber production per unit area is generally related to the plant population. According to Wiersema (1984) the optimum number of TPS per hill in nursery beds was defined as that density whereby a large number of useable seedling tuber are produced and increasing TPS per hill had a positive effect on tuber yield.

Plant spacing and number of TPS per hill are considered very important factors for the production of potato. Unlike other crops, potato needs high investment in seed which is nearly 40% of the total Production cost (Verma *et al.*, 2007). Khalafalla (2001) reported that the smaller the seed size, higher the profit in potato cultivation. However, plant spacing has a direct influence on seed rate and ultimately on cost of production. In traditional method of potato production, seed tuber weight and plant spacing have been found to influence the yield and economic return (BongKyoon *et al.*, 2001; Conley *et al.*, 2001; Upadhya and Cabello, 2001; Malik *et al.*, 2002; Patel *et al.*, 2002; Shingrup *et al.*, 2003; Bayorbor and Gumah, 2007). But only a few studies have been done considering size of seedling tubers and plant spacing on the growth and yield of potato in Bangladesh. Therefore the present experiment was undertaken with the following objectives:

i) to find out the effect of plant spacing on growth, yield and economic return of seedling tuber;
ii) to assess a suitable number of TPS $hill^{-1}$ for getting higher yield of seedling tuber; and
iii) to study the combined effect of plant spacing and number of TPS $hill^{-1}$ on growth and yield of seedling tuber.

Chapter II

Review of Literature

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

CHAPTER II

REVIEW OF LITERATURE

Potato is one of the important food crops of the world, but in Bangladesh is mainly used as a vegetable. The average yield of potato in Bangladesh is very low compared to many potato growing countries of the world. The main limiting factor for potato production and its low yield in Bangladesh is the non-availability of good quality seed. True potato seed can be used successfully for raising seed potato in order to mitigate the acute seed problem of Bangladesh. Seedling tubers derived from TPS offer a promise of getting healthy planting material at low cost which can maintain better yield potential for at least 2-3 successive clonal generations with higher or equivalent yield with that of standard potato varieties.

The production of seedling tubers derived from TPS is greatly influenced by several factors, such as germination uniformity and establishment of seedlings, plant population, earthing-up system, fertilizer management and other crop production practices. Potato production from seedling tubers is also influenced by crop management practices. A good number of experiments have been conducted around the world in order to improve the production technology of TPS seedling tubers. Sporadic research for the improvement of production practices of TPS seedling tubers have also been conducted in Bangladesh. But systematic studies in this context under Bangladesh condition are inadequate and inconclusive. However, the research findings and information related to the present study, so far collected from different relevant publications and sources have been reviewed below:

2.1 Production and importance of potato in Bangladesh

Potato is the third important crop of Bangladesh and about 3216 thousand of potato are produced in Bangladesh from about 284 thousand hectares land with an average yield of 12.89 tonnes per hectare (BBS, 2010). The yield is very low compared to many potato growing countries of the world like Belgium, the Netherlands, Denmark, UK, USA, India and Pakistan where the average yields are 49.0, 43.0, 40.7, 39.6, 38.4, 16.7 and 13.6 t/ha respectively (FAO, 2010).

In Bangladesh potato is mainly used as vegetable and is available in the market throughout the year with reasonable price as compared to other vegetables. According to Kadly (1972), among crops, the potato ranks first in protein production per hectare per day. Biological value, which is an index of the protein of absorbed nitrogen retained in body for growth or maintenance or both, is 73 for potato compared to 54 for maize and 53 for wheat flour. Potato contributes appreciable quantity of energy as well as substantial amounts of quality protein and essential vitamins, minerals and trace elements to the human diet (Horton, 1987).

2.2 History of the use of true potato seed (TPS)

Potato has been propagated traditionally from tubers and rarely from true seed. The history of TPS use in potato production system is very old. In the canter of origin of the potato, South American Indians used TPS to rejuvenate their potato stocks from time to time (Salaman, 1949). A good number of Andean cultivars, presently being maintained at the CIP (CIP, 1981 and 1982), may also have resulted from selection of plants from TPS by ancient farmers (Wiersema, 1984). Haan (1953) reported that in Europe, during the year 1845 when the late blight epidemics wiped out most of the potato crops in the Netherlands, the country imported TPS from abroad.

In China, potato production using TPS has been practiced successfully since 1967 in many communes and state farms in Inner Mongolia, Yunnan, Sichuan, Heilongjiang and Anhwei provinces (Li, 1983). In 1979, seedling tubers derived from TPS were planted on 21660 hectares of land in China with an average yield of 29 -155% more than standard cultivars (Li and Shen, 1979). In India, studies with TPS were carried out as early as the late forties (Upadhya, 1979) while in the United Kingdom, potatoes were produced from directly sown TPS in the nineteen-sixties (Gray, 1979).

The International Potato Canter (CIP) has initiated research work on TPS in 1977 and since then most potato producing countries are experimenting with TPS technology (Accatino, 1979; Malagamba, 1988). In Bangladesh, research on TPS technology did initiate in 1980-81 at the Bangladesh Agricultural Research Institute (BARI) in collaboration with CIP.

2.3 Role of TP technology in potato production around the world

Commercial potato production traditionally has been based on using tubers for propagation. This method, especially in developing countries, is a major limiting factor in potato production because of high cost and unavai1abilit of good quality seed tuber for planting and rapid degeneration of seed tuber stocks due to pathological and physiological reasons (Accatino and Malagamba, 1983; Wiersema, 1984). Among the various means of reducing the cost of production of potato and way of getting good quality seed, the use of true potato seed (TPS) has recently been emerged as a new technology (Malagamba, 1988; CIP, 1992; Rashid *et al.*, 1993; Singh, 1999).

True potato seeds are formed in small fruits produced on potato plants and the fruits are termed as berries. Singh (1999) reported that depending on genotype and environment, a single potato plant may have 50-100 berries; single berry contains 150-200 seeds and 1 g TPS may contain 1500-2000 seeds. He also mentioned that TPS technology is labour-intensive and requires less initial capital for raising a potato crop. This combination suits to small and marginal farmers of developing countries who have generally plenty of family labourers and less capital. Kadian *et al.* (1987) pointed out that in the developing countries TPS technology can successfully be adopted by the farmers in those areas where i) seed tuber cost is very high, ii) yields are very poor due to non-availability of good quality seed and iii) cheap labour is easily available.

Chilver *et al.* (1999) reported that the on-farm profitability of TPS related technologies was assessed in several agro-ecologies in Egypt, India, Indonesia and Peru based on results of on-farm research conducted in the mid 1990s. TPS technology was found substantially more profitable than clonal propagation. TPS seedling tubers gave heavy yields compared to standard cultivars. They also suggested that prospects for TPS technologies were reasonably good when the cost of planting material in the conventional system exceeds 22% of the value of production.

According to Hussain (2000), in Bangladesh major breakthrough in free seed potato production has taken place by the efforts of private sectors companies through adopting i) Tissue culture technique and ii) True seed technology. If these technologies are fully exploited, cost of seed potato will be reduced at the farmers level. Elias *et al.* (1997) suggested that

Bangladesh condition only 40-45g of TPS is needed to sow 200 m^2 of nursery bed area which will produce sufficient amount of seedling tubers necessary to plant one hectare of land in the next year to produce seed potato or were potato.

The Bangladesh Agricultural Research Institute (BARI) has released two hybrid TPS varieties, namely, BARI TPS-1 and BARI TPS-2 (Razzaque *et al.*, 2000).

True potato seed can be used for potato production in three different methods methods (Sadik. 1983, Chaudhury *et al.*, 1987; Upadhya *et al.*, 1990; Kadian *et. al.*, 1992):

i) Direct field sowing of TPS

ii) Transplanting of seedlings raised in beds to the field

iii) Production of seedling tubers through direct sowing of TPS in raised beds which are then used as planting material in the subsequent years either for seed potato production or for ware potato production.

2.4 Production of TPS seedling tubers in nursery bed

Research results and experiences indicate that areas where the growing season of potato is short like Bangladesh, among the various methods of TPS use, production of seedling tubers in raised beds for use as seed tuber in the subsequent years is relatively advantageous and economic, and could be considered as an alternative technology in seed potato production (Tsao and Chang, 1982; Song, 1984; Anonymous, 1986; Chaudhury, 1989; Batra *et al.*, 1992; Kadian *et al.*, 1992 and Elias *et al.*, 1997). Sadik (1983) stated that potato seeds are small and germinate slowly over a narrow range of temperature. TPS sown directly in the field has little chance to germinate and develop into strong seedlings, except under optimal conditions of soil structure, moisture and temperature conditions. Because of these precise requirements, the use of transplants and seedling tubers derived from TPS have been suggested as practical methods for growing potatoes from true seed.

2.5 Utilization of TPS seedling tubers for potato production

Seedling tubers are normally produced in raised beds under high density planting, and a considerable success has been achieved in this regard under the agro-ecological conditions of Bangladesh (Sikka, 1987; Hossain *et al.*, 1994; Chaudhury and Rasul, 1995; Maleque, 1997; Choudhury, 1997; Alam, 1999). In high density seed sowing, seedling tubers of different sizes ranging from <1 g to >20 g are produced in nursery beds. Research results indicate that, seedling tubers of all sizes are potentially high quality planting material and can be used effectively in seed potato production (Rashid *et al.*, 1993; Anonymous, 1997; Kamaly, 1997 and Roy, 1997). Seedling tubers derived from TPS produce higher or equivalent yield with that of standard potato varieties and cam maintain better yield potential for at least 2-3 successive clonal generation of potato production without much reduction in yield (CIP, 1989; Pande *et al.*, 1990; Hossain *et al.*, 1992; Hossain *et al.*, 1994).

4.6 Effect of plant spacing on seedling tuber production from TPS

In a field trial Gregoriou (2000) planted seed tubers within-row spacings of 10, 20, 30 or 40 cm and reported that seedling emergence was reduced at 10 cm spacing. The author further reported that tuber yield decreased with increasing spacing. The best combination of total potato yield was estimated to be with a 30 cm planting distance.

An experiment was conducted by Yenagi *et al.* (2004) in 1995 and 1996 to determine optimum spacing for the potato cultivars, Awash, Menagesha and Tolcha and reported that there were significant varietal and spacing effects on seed tuber size, average tuber weight and number per square metre. The highest yields of 38.5, 62.6 and 46.5 t ha^{-1} were obtained for Awash, Menagesha and Tolcha, respectively, from a 45 cm between-row spacing with either 25 or 30 cm in-row spacing. However, in Menagesha tuber weight exceeding 40 mm constituted >80% of the total yield thus showing the need for a narrower in-row distance for seed size tuber production. In-row spacing regulated tuber weight more than yield. The cultivars showed different requirements for spacing for the development of optimum leaf area and maximum tuber number and yield.

An experiment was conducted by Ahire *et al.* (2000) at Rahuri, Maharashtra, India, during the rabi season of 1996-97. Treatments consisted of 2 row spacing (60 and 45 cm), 2 planting systems (normal and paired row) and 2 irrigation methods (trickle and surface). The authors reported that the wider spacing of 60 cm increased plant growth and tuber yield (20.29 t/ha) compared with the narrow spacing of 45 cm (17.86 t/ha). Normal planting resulted in higher growth and yield components compared to paired row planting.

Wadhwa *et al.* (2000) were transplanted fifty-day-old potato seedlings at 3 inter-row (40, 50 and 55 cm) and intra-row (5, 10 and 15 cm) plot spacings on one side of the furrow ridge during 14 and 15 December 1991 and 1992, respectively, in Hisar, Haryana, India and reported that plant height and growth was not influenced by spacing. Increases in plant to plant spacing from 5-10 and 10-15 cm decreased seedling mortality. The number of leaves, branches and tubers per plant increased, while yield and leaf dry weight decreased with an increase in row and plant spacing.

Conley *et al.* (2001) studied the effect of inter-row (76 and 91 cm) and intra-row (30 cm) spacing of potato cultivars (Russet Burbank, Russet Norkotah, Goldrush, Dark Red Norland, Snowden and Atlantic) and reported that the total marketable yield (TMY) and the net crop value (NCV) of the cultivars were higher in the 91 cm than in the 76 cm row spacing. Reduced weed biomass coupled with a high TMY and NCV indicated that the 91 cm row spacing was optimal for all cultivars.

The effects of intra-row spacing (15, 25 and 35 cm) and seed size (whole, half-seed and farmer's seed piece) on the growth and yield of potato were investigated by Khalafalla (2001) during winter of 1991, 1992 and 1993 at Shambat and Shehainab in Sudan. The author observed that yield decreased with decrease in seed size and increase in spacing at both locations. Seed size had significant effect on marketable tubers per plant, marketable tuber weight, and number of stems per plant. Plant spacing had significant effect on these parameters, except for number of stems per plant.

The effects of shade, unshaded control (C), 48% shading and 76% shading at different growth stages, vegetative to beginning of tuber initiation (stage I), tuber initiation to initial tuber bulking (stage II) and tuber bulking to maturity (stage III) on nitrate reductase (NR) activity, plant growth and yield of field grown potatoes (*Solanum tuberosum* cultivars May Queen and Dejima) under two levels of spacing, (66 cm × 30 cm and 66 cm × 15 cm) were studied by Ghosh *et al.* (2002). The authors observed that main stem length was increased by denser plant spacing but decreased stem and leaf number $plant^{-1}$. Denser plant spacing also increased the leaf area index (LAI).

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

An experiment was conducted by Yenagi *et al.* (2002) during the Kharif season of 1999 in Dharwad, Karnataka, India to determine the optimum row spacing (45 and 60 cm), planting date (18 and 25 June and 10 July) and N level (0, 50, 100, and 150 kg/ha) requirements of potato (cv. Kufri Chandramukhi) and reported that high tuber yield was obtained with 45 cm spacing (12.21 tha^{-1}) than 60 cm spacing, 18 June planting (12.76 t ha^{-1}) and application of 150kg Nha^{-1}(15.68 tha^{-1}).

Fifty-day-old potato cv. HPS-1/13 seedlings were planted at 45, 50 and 55 cm row spacing and 5, 10 and 15 cm plant spacing in a field experiment conducted in Haryana, India during 1991-92 by Wadhwa *et al.* (2002) to determine the optimum spacing for transplanting potato seedlings. The authors reported that plant and row spacing did not influence plant height. The number of branches per plant was not influenced by row spacing but increased with increasing plant spacing. Crop yield and dry weight of foliage were highest at 45 cm row and 5 cm plant spacing while the number of tuber plant was highest with 55 cm row spacing and 15 cm plant spacing.

Khurana and Bhutani (2003) studied the effect of spacing (60 ×15 and 60 × 10 cm), fertilizer rate and crop duration on the production of seed number of stems per plant tubers of potato and reported that the number and yield of small (<10 g) and medium-sized tubers increased with decrease in spacing from 15 to 10 cm.

Trials were conducted in 2000, 2001 and 2002 in Tamil Nadu, India by Ravichandran and Singh (2003) to investigate suitable agro-techniques for obtaining the maximum number of seed size tubers from potato cultivars Kufri Swarna and Kufri Jyoti. Treatments included: tuber weights of 10-20, 20-30, 30-40 and 40-50 g; intra-row spacing of 10, 15 and 20 cm; and 2 dates of haulm killing (75 and 90 days after planting). The authors observed that in both cultivars, 30-50 and 20-50 g tubers, may be used at an intra-row spacing of 10 cm, and with haulm killing at 90 days after planting to obtain the maximum number of seed size tubers.

An experiment was conducted by Suman *et al.* (2003) with potato cv. Kufri Sutlej in Hisar, Haryana, India, in 2001, involving 3 plant spacings (10, 15 and 20 cm) and 2 crop durations (75 and 85 days) and reported that decrease in plant spacing increased stems per unit area, plant height, haulm weight, total as well as number of different size tubers per unit area, and yield of total as well as of >25-50, >50-75 and >75 g size tubers.

A field experiment was conducted by Shingrup *et al.* (2003) on clayey soil during the rabi season of 1999-2000 at the farm of the Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India, to study the effect of row spacing, seed tuber size and fertility level on the economics of potato cultivation. The authors reported that that cost of cultivation and gross monetary returns were significantly greater under 45 cm row spacing, as compared to 60 cm row spacing.

Yadav *et al.* (2003) studied the effects of irrigation level and spacing (15, 20 or 25 cm) on the performance of potato cv. Kufri Sutlej were studied in Hisar, Haryana, India and reported that yield (153.32 and 104.94 quintal/ha) and number (101.46 and 84.32 per plot) of large tubers were highest with a spacing of 20 cm.

An experiment was conducted by Sonawane and Dhoble (2004) during the winter (rabi) seasons of 1996-97 and 1997-98 in Maharashtra, India, to find out suitable and economical combination of inter and intra row spacing with seedling tuber size of potato (*Solanum tuberosum*). The authors observed that significant increase in the tuber yields was recorded due to spacing of 45 cm. The intra-row spacing of 10 cm was at par with 15 cm, but was significantly superior to 20 cm plant spacing. The net returns and benefit cost ratio, plant spacing of 15 cm was found advantageous over 10 and 20 cm, whereas row spacing was equally effective.

Yenagi *et al.* (2004) conducted an experiment during kharif 1999 at the Main Agricultural Research Station of the University of Agricultural Sciences in Dharwad, Karnataka, India, to determine the effect of row spacing (60 and 45cm), planting date (18 June, 25 June and 10 July) and nitrogen rate (0, 50, 100 and 150 kg N/ha) on the tuber grade, yield and economics of potato (cv. Kufri Chandramukhi) and reported that higher tuber yield (12.21 t ha^{-1}) was recorded with narrow row spacing (45 cm), although more A-grade tubers were recorded with the wider row spacing. However, the net income (Rs. 41 906 ha^{-1}) and B:C ratio of 2.84 were higher with treatment combination of June 3rd week planting with 45-cm row spacing supplied with 150 kg N ha^{-1}.

A field experiment was conducted by Yenagi *et al.* (2005) during the kharif season in Dharwad, Karnataka, India, on potato to determine the effect of row spacing (45 and 60 cm), planting date (18 and 25 June, and 10 July) and N fertilizer rates (0, 50, 100 and 150 kg/ha) and reported that plant height, leaf area index, total dry matter production, crop growth rate, tubers per plant and tuber yield was highest with 45 cm row spacing, 18 June planting and 150 kg N/ha supplementation. Tuber weight was highest with 60 cm row spacing, 18 June planting and 150 kg N/ha supplementation.

Kushwah and Singh (2008) conducted an experiment during 2004-05, in Madhya Pradesh, India, to evaluate the effects of intra-row spacing (10.0, 12.5, 15.0, 17.5, 20, 22.5 and 25.0 cm) and haulm cutting date (60, 65, 70, 75 and 80 days after planting (DAP)) on the production of small-sized tubers of potato. Data were recorded for plant height, stems plant^{-1}, fresh haulm weight, tuber yield per hectare and NPK content of soil after potato harvest. Intra-row spacing of 25 cm and haulm cutting at 80 DAP recorded the highest values for plant height, stems per plant, fresh haulm weight, tuber yield per hectare and NPK content of soil as well as the highest net returns and benefit cost ratio.

Bayorbor and Gumah (2007) studied the effects of four different 'seed' tuber weights and three intra-row spacing on the yield and yield components of 'Frafra' potato. The 'seed' tubers were categorized according to weight: A (10. 0 g), size B (7.0-9.9 g), size C (3.0-6.9 g) and size D (<3.0 g); three intra-row spacings of 20 cm, 30 cm and 40 cm were also used. Neither 'seed' tuber nor spacing had significant effect on percentage survival at three (3) weeks after planting (WAP), number of branches at 3WAP and 6WAP, number of tubers and tuber weight. However, percentage survival at 6WAP reflected the importance of relatively large 'seed' tubers and wide plant spacing. The response of the leaf area index (LAI) to intra-row spacing was also significant with plants closely spaced exhibiting the highest LAI. Yield increased with decreasing intra-row spacing: 20 cm > 30 cm > 40 cm. The plants produced by category B 'seed' tubers and 20 cm intra-row spacing were the most promising in terms of yield, they reported.

To improve the production of seed-size potato tubers, 31 experiments were conducted in India, from 1999 to 2003 at 9 centres, situated in different agroclimatic regions of the country by Garg *et al.* (2008). Two levels each of spacing (60 × 15 and 60 × 10 cm), fertilizer rates (100 + 35 + 66 and 150 + 52 + 66 kg of N + P + K/ha, respectively) and dates of haulm cutting (70 and 80 days after planting) were imposed on popular potato cultivars of the regions. The authors reported that yield of seed-size tuber at closer spacing (13.9 t/ha) increased by a 15.7% compared to that at wider spacing. Economics of potato cultivation for production of seed size tubers also favoured planting at wider spacing (60 × 15 cm), with higher fertilizer rate (150 + 52 + 66 kg of N + P + K/ha) and dehaulming at 80 days after planting.

The growth (plant height, number of stem per hill, leaf area and total dry matter production (leaves, stems and tubers plant^{-1}), yield and quality (reducing sugar content) of potato cv. 'Kufri Pukraj' were evaluated at different intra-row spacings (60 × 15, 60 × 20 and 60 × 25 cm) and fertilizer levels by Kumar *et al.* (2009). The author reported that potato seed crop grown by seed tuber at a spacing of 60 × 15 cm with application of 125% of the RDF (recommended dose of fertilizer), followed by 60 × 20 cm with application of 100% of the RDF, was proved advantageous to obtain higher yield of seed-size tuber as well as total tuber yield/ha during the rainy season.

Optimizing plant density and seed size are the most important subjects of potato production systems due to their effects on seed cost, plant development, yield and quality of the crop. In this relations an experiment was conducted by Gulluoglu and Aroglu (2009) to know the effects of different in-row spacing (20, 25, 30 and 35 cm) and seed size (small, medium and large) treatments on yield components and tuber yield of potato. The authors observed that closer spacing reduced tubers hill^{-1}, average tuber weight, tuber yield per hill and percentages of large and medium weight tubers. Total yields increased as increasing planting density up to 20 cm spacing. The authors opined that seed size should be considered during recommendation for planting density in potato production.

To maintain 100 seedlings per sq. m., three different spacing (10 × 10 cm, 25 × 4 cm and 14 × 17 cm) were studied by Kadian *et al.* (1990) to select the best one for seedling tuber production. The differences among the three spacing for tuber yield, tuber number and average tuber weight were non-significant. To maintain 100 seedlings per sq. m., two planting geometry (25 × 4 cm and 10 × 10 cm) were studied by Chaudhury and Rasul (1995) for seedling tuber production in beds. 25 cm × 4 cm sowing system produced 10.3% higher yield and also required 14.3% lower labour cost over 10 cm x 10 cm sowing system. Hoque (2000) stated that in a field experiment, three spacing (10 × 10, 25 × 4 and 20 × 5 cm) failed to produce any significant effect on seedling tuber production from TPS in beds. Siddique (1995) reported that when TPS were sown in l0 m × l0 m beds at a spacing of 25 cm × 4 cm, a high yield of seedling tubers was obtained and out of the seedling tubers produced, 13% were of 1-5 g size, 54% of 5-20 g size and 33% of above 20 g size.

In a field trial at BAU, Mymensingh, six spacing (25 × 4, 30 × 4, 25 × 6, 30 × 6, 25 × 8 and 30 × 8 cm) was made by Choudhury (1997) for seedling tuber production from TPS in bed. The number and weight of seedling were significantly higher at wider spacing. Tuber yield per unit area significantly with the decrease in plant spacing and the highest yield was obtained from the closest spacing of 25 cm × 4 cm. A planting density of 100 plants/m^2 (25 cm × 4 cm) was found optimal for the of TPS seedling tubers in beds. In another experiment, Sarker and Kabir (1989) studied nine different spacing from 10 cm × 5 cm to 30 cm × 15 cm for seedling tuber production in beds and found that the maximum foliage was obtained from the closest spacing (10 × 5 cm). This spacing also gave the highest yield (39.67 t/ha), while the lowest yield (24.17 t/ha) was from the widest spacing (30 × 15 cm). The maximum number of tuber was also produced from closer spacing. But in a study at BAU, Mymensingh, Siddique (2001) found no significant variation in the yield of TPS seedling tuber per unit area due to variation in plant density in the range of 250 plants/m^2, which indicates that above the population of 100 plants/m^2 the yield of seedling tuber did not increased significantly.

In a trial where TPS seedlings were transplanted at nine different spacing (50 × 33 cm to 10 × 10 cm), the yield and number of seedling tubers were increased but average weight of tubers decreased with the increase of spacing (Anonymous, 1986).

Singh (1994) found that the higher plant population in the same inter- row spacing gave higher yields. On an average 10 cm intra-row spacing gave 15.5% more yield over 15 cm and 30.7% over 20 cm intra-row spacing. The number of tubers produced per plant was increased with increasing in spacing, but higher number of tuber/sq. m was obtained from closer spacing.

Upadhya *et al.* (1990) obtained higher yield at higher plant density. It was observed that spacing could not affect much the production of >80 g and <10 g tubers. Medium sized tuber was significantly influenced due to spacing. A spacing of 30 × 10 cm gave production in the ratio of 10:57:33 of large (>80 g), medium (20-80 g) and small (<20 g) tubers respectively; whereas 40 × 10 cm spacing gave production in the ratio of 9:57:34 and 50 × 10 cm spacing gave in the ratio of 12:58:30.

A field trial was conducted at the Horticulture Farm, BAU, Mymensingh by Kabir (2001) which consisted of six plant spacings viz. 20 × 4, 20 × 8, 25 × 4, 25 × 8, 30 × 4 and 30 × 8 cm and three dates of harvesting viz. 95, 102 and 109 DAS with a view to standardize optimum plant spacing and also to find our optimum date of harvesting for the production of TPS seedling tubers. The result of the experiment reveal that the number and weight of tubers per plant were maximum in the widest spacing (30 × 8 cm) and increased up to the final harvest (109 DAS). But the highest yield (35.85 t/ha) was obtained from the closest spacing of 20 × 4 cm, which was closely followed by the yield of 25 × 4 cm spacing. The yield also increased gradually with delay in harvesting and maximum yield (35.93 t/ha) was obtained at final harvest (109 DAS).

Uddin *et al.* (2001) reported that in an on-farm trial at Rangpur for seedling tuber production from TPS, 25 × 4 cm spacing gave higher yield than 10 × 10 cm spacing. Farmers also opined that intercultural operations, application of fertilizers and pesticides etc. were easier at 25 × 4 cm spacing than that of 10 × 10 cm spacing.

Gojski (1979) conduced a trial with various seed sizes and the materials were planted at 10, 20, 30 and 40 cm spacing. He observed that haulm mass increased due to increased spacing and larger seed tubers.

Bishop and Wright (1959) observed that the size of tubers produced was related to the plant spacing. Kamal and Khan (1973) reported that increased spacing decreased the yield of potato and closest spacing gave the highest yield. Eddowes (1975) observed that higher total yield was always associated with closer spacing and higher seed weight per hectare.

Cloete and Els (1982) reported that a positive correlation was found between number of stems per plant and yield. As the number of step increased by planting large tubers or by closer spacing the total yield increased.

Khurana (1990) reported that seedling tubers of nine TPS families were tested against two seed sizes (10 g and 20 g). Seedling tubers of 10 g were planted at 60 × 12 cm and 20 g at 60 × 20 cm spacing. The crop raised from 10 g tubers gave lower yield that that raised from 20 g tubers. Major difference in yield was due to a reduction in proportion of large size tubers. The mean tuber weight of the crop raised from 10 g tubers was also lower than for the crop raised from 20 g tubers.

Wiersema (1982) suggested that for the production of ware potato from tuber of 1-5 g size the Spacing should be 50 cm × 10-15cm. He also found that the multiplication rate (yield/planting rate) for small (1-5 g) seedling tubers was the highest (33) compared to 10-20 g sized (23) and 40-60 g sized (10) seedling tubers. To find out an optimum planting density of seedling tubers, two spacing (50 cm × 20 cm and 50 cm × 10 cm) were studied by Saikia and Rajkhowa (1998) and they found that both total and marketable yields were higher in closer spacing (50 cm × 10 cm) over the spacing of 50cm × 20 cm.

According to Singh *et al.* (1998) four nitrogen doses (100, 150, 200 and 250 kg N/ha) and three different seed sizes (<10 g, 10-20 g and 20-30 g) were studied for potato production from seedling tuber with a spacing of 60 × 20 cm and they obtained highest tuber yield from large (20-30 g) sized seeds and lowest yield from small (<10 g) seeds Singh *et al.* (1999) reported that four sizes of seedling tubers (5-10, 10-20, 20-40 and >40 g) in addition to 40-60 g size seed tubers of Kufri Badsha were compared for tuber yield. The total tuber yield as well as marketable tuber yield increased with increase in seedling tuber size, however, seedling tuber sizes 10-20, 20-40 and >40 g were not significantly different. Yield of Kufri Badsha was statistically at per with the yield of 5-10 g size seedling tubers.

Four sizes of seedling tubers (5 g, 10 g, 20 g and 30 g) in combination with four interplant spacing (10, 15, 20 and 25 cm) were studied for potato production by Rashid *et al.* (1993). Closer planting as well as larger seedling tubers increased tuber yield significantly. Closer spacing produced a higher proportion of small tubers, while larger seedling tubers produced more large tubers. In case of multiplication rate, when the seed weight was considered, smaller seeds yielded much higher that larger ones. The multiplication rate was 31.3 and 8.3 times for 5 g and 30 g seeds, and 14.6 and 19.0 times for 60 × 15 cm and 60 × 30 cm spacing respectively.

Chaudhury and Rasul (1995) reported that small (<20 mm), medium (20-28 mm) and large (>28 mm) sized seedling tubers were studied at 60 × 10, 60 × 15 and 60 × 20 cm spacing respectively and irrespective of seed size the yield was found to be increased with the increase of plant population. Four sizes of seedling tubers (5.0, 7.5, 12.5 and 17.5 g) and four depth of planting (surface level, 2.5, 5.0 and 7.5 cm) was studied at BAU, Mymensnigh by Sultana (1998) for potato production from seedling tubers. Seedling tuber size significantly influenced the growth and yield of potato. The yield as found to increase with the increase of seedling tuber size and the maximum yield (39. 34 t/ha) was obtained from the large seeds.

A trial with four different sizes of seedling tubers (5, 5-10, 10-15 and 15-20 g) combined with four spacing (60 × 10, 60 × 15, 60 × 20 and 60 × 25 cm) was conducted by Islam (1992) at BAU, Mymensingh. Plant vigour and foliage coverage was significantly higher at early stage of plant growth when large were planted at closer spacing. However, at the later stage no significant variation was observed. The number of tuber/hill and yield increased when larger seeds and closer spacing were used. The multiplication rate on the basis of unit of weight of seed was higher in smaller seeds than larger ones.

Three sizes of seedling tubers (<15 mm planted at 60 x 10 cm spacing, 15-20 m planted at 60 x 15 cm spacing and 21-28 mm planted at 60 × 20 cm spacing) were studied by Roy (1997) and found that number and weight of tubers per hill increased with the increase in seedling tuber size, but significantly higher yields of total and seed grade tubers were obtained from small seedling tubers, particularly due to closer planting.

4.7 Effect of number of TPS hill^{-1} on seedling tuber production from TPS

The number of TPS seedling tubers produced per unit area is an important factor, because these are the planting materials to produce either seed potato or ware potato in the subsequent years. Seedling tubers produced per unit area is generally related to the plant population. In general wider spacing produce minimum and closer spacing produce maximum number of seedling tubers. According to Wiersema (1984) the optimum population density of seedlings in nursery beds was defined as that density whereby a large number of useable seedling tubers (1 g and above) are produced but whereby close plant spacing would not hinder agronomic practices.

According to CIP (1984) the productivity of TPS can reach as high as 1500 useable seed tubers/m^2 under optimal conditions, with a plant population of 100 plants/m^2 after thinning.

According to Rashid *et al.* (1990) in a study with one or two TPS per hill for seedling tuber production in transplanting method, it was found that higher plant density increased the yield and number of seedling unit area but reduced the average tuber weight. Two TPS per hill produced higher yield and tuber number over one TPS.

Zakaria *et al.* (1992) in a study with one or two or three seedlings/hill, found that increasing plant density significantly increased the number of seedling tubers but decreased the average tuber weight. Three seedlings/hill with 10 × 10 cm spacing though produced the highest number of seedling tubers but its yield was not the highest. Significantly highest yield was obtained with 2-seedlings/hill.

Engels *et al.* (1993) found that tuber yields from small seedling tubers to produce tubers of marketable weight decreased with decreasing seedling tuber size.

According to Nankar (1990) nearly 50% of the seedling tubers produced in nursery beds were below 5g size. To assess the possibility of using <5 g seedling tubers as planting material one, two and three seedling tubers/hill were planted in the inter-cropping system. Three seedling tubers/hill gave the highest yield. To evaluate the potential of seedling tubers of TPS families for commercial potato production, seedling tubers of 15-35 mm size were tested by Kadian *et al.* (1992). In comparison to smaller tuber size, the larger tubers gave better performance for yield. Marketable yield and tuber size declined marginally with decreasing seedling tuber size.

Chapter III

Materials & Methods

CHAPTER III

MATERIALS AND METHODS

This chapter presents a brief description about experimental period, site description, climatic condition, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis. The details of experiments and methods are described below:

A - 39786 16.11.16

3.1 Experimental period

The experiment was conducted during the period from November 12, 2013 to February 03, 2014 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The present piece of research work was conducted in the experimental plot of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is $23^{0}74^{\prime}$N latitude and $90^{0}35^{\prime}$E longitude with an elevation of 8.2 m from sea levels (Anon, 1989). The experimental site was shown in the map of Bangladesh in Appendix I.

3.2.2 Agro-Ecological Region

The experimental site belongs to the agro-ecological zone of "Modhupur Tract", AEZ-28 (Anon., 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur

Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988b). The agro-economic region was shown in the map of AEZ of Bangladesh in Appendix II.

3.2.3 Soil

Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood levels. The selected plot was medium high land. The details were presented in Appendix III.

3.2.4 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone, set a parted by winter during the months from November, 10 to Marcy, 10 (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix IV.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

3.3 Details of the Experiment

3.3.1 Experimental treatments

The experiment consisted of two factors such as plant spacing and number of TPS hill^{-1}. The treatments were as follows:

Factor A: Plant spacing (3 levels)
S_1 – 25 cm × 4 cm
S_2 - 25 cm × 5 cm
S_3 - 25 cm × 6 cm

Factor B: number of TPS hill^{-1} (3 levels)
P_1 – 1 TPS hill^{-1}
P_2 – 2 TPS hill^{-1}
P_3 – 3 TPS hill^{-1}

Nine treatment combinations were as:

S_1P_1 = 25 cm × 4 cm with 1 TPS hill^{-1}

S_1P_2 = 25 cm × 4 cm with 2 TPS hill^{-1}

S_1P_3 = 25 cm × 4 cm with 3 TPS hill^{-1}

S_2P_1 = 25 cm × 5 cm with 1 TPS hill^{-1}

S_2P_2 = 25 cm × 5 cm with 2 TPS hill^{-1}

S_2P_3 = 25 cm × 5 cm with 3 TPS hill^{-1}

S_3P_1 = 25 cm × 6 cm with 1 TPS hill^{-1}

S_3P_2 = 25 cm × 6 cm with 2 TPS hill^{-1}

S_3P_3 = 25 cm × 6 cm with 3 TPS hill^{-1}

3.3.2 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with five replications thus comprised 45 plots. The layout of the experiment was prepared for distributing the combination of plant spacing and number of TPS hill^{-1}. The size of each unit plot 10 m × 1 m.

The spacing between blocks and plots were 1.0 m and 1.0 m, respectively.

3.4 Planting material

The planting materials comprised the TPS seedling tubers of BARI TPS-I. The variety is a hybrid between female parent MF-II and male parent TPS-67 and was released by the National Seed Board (NSB) during 1997. Plants of the variety are medium with spreading habit, tuber are turned oval, shining creamy skin with light yellow flesh (Razzaque *et al.*, 2000).

3.5 Crop management

3.5.1 Collection of seed

All variety of seed potato (certified seed) was collected from, Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5.2 Preparation of seed

Collected seed were kept in room temperature to facilitate sprouting.

3.5.3 Land preparation

The land of the experimental site was first opened in the last week of October with power tiller. Later on, the land was ploughed and cross-ploughed four times followed by laddering to obtain the desirable tilth. The corners of the land were spaded and weeds and stubbles were removed from the field. The land was finally prepared on 10 November 2013 three days before planting the seed. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @10 kg ha^{-1} when the plot was finally ploughed to protect the young plant from the attack of cut worm.

3.5.4 Fertilizer application

The crop was fertilized as per recommendation of TCRC (2004). The experimental plot was fertilized with following dose of urea, triple super phosphate (TSP) and Muriate of Potash (MoP).

Fertilizers	**Dose ($kg\ ha^{-1}$)**	**Dose ($g\ plot^{-1}$)**
Cowdung	5,000	2500
Urea	175	87.50
TSP	115	57.50
MoP	210	105.00

Source: Mondal *et al.*, 2011.

Cowdung was applied 10 days before final land preparation. Total amount of triple superphosphate, muriate of potash and half of urea was applied at basal doses during final land preparation. The remaining 50% urea was side dressed in two equal splits at 35 and 50 days after sowing (DAS) during first and second earthing up.

3.5.5 Application of mulch treatment

Mulches of rice straw was applied immediately after seed sowing.

3.5.6 Sowing of seed

The healthy and uniform sized TPS were sowed. On an average, TPS were sowed at 1-1.5 cm depth in plot on November 12, 2013.

3.5.7 Intercultural operations

3.5.7.1 Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully after complete emergence of sprouts and afterwards when necessary.

3.5.7.2 Watering

Frequency of watering was done upon moisture status of soil retained as requirement of plants. Excess water was not given, because it always harmful for potato plant.

3.5.7.3 Earthing up

Earthing up process was done by pouring the soil in the plot at two times, during crop growing period. First pouring was done at 35 DAS and second was at 50 DAS.

3.5.7.4 Plant protection measures

Dithane M-45 was applied at 30 DAP as a preventive measure for controlling fungal infection. Ridomil (0.25%) was sprayed at 45 DAP to protect the crop from the attack of late blight.

3.5.7.5 Haulm cutting

Haulm cutting was done at February 22, 2014 at 100 DAS, when 40-50% plants showed senescence and the tops started drying. After haulm cutting the tubers were kept under the soil for 10 days for skin hardening. The cut haulm was collected, bagged and tagged separately for further data collection.

3.5.7.6 Harvesting of seedling tuber

Harvesting of seedling tuber was done at March 3, 2014 at 10 days after haulm cutting. The potatoes of each plot were separately harvested, bagged and tagged and brought to the laboratory. The yield of seedling tuber $hill^{-1}$ was determined in gram. Harvesting was done manually by hand.

3.5.8 Grading of seedling tubers

After harvest, the tubers were graded in different size grades. Grading was done manually with the help of a grader. The seedling tubers from TSP were graded in four grades viz. <1-5 g, >5-10 g, >10-20 g and >20 g size. Grade-wise weight of seedling tubers was recorded.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

3.5.9 Recording of data

Experimental data were recorded from 30 DAS and continued until harvest. The following data were collected during the experimentation.

3.5.10 Experimental measurements

A brief outline of the data recording procedure followed during the study is given below:

i. Plant height (cm)

Plant height refers to the length of the plant from ground levels to the tip of the tallest stem. It was measured at an interval of 15 days starting from 30 DAS till harvesting time. The height of each plant of each plot was measured in cm with the help of a meter scale and mean was calculated.

ii. Foliage coverage (%)

The foliage coverage (%) was determined by visual observation, on the basis of % soil area covered by the foliage and was recorded at 30, 60 and harvesting time.

iii. Number of seedling tuber m^{-2}

The number of seedling tubers m^{-2} was recorded from the middle (1 m × 1 m area; 4 rows of 1 m each with 25 cm inter-row spacing) of each unit plot.

iv. Average weight of seedling tuber

The average weight of seedling tuber was recorded in gram (g) from the per m^2 data of each unit plot, using following formula:

$$Average\ seedling\ tuber\ weight\ (g) = \frac{Weight\ of\ seedlingtuber\ m^{-2}\ in\ gram}{Number\ of\ seedling\ tuber\ m^{-2}}$$

v. Yield of seedling tubers m^{-2}

The yield of seedling tubers m^{-2} was recorded in kilogram (Kg) from the middle (1 m × 1 m area; 4 rows of 1 m each with 25 cm inter-row spacing) of each unit plot.

vi. Yield of seedling tubers per hectare

The effective yield of seedling tubers per hectare was calculated from the per m^2 yield data and was recorded in tonnes, considering the yield of seedling tubers in the effective bed area of 6350 m^2/ha (635 standard beds per hectare each measuring 10 m × 1 m, with a bed to bed spacing of 1 m in all directions). The yield of seedling tubers per hectare was thus calculated as follows:

$$Yield\ (t\ ha^{-1}) = \frac{Yield\ of\ seedling\ tubers\ m^{-2} in\ kg}{1000} \times 6350$$

vii. Grade of seedling tubers

The seedling tubers harvested from 1 m^2 area of each unit plot were graded in to four size grades (<1-5 g, >5-10 g, >10-20 g and >20 g) and the yield of seedling tubers in each grade was recorded in weight (kg). Using the data of seedling tubers in each grade by weight and the yield of seedling tubers per hectare, yield of different grades of seedling tubers in tonnes per hectare was estimated for each replication of treatment.

3.6 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C treatment means were compared by Least Significant Different (LSD) at 5% levels of probability (Gomez and Gomez, 1984).

3.7 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of plant spacing and number of TPS $hill^{-1}$. All input cost and interest on running capital were considered in computing the cost of production. The interest on running capital was calculated @ 16% per year for six months. In order to determine the gross reture, the price of small (<1-10 g), medium (10-20 g) and large (>20 g) size TPS seedling tubers were considered to be Tk. 12, 10 and 8 per kg, respectively at harvest. The benefit cost ratio (BCR) was calculated as follows:

$$Benefit\ cost\ ratio = \frac{Gross\ return\ per\ hectare\ (Tk.)}{Total\ cost\ of\ production\ per\ hectare\ (Tk.)}$$

Chapter IV

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the response of spacing and number of TPS hill^{-1} on the growth, yield and economic return of seedling tuber derived from true potato TPS (TPS). The results obtained from the study have been presented, discussed and compared in this chapter through table(s), figures and appendices. The analysis of variance of data in respect of all the parameters has been shown in Appendix V-VIII. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

4.1 Plant height (cm)

4.1.1 Effect of spacing

Significant variation of plant height was found due to different spacing in all the studied durations (Figure 1 and Appendix V). At 30, 45, 60 DAS and at harvest, the tallest plant (7.60, 18.95, 37.65 and 67.40 cm, respectively) was obtained fromS_1treatment (25 cm × 4 cm); whereas, the shortest plant (6.35, 17.80, 32.75 and 63.65 cm, respectively) was obtained from S_3 treatment (25 cm × 6 cm).

4.1.2 Effect of number of TPS hill^{-1}

The plant height of potato was measured at 30, 45, 60 DAS and at harvest (Figure 2 and Appendix V). It was evident from Figure 2 that the height of plant was significantly influenced by different number of TPS hill^{-1} at 60 DAS and at harvest but was non-significant at 30 and 45 DAS. Figure 2 showed that plant height increased with advancing growing period irrespective of number of TPS $hill^{-1}$, the potato plant height increased rapidly at the early stages of growth and rate of progression in height was slow at the later stages.At 30 DAS, P_1treatment (1 TPS $hill^{-1}$)showed the tallest plant (7.03 cm) and the shortest plant (7.00 cm) was found from P_3treatment (3 TPS $hill^{-1}$) which was statistically insignificant. At 45 DAS, P_3treatment (3 TPS $hill^{-1}$) gave the highest plant height (18.43 cm) and the lowest height was recorded from P_1treatment (1 TPS $hill^{-1}$)(18.33 cm) which was statistically insignificant. At 60DAS, P_3treatment (3 TPS $hill^{-1}$) gave the highest plant height (35.33 cm) which was statistically similar (35.02 cm) with P_2treatment (2 TPS $hill^{-1}$) whereas, the lowest height (34.70 cm) was recorded from P_1treatment (1 TPS $hill^{-1}$).At harvest, the tallest plant (67.00cm) was recorded from P_3treatment (3 TPS $hill^{-1}$) whereas, the shortest plant (63.57 cm) was obtained from P_1treatment (1 TPS $hill^{-1}$). Plant height of a crop depends on the plant vigor, cultural practices, growing environment and agronomic management. In the present experiment since potato was grown in the same environment and were given same cultural practices except number of TPS $hill^{-1}$.So, the variation of plant height might be due to the effect different number of TPS $hill^{-1}$.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

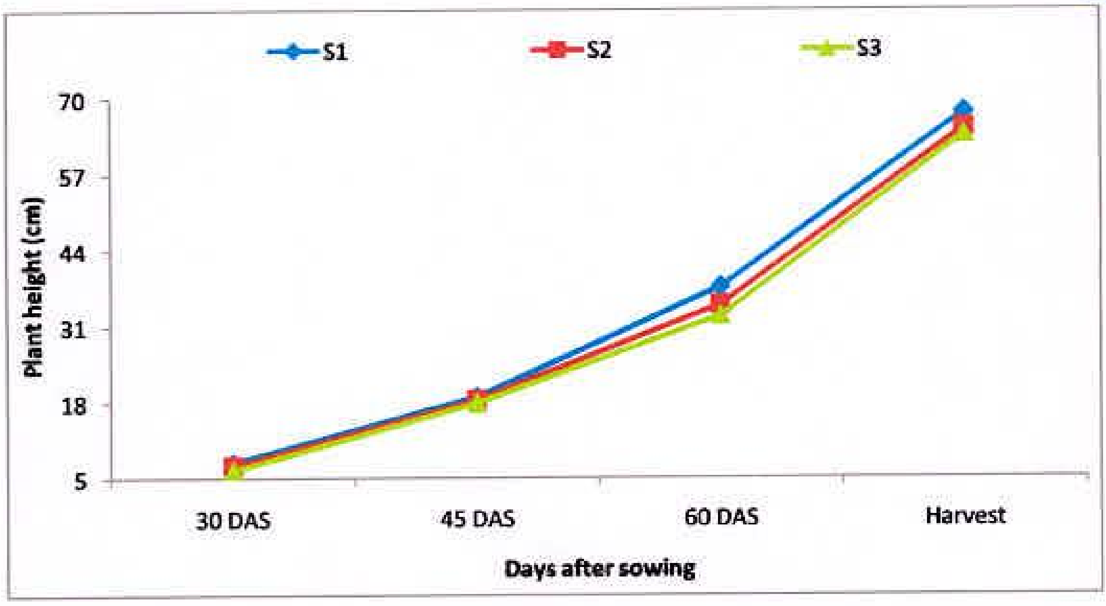


Figure 1: Effect of spacing on plant height (cm) of true potato TPS at different days after sowing (LSD value = 0.09, 0.29, 0.39 and 0.63 at 30, 45, 60 DAS and at harvest, respectively).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

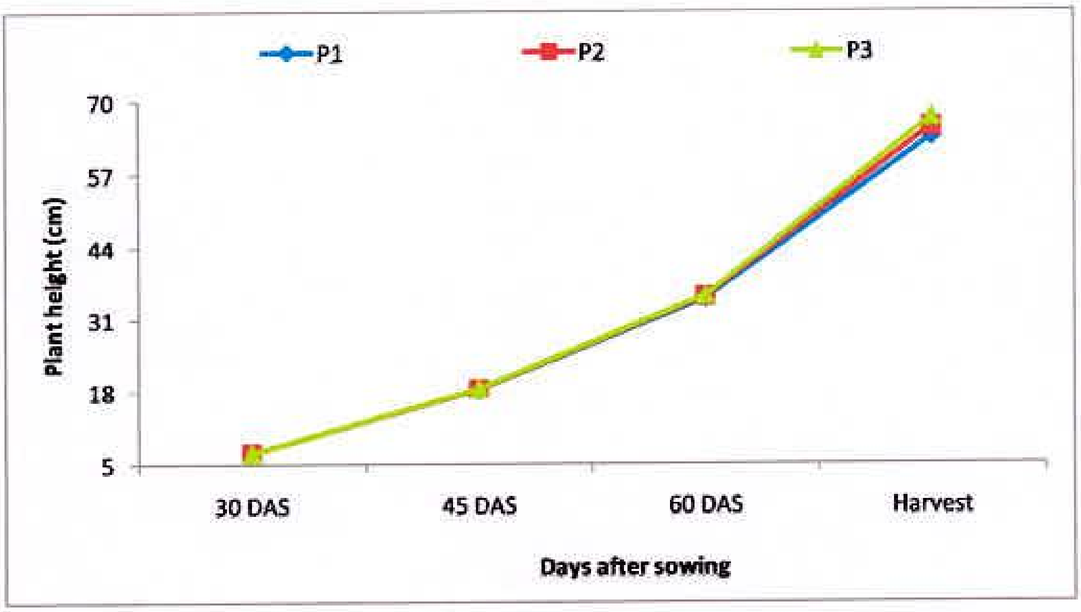


Figure 2: Effect of number of TPS hill^{-1} on plant height (cm) of true potato Seed (TPS) at different days after sowing (LSD value = NS, NS, 0.39 and 0.63 at 30, 45, 60 DAS and at harvest, respectively).

P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

4.1.3 Interaction effect of spacing and number of TPS hill^{-1}

Significant interaction effects of spacing and number of TPS hill^{-1} on plant height was observed at 30, 45, 60 DAS and at harvest (Table 1and Appendix V). Plant height increased with advancing growing period irrespective of spacing and number of TPS hill^{-1} (Table 1). At 30 DAS, the tallest plant (7.70 cm) was obtained from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS hill^{-1})and the shortest plant (6.20 cm) was obtained from the S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS hill^{-1}).At 45 DAS, the highest plant height (19.20 cm) was observed from the S_1P_1 treatment combination (25 cm × 4 cm spacing with 1 TPS hill^{-1}) which was statistically similar (18.95 cm) with S_2P_1 treatment combination (25 cm × 5 cm spacing with 1 TPS hill^{-1}), whereas; the lowest plant height (17.50 cm) was obtained from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS hill^{-1}).The tallest plant at 60 DAS (37.80 cm) was produced from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS hill^{-1}) which was statistically similar with S_2P_1 (37.65 cm) and S_1P_1 (37.50 cm) treatment combination. On the other hand, the shortest plant at 60 DAS (31.50 cm) was recorded from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPShill^{-1}).At harvest, the maximum height of plant (70.10 cm) was obtained from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS hill^{-1}) and the minimum height of plant (62.20 cm) was obtained from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS hill^{-1}).

Table 1: Interaction effect of spacing and number of TPS hill^{-1} on plant height (cm) of true potato TPS at different days after sowing

Treatments	Plant height (cm) at			
	30 DAS	45 DAS	60 DAS	Harvest
S_1P_1	7.50 c	19.20 a	37.50 a	64.70 d
S_1P_2	7.10 d	18.30 de	35.10 b	63.80 e
S_1P_3	6.50 e	17.50 g	31.50 f	62.20 f
S_2P_1	7.60 b	18.95 ab	37.65 a	67.40 b
S_2P_2	7.10 d	18.40 d	34.65 c	64.80 d
S_2P_3	6.35 f	17.80 f	32.75 e	63.65 e
S_3P_1	7.70 a	18.70 bc	37.80 a	70.10 a
S_3P_2	7.10 d	18.50 cd	34.20 d	65.80 c
S_3P_3	6.20 g	18.10 e	34.00 d	65.10 d
$LSD_{(0.05)}$	0.09	0.29	0.39	0.63
CV (%)	5.42	4.38	7.38	6.37

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.
S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm and P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

4.2 Foliage coverage (%)

4.2.1 Effect of spacing

Different levels of spacing exhibited significant variation in respect of foliage coverage. Results revealed that, the foliage coverage of potato plant decreased with increased spacing at 30 and 60 DAS and at harvest (Figure 3 and Appendix VI). At 30 and 60 DAS and at harvest, the maximum foliage coverage (29.00, 51.00 and 95.50 %, respectively) was observed from S_1 treatment (25 cm × 4 cm) and the minimum foliage coverage (20.70, 35.50 and 85.00 %, respectively) was observed from S_3 treatment (25 cm × 6 cm).

4.2.2 Effect of number of TPS hill^{-1}

Number of TPS hill^{-1} significantly influenced foliage coverage of potato plant at 30 and 60 DAS and at harvest (Figure 4 and Appendix VI). Foliage coverage increased with advancing growing period up to harvest (Figure 4). At 30, 60 DAS and at harvest, the highest foliage coverage (27.13, 47.67 and 94.60 %, respectively) was found in P_3treatment (3 TPS hill^{-1}) and the lowest foliage coverage (23.67, 36.67 and 85.67 %, respectively) was found in P_1treatment (1 TPS hill^{-1}). Study referred that the 3 TPS hill^{-1} exposed the best result in terms of foliage coverage.

4.2.3 Interaction effect of spacing and number of TPS hill^{-1}

There was significant variation observed due to the interaction of spacing and number of TPS hill^{-1} on the foliage coverage of true potato TPS at 30 and 60 DAS and at harvest (Table 2and Appendix VI). Foliage coverage increased with advancing growing period up to harvest irrespective of spacing and number of TPS hill^{-1} (Table 2).At 30, 60 DAS and at harvest, the maximum coverage of foliage (31.00, 57.00 and 98.00 %, respectively) was recorded from the combination of S_3P_1 treatment (25 cm × 6 cm spacing with 1 TPS hill^{-1}). On the other hand, the minimum coverage of foliage at 30 and 60 DAS and at harvest (19.00, 31.00 and 79.00 %, respectively) was obtained in the combination of S_1P_3 treatment (25 cm × 4 cm spacing with 3 TPS hill^{-1}).Present study showed that 25 cm × 6 cm spacing with 1 TPS hill^{-1} produced maximum foliage coverage.

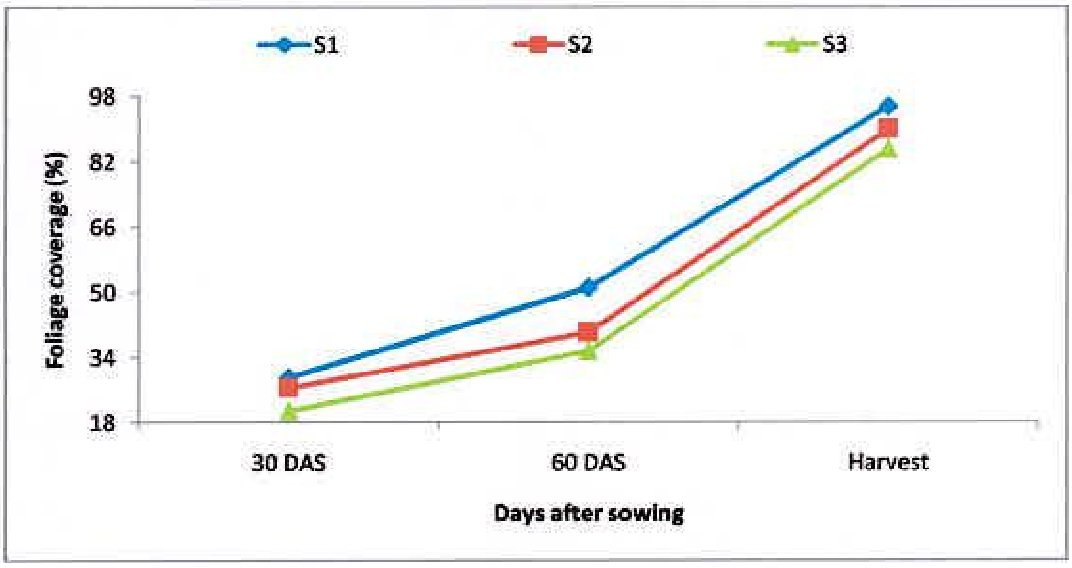


Figure 3: Effect of spacing on foliage coverage (%) of true potato Seed (TPS) at different days after sowing (LSD value = 0.84, 2.07 and 1.44 at 30 and 60 DAS and at harvest, respectively).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

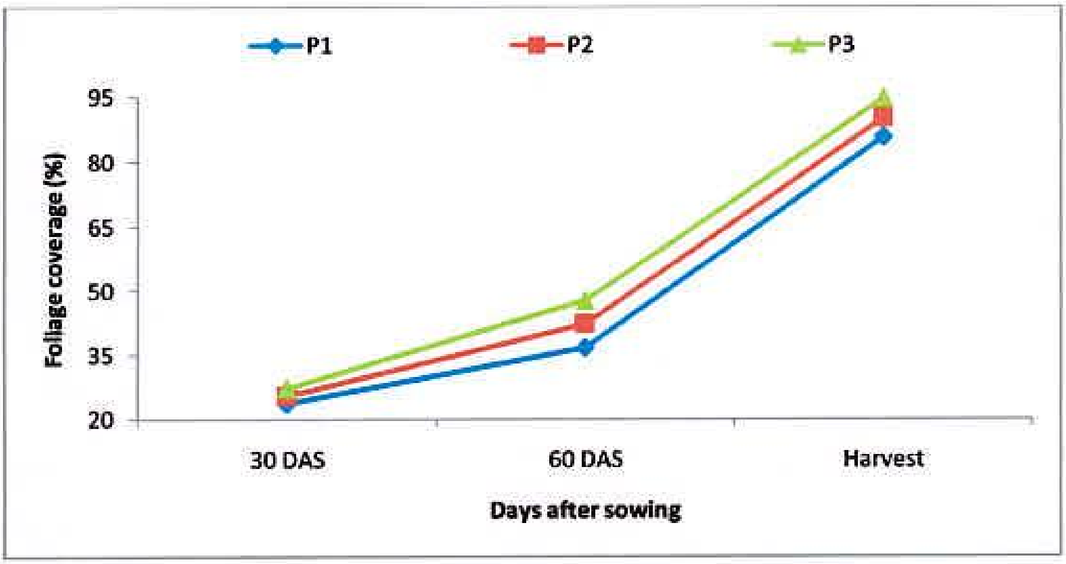


Figure 4: Effect of number of TPS $hill^{-1}$ on foliage coverage (%) of true potato Seed (TPS) at different days after sowing (LSD value = 0.84, 2.07 and 1.44 at 30 and 60 DAS and at harvest, respectively).

P_1 – 1 TPS $hill^{-1}$, P_2 – 2 TPS $hill^{-1}$, P_3 – 3 TPS $hill^{-1}$

Table 2: Interaction effect of spacing and number of TPS hill^{-1} on foliage coverage (%) of true potato TPS at different days after sowing

Treatments	Foliage coverage (%) at		
	30 DAS	60 DAS	Harvest
S_1P_1	27.00 d	45.00 c	93.00 c
S_1P_2	25.00 e	34.00 e	85.00 e
S_1P_3	19.00 h	31.00 f	79.00 f
S_2P_1	29.00 b	51.00 b	95.50 b
S_2P_2	26.50 d	40.00 d	89.90 d
S_2P_3	20.70 g	35.50 e	85.00 e
S_3P_1	31.00 a	57.00 a	98.00 a
S_3P_2	28.00 c	46.00 c	94.80 b
S_3P_3	22.40 f	40.00 d	91.00 d
$LSD_{(0.05)}$	0.84	2.07	1.44
CV (%)	5.27	4.46	4.17

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.
S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm and P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

4.3 Number of seedling tuber m^{-2}

4.3.1 Effect of spacing

Number of seedling tuber m^{-2} was significantly influenced by different spacing (Figure 5 and Appendix VII). The maximum number of seedling tuber m^{-2} (734.00) was recorded from S_1 treatment (25 cm × 4 cm) and the minimum number of seedling tuber m^{-2} (471.00) was found from the S_3 treatment (25 cm × 6 cm).

4.3.2 Effect of number of TPS $hill^{-1}$

Different number of TPS $hill^{-1}$ showed significant influence on number of seedling tuber m^{-2} of true potato TPS (Figure 6 and Appendix VII). The highest number of seedling tuber m^{-2} (686.30) was recorded from P_2treatment (2 TPS $hill^{-1}$) and the lowest number of seedling tuber m^{-2} (535.00) was found from the P_3treatment (3 TPS $hill^{-1}$).

4.3.3 Interaction effect of spacing and number of TPS $hill^{-1}$

Interaction effect of spacing and number of TPS $hill^{-1}$ showed significant variation in respect of number of seedling tuber m^{-2} (Table 3 and Appendix VII). The maximum number of seedling tuber m^{-2} (837.00) was recorded from the combination of S_2P_1 treatment (25 cm × 5 cm spacing with 1 TPS $hill^{-1}$) whereas, the minimum number of seedling tuber m^{-2} (415.00) was obtained at the combination of S_3P_3 treatment (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$).

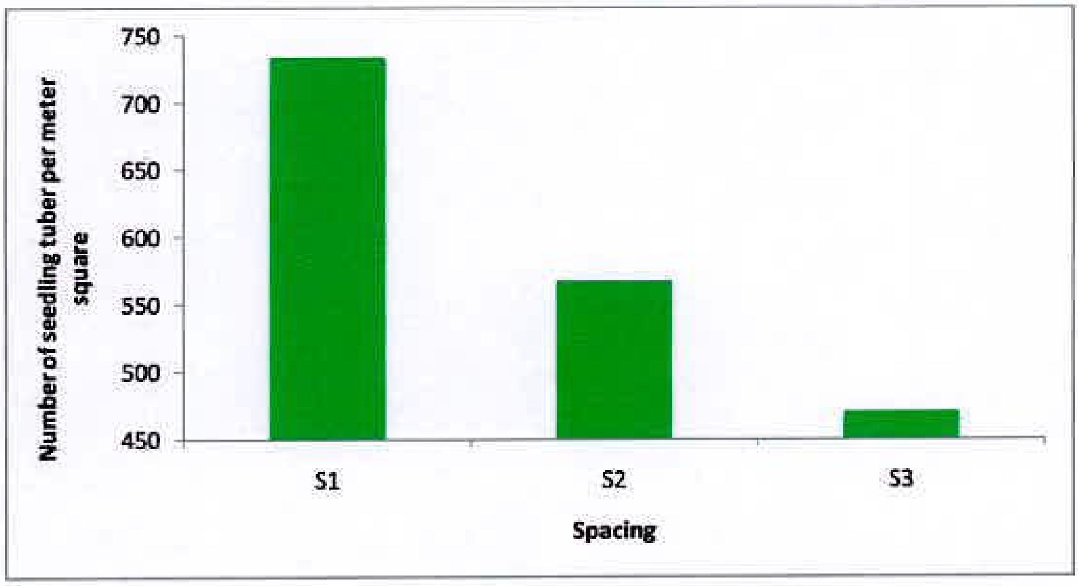


Figure 5: Effect of spacing on number of Seedling tuber per meter square of true potato TPS(LSD value = 8.57).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

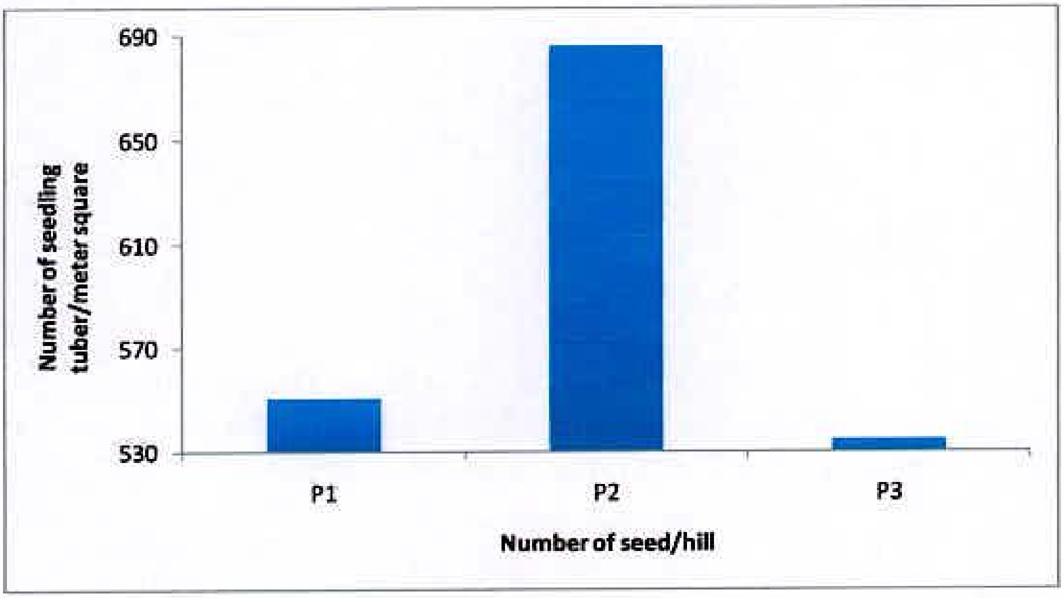


Figure 6: Effect of number of TPS hill^{-1} on number of Seedling tuber per meter square of true potato TPS(LSD value = 8.57).

P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

Sher-e-Bangla Agricultural University Library * Sher-e-Bangla Nagar, Dhaka *

4.4 Average weight of seedling tuber (g)

4.4.1 Effect of spacing

The average weight of seedling tuber varied significantly due to different levels of spacing (Figure 7 and Appendix VII). The maximum average weight of seedling tuber (8.78 g) was recorded from S_3 treatment (25 cm × 6 cm), whereas; the minimum average weight of seedling tuber (7.60 g) was obtained from S_1 treatment (25 cm × 4 cm).

4.4.2 Effect of number of TPS hill^{-1}

The average weight of seedling tuber varied significantly due to different number of TPS hill^{-1}(Figure 8 and Appendix VII). The maximum average weight of seedling tuber (9.18 g) was recorded from P_1treatment (1 TPS hill^{-1}), whereas; the minimum average weight of seedling tuber (7.08 g) was obtained from P_3treatment (3 TPS hill^{-1}).

4.4.3 Interaction effect of spacing and number of TPS hill^{-1}

Interaction of spacing and number of TPS hill^{-1} had significant effect on average weight of seedling tuber (Table 3and Appendix VII). The highest average weight of seedling tuber (9.73 g) was recorded from S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS hill^{-1}), whereas; the lowest average weight of seedling tuber (6.64 g) was recorded from S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS hill^{-1}) which was statistically similar (6.78 g) with S_3P_2 treatment combination (25 cm × 6 cm spacing with 2 TPS hill^{-1}).

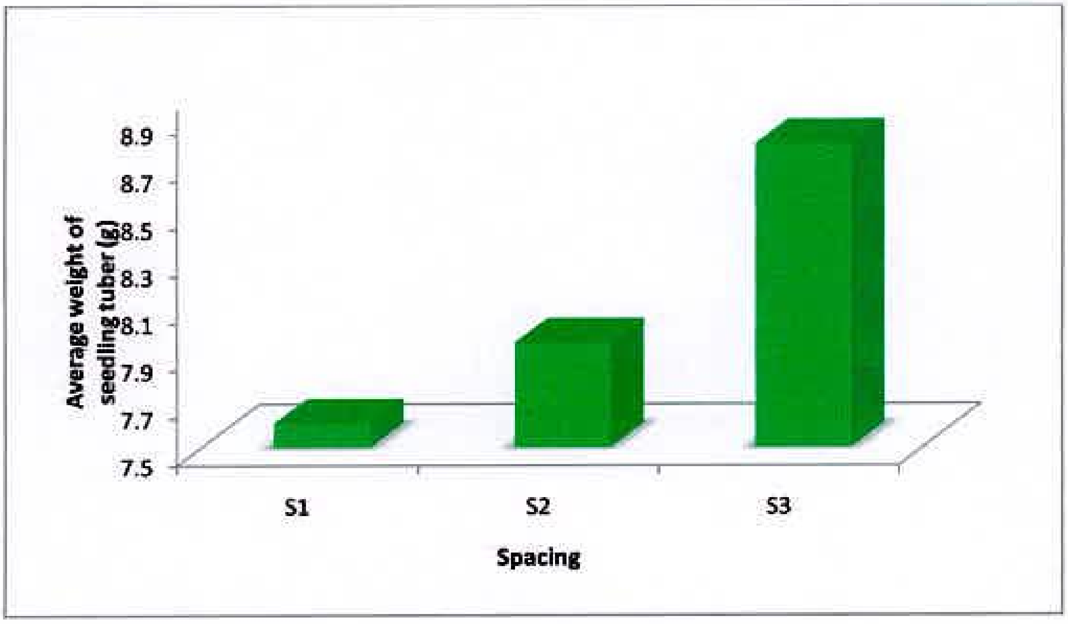


Figure 7: Effect of spacing on average weight of Seedling tuber (g) of true potato Seed (TPS) (LSD value = 0.23).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

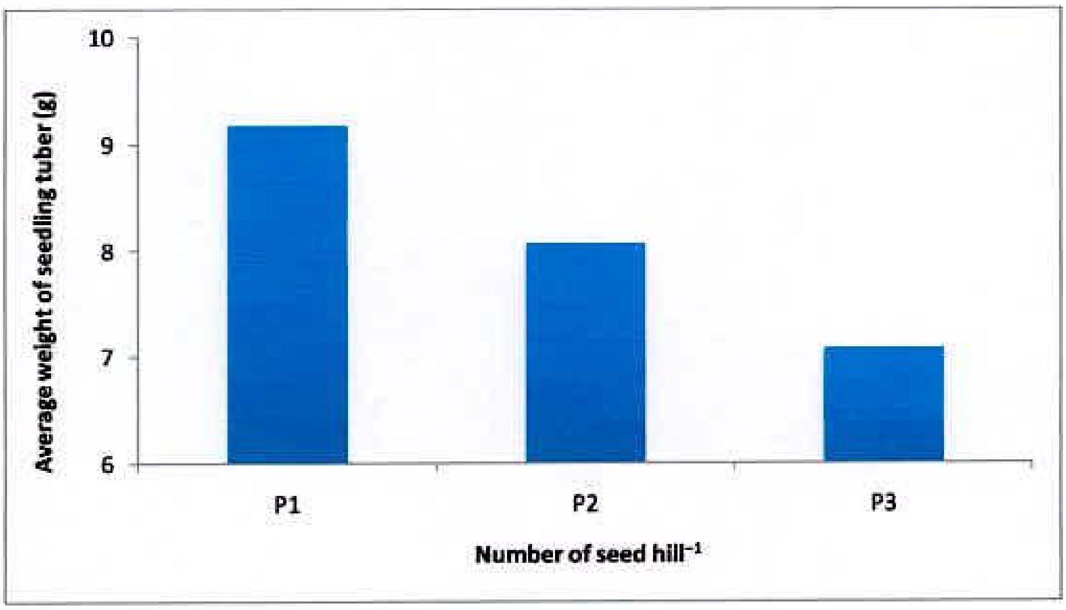


Figure 8: Effect of number of TPS hill^{-1} on average weight of Seedling tuber (g) of true potato Seed (TPS) (LSD value = 0.23).

P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

4.5 Yield (kg m^{-2})

4.5.1 Effect of spacing

The yield (kg m^{-2}) was significantly affected by the different spacing (Figure 9 and Appendix VII). The highest yield (8.63 kg m^{-2}) was recorded from S_2 treatment (25 cm × 5 cm) and the lowest yield (7.26 kg m^{-2}) was recorded from S_3 treatment (25 cm × 6 cm).

4.5.2 Effect of number of TPS $hill^{-1}$

The yield (kg m^{-2}) was significantly affected by different number of TPS $hill^{-1}$ (Figure 10 and Appendix VII). The highest yield (8.22kg m^{-2}) was recorded from P_2treatment (2 TPS $hill^{-1}$) and the lowest yield (7.53kg m^{-2}) was recorded from P_3treatment (3 TPS $hill^{-1}$).

4.5.3 Interaction effect of spacing and number of TPS $hill^{-1}$

Interaction between spacing and number of TPS $hill^{-1}$ played an important role for promoting the yield. Yield (kg m^{-2}) was significantly influenced by the interaction effects of spacing and number of TPS $hill^{-1}$ (Table 3and Appendix VII). Among the treatments, the maximum yield (8.93 kg m^{-2}) was observed in S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$) whereas, the minimum yield (6.95 kg m^{-2}) was found from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$), which was statistically similar (7.01 kg m^{-2}) with S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$).

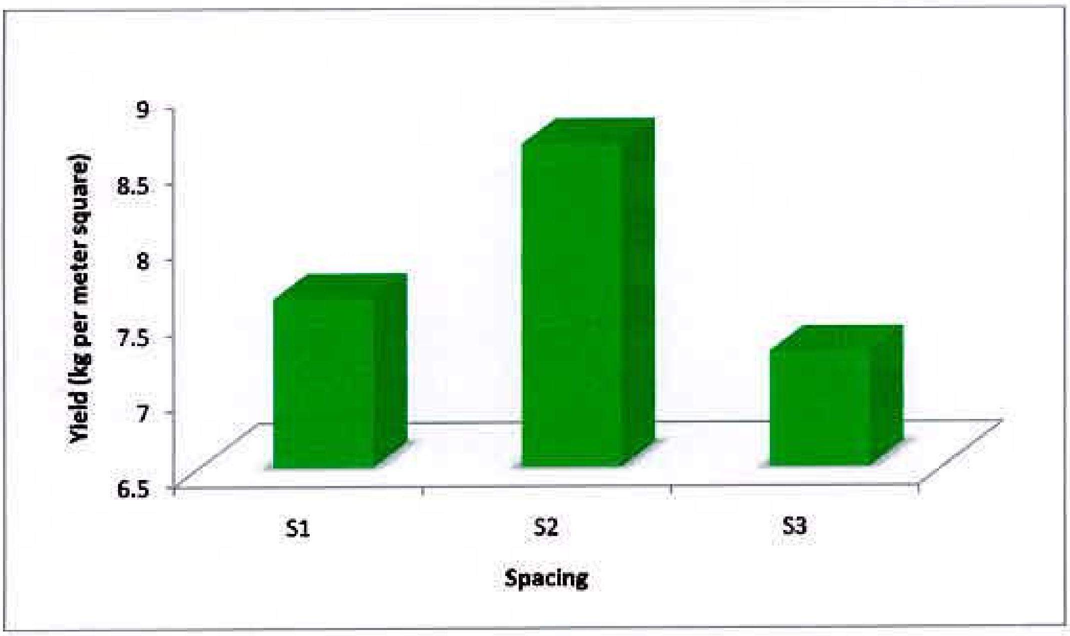


Figure 9: Effect of spacing on yield (kgm^{-2}) of true potato Seed (TPS) (LSD value = 0.18).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

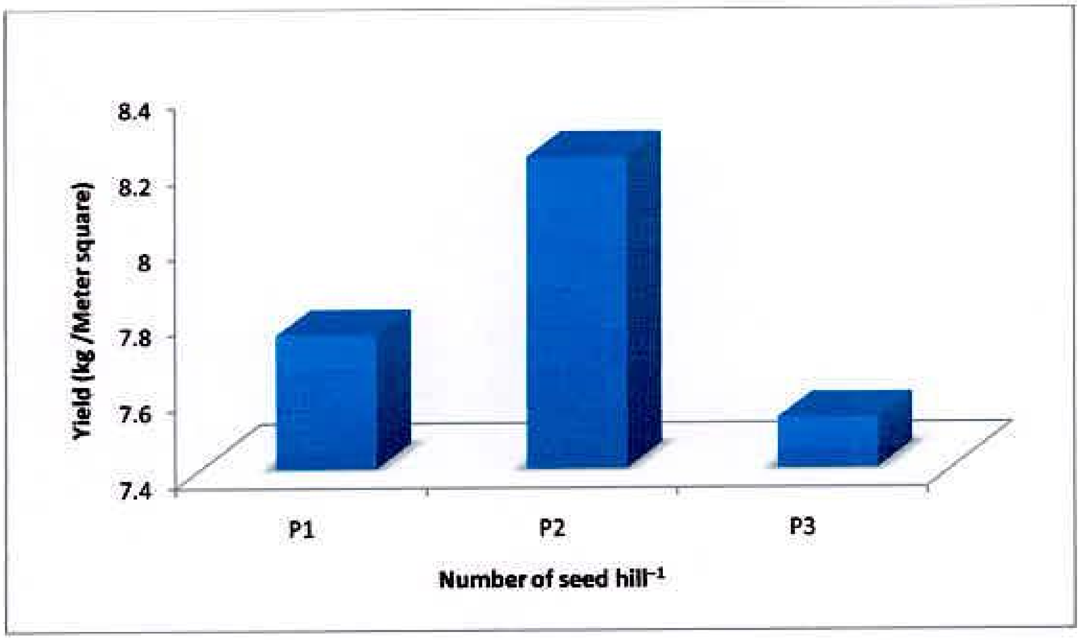


Figure 10: Effect of number of TPS $hill^{-1}$ on yield ($kg\ m^{-2}$) of true potato Seed (TPS) (LSD value = 0.18).

P_1 – 1 TPS $hill^{-1}$, P_2 – 2 TPS $hill^{-1}$, P_3 – 3 TPS $hill^{-1}$

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

4.6 Yield (t ha^{-1})

4.6.1 Effect of spacing

Different levels of spacing had significant influence on yield (t ha^{-1}) of true potato TPS (Figure 11 and Appendix VII). The highest yield (52.23 t ha^{-1}) was recorded from S_2 treatment (25 cm × 5 cm) and the lowest yield (43.95 t ha^{-1}) was recorded from S_3 treatment (25 cm × 6 cm).

4.6.2 Effect of number of TPS $hill^{-1}$

Different number of TPS $hill^{-1}$ had significant influence on yield (t ha^{-1}) of true potato TPS (Figure 12and Appendix VII). The highest yield (49.71 t ha^{-1}) was obtained from P_2treatment (2 TPS $hill^{-1}$)and the lowest yield (45.63 t ha^{-1}) was recorded from P_3treatment (3 TPS $hill^{-1}$).

4.6.3 Interaction effect of spacing and number of TPS $hill^{-1}$

Yield (t ha^{-1})of true potato TPS was significantly influenced by the interaction effects of spacing and number of TPS $hill^{-1}$ (Table 3and Appendix VII). Among the treatments, the highest yield (53.93 t ha^{-1}) was observed in S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$), whereas; the lowest yield (42.11 t ha^{-1}) was found from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$).

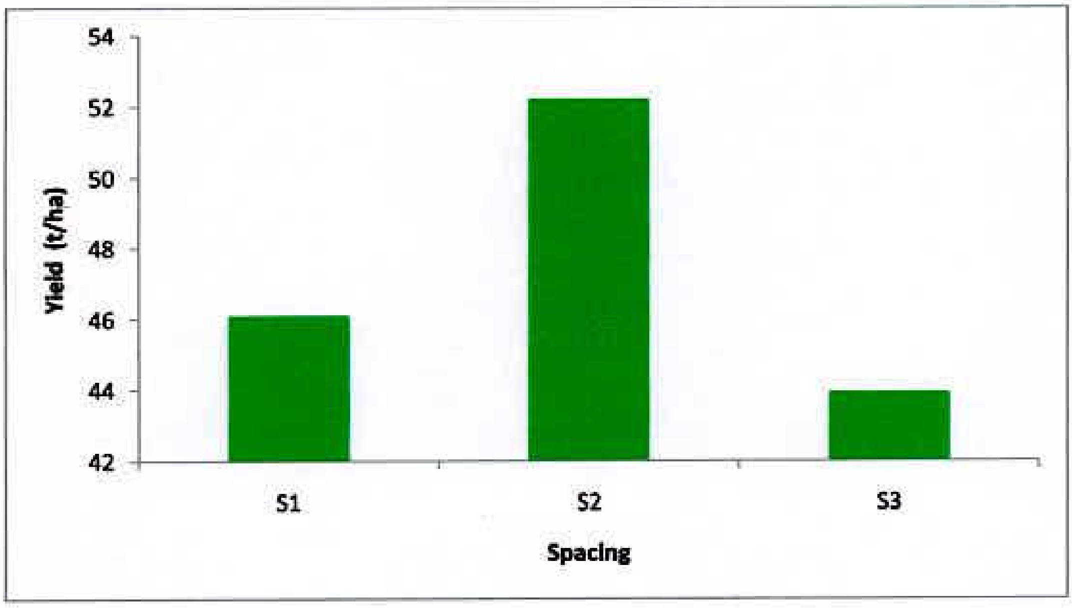


Figure 11: Effect of spacing on yield (t/ha) of true potato Seed (TPS) (LSD value = 0.21).
S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

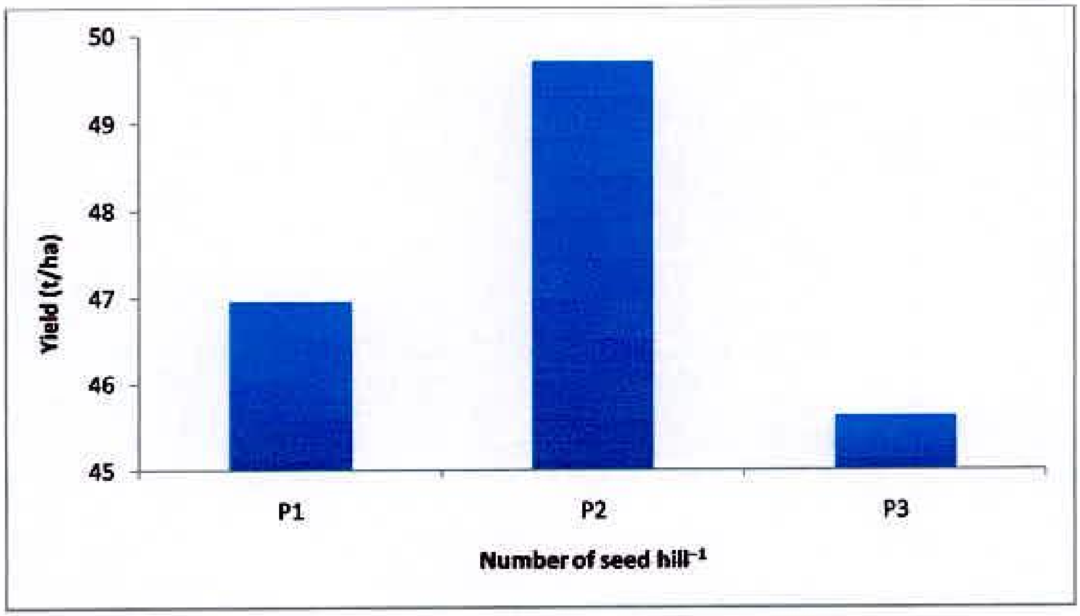


Figure 12: Effect of number of TPS hill^{-1}on yield (t/ha) of true potato Seed (TPS) (LSD value = 0.21).
P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

Table 3: Interaction effect of spacing and number of TPS hill^{-1} on number of seedling tuber m^{-2}, average weight of seedling tuber (g) and yield of true potato TPS

Treatments	Number of seedling tuber m^{-2}	Average weight of seedling tuber (g)	Yield (kg m^{-2})	Yield (t ha^{-1})
S_1P_1	690.00 b	8.53 d	7.61 e	46.11 f
S_1P_2	532.00 f	9.27 b	8.63 b	52.29 b
S_1P_3	431.00 h	9.73 a	7.01 g	42.48 h
S_2P_1	837.00 a	7.64 e	7.91 d	47.93 d
S_2P_2	655.00 d	7.78 e.	8.93 a	53.93 a
S_2P_3	567.00 e	8.81 c	7.81 d	47.26 e
S_3P_1	675.00 c	6.64 f	7.31 f	44.29 g
S_3P_2	515.00 g	6.78 f	8.33 c	50.48 c
S_3P_3	415.00 i	7.81 e	6.95 g	42.11 i
$LSD_{(0.05)}$	8.57	0.23	0.18	0.21
CV (%)	5.28	4.68	5.52	5.72

In a column means having similar letter(s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability.
S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm and P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

4.7 Grading wise yield of seedling tuber (t ha^{-1})

4.7.1 Effect of spacing

There was significant variation observed in grading wise yield of seedling tuber (t ha^{-1}) of true potato TPS (Figure 13and Appendix VIII). The maximum yield of seedling tuber from <1–5 g tuber (13.42t ha^{-1}) was recorded from S_1 treatment (25 cm × 4 cm) and the minimum yield (8.20 t ha^{-1}) was produced by S_3 treatment (25 cm × 6 cm). The highest yield from >5–10 g, >10–20 g and >20 g of tuber (19.77, 13.67 and6.91 t ha^{-1},respectively) was recorded from S_2 treatment (25 cm × 5 cm), whereas; the lowest yield (16.03, 11.86 and 4.78 t ha^{-1}, respectively) was obtained from S_1 treatment (25 cm × 4 cm).

4.7.2 Effect of number of TPS $hill^{-1}$

Grading wise yield of seedling tuber (t ha^{-1}) of true potato TPS was significantly influenced by different number of TPS $hill^{-1}$ (Figure 14and Appendix VIII). The maximum yield of seedling tuber from <1–5 g and >5–10 g oftuber (12.75 and 19.18 t ha^{-1}, respectively) was recorded from P_2treatment (2 TPS $hill^{-1}$) and the minimum yield (8.23 and 14.21 t ha^{-1}, respectively) was produced by P_1 treatment (1 TPS $hill^{-1}$). The highest yield from >10–20 g and >20 g of tuber (15.39 and 9.09 t ha^{-1},respectively) was recorded from P_1 treatment (1 TPS $hill^{-1}$), whereas; the lowest yield (10.29 and 4.12t ha^{-1}, respectively) was obtained from P_3 treatment (3 TPS $hill^{-1}$).

4.7.3 Interaction effect of spacing and number of TPS $hill^{-1}$

Interaction effect of spacing and number of TPS $hill^{-1}$ significantly influenced the grading wise yield of seedling tuber (Table 4and Appendix VIII). The highest yield with <1–5 g of tuber (15.87 t ha^{-1}) was recorded from S_2P_1 treatment combination (25 cm × 5 cm spacing with 1 TPS $hill^{-1}$), whereas; the lowest yield (5.90 t ha^{-1}) was produced by S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$).In case of >5–10 g tuber, the highest yield (22.13 t ha^{-1}) was observed from S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (12.48 t ha^{-1}) was obtained from S_1P_1 treatment combination (25 cm × 4 cm spacing with 1 TPS $hill^{-1}$). Again, in case of >10–20 g tuber, the highest yield (16.60 t ha^{-1}) was observed from S_1P_2 treatment combination (25 cm × 4 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (9.39 t ha^{-1}) was obtained from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$) which was statistically similar (9.62 t ha^{-1}) with S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$). In case of large sized tuber (>20 g), the highest yield (10.71 t ha^{-1}) was observed from S_1P_2 treatment combination (25 cm × 4 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (3.33 t ha^{-1}) was obtained from S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$) which was statistically similar (3.50 t ha^{-1}) with S_2P_1 treatment combination (25 cm × 5 cm spacing with 1 TPS $hill^{-1}$).

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

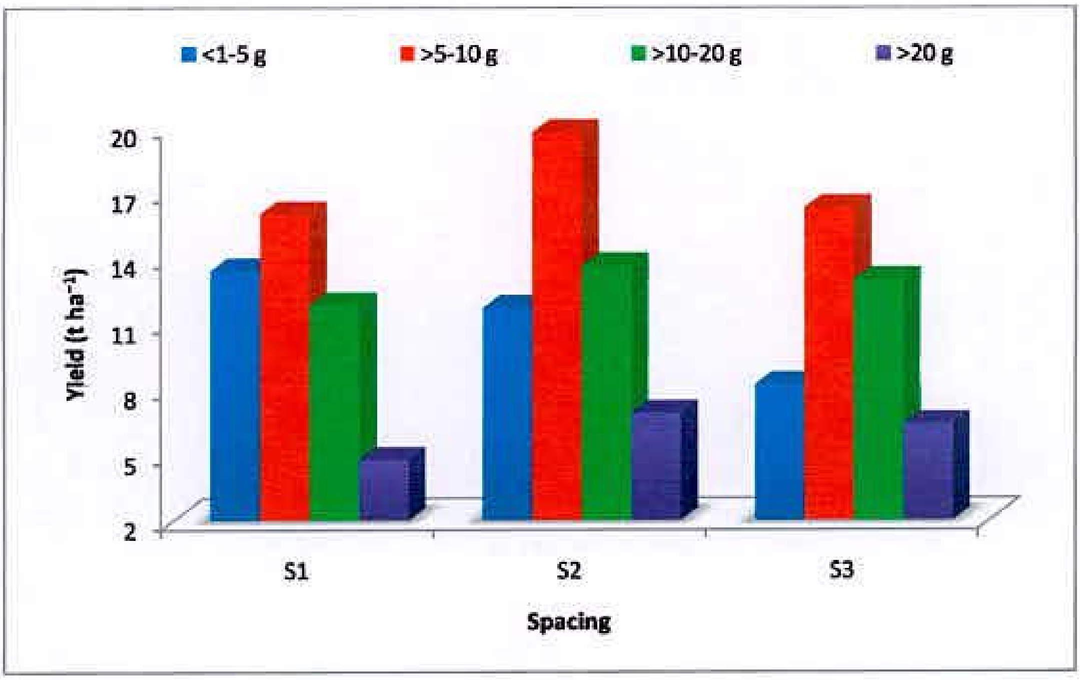


Figure 13: Effect of spacing on grading wise yield of seedling tuber (t ha^{-1}) of true potato Seed (TPS) (LSD value = 0.17, 0.29, 0.34 and 0.22 at <1–5 g, >5–10 g, >10–20 g and >20 g, respectively).

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm

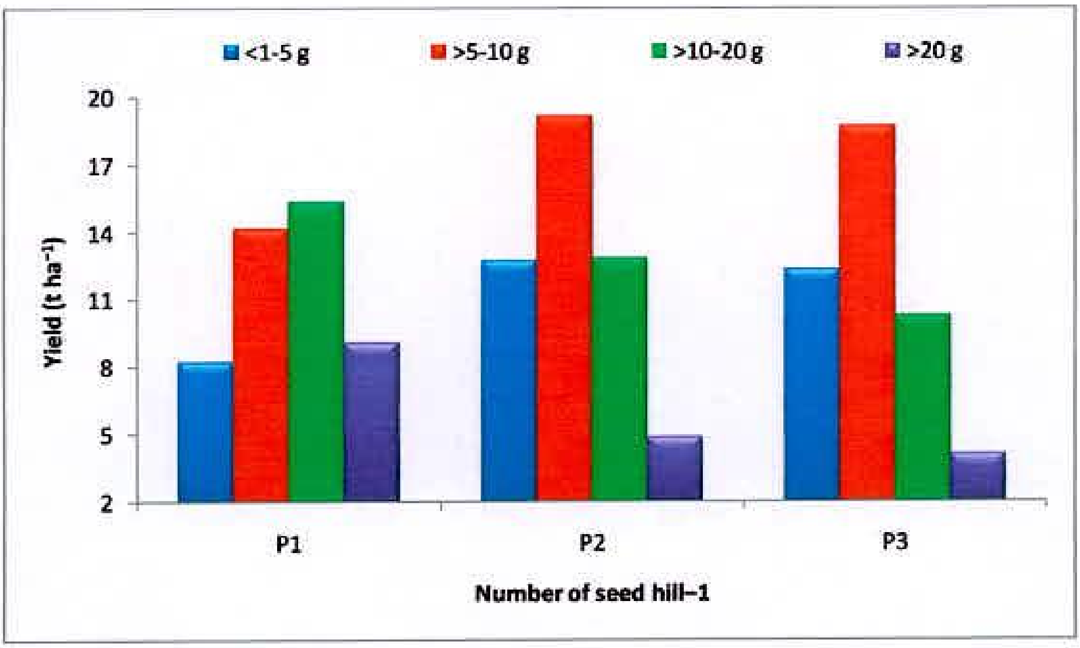


Figure 14: Effect of number of TPS hill^{-1} on grading wise yield of seedling tuber (t ha^{-1}) of true potato Seed (TPS) (LSD value = 0.17, 0.29, 0.34 and 0.22 at <1–5 g, >5–10 g, >10–20 g and >20 g, respectively).

P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

Table 4: Interaction effect of spacing and number of TPS $hill^{-1}$ on grading wise yield of seedling tuber ($t\ ha^{-1}$) of true potato TPS

Treatments	Grading wise yield of Seedling tuber ($t\ ha^{-1}$)			
	<1–5 g	>5–10 g	>10–20 g	>20 g
S_1P_1	10.17 e	12.48 h	15.94 b	7.51 c
S_1P_2	8.63 f	16.26 f	16.60 a	10.71 a
S_1P_3	5.90 h	13.88 g	13.62 c	9.06 b
S_2P_1	15.87 a	18.52 c	10.01 f	3.50 h
S_2P_2	13.99 c	22.13 a	12.55 d	5.23 e
S_2P_3	8.39 g	16.89 e	16.04 b	5.91 d
S_3P_1	14.23 b	17.09 e	9.62 g	3.33 h
S_3P_2	12.53 d	20.92 b	11.86 e	4.80 f
S_3P_3	10.31 e	18.15 d	9.39 g	4.24 g
$LSD_{(0.05)}$	0.17	0.29	0.34	0.22
CV (%)	6.37	4.82	6.01	5.80

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability.
S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm and P_1 – 1 TPS $hill^{-1}$, P_2 – 2 TPS $hill^{-1}$, P_3 – 3 TPS $hill^{-1}$

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

4.8 Economic analysis

A detailed cost and return analysis was done according to the procedure of Alam*et al.,* (1989). The details of analysis were shown in Table 5 and Appendix IX. The input and overhead cost were recorded for all the treatments and calculated on per hectare basis. Input costs for land preparation, seed cost, organic manure, irrigation and manpower required for all the operations from planting to harvesting of TPS were recorded for unit plot and converted into cost per hectare. Price of seedling tuber was considered as per market rate. The economic analysis presented under the following headings-

4.7.1 Gross income

The combination of plant spacing and number of TPS hill^{-1}showed different gross return. The highest gross return (Tk.3,88,640.00) was obtained from S_1P_2 (25 cm × 4 cm with 2TPS hill^{-1}) treatment and the second highest gross return (Tk. 3,69,420.00) was found in S_2P_2 (25 cm × 5 cm with 2TPS hill^{-1}) treatment. On the other hand, the lowest gross return (Tk.2,88,280.00) was obtained from S_3P_3 (25 cm × 6 cm with 3TPS hill^{-1}) treatment (Table 5).

4.7.2 Net return

In case of net return different treatment combination showed different concentration of net return. The highest net return (Tk. 2,57,396.18) was found from S_1P_2 (25 cm × 4 cm with 2TPS hill^{-1}) treatment and the second highest net return (Tk. 2,38,176.18) was obtained from S_2P_2 (25 cm × 5 cm with 2TPS hill^{-1}) treatment. The lowest (Tk. 1,49,352.18) net return was obtained S_3P_3 (25 cm × 6 cm with 3TPS hill^{-1}) treatment (Table 5).

4.7.3 Benefit cost ratio

In the combination of plant spacing and number of TPS hill^{-1}, the highest benefit cost ratio (2.96) was noted from S_1P_2 (25 cm × 4 cm with 2TPS hill^{-1}) treatment and the second highest benefit cost ratio (2.81) was estimated from S_2P_2 (25 cm × 5 cm with 2TPS hill^{-1}) treatment. The lowest benefit cost ratio (2.08) was obtained from S_3P_3 (25 cm × 6 cm with 3TPS hill^{-1}) treatment (Table 5).

From economic point of view, it was apparent from the above results that the combination of S_1P_2 (25 cm × 4 cm with 2TPS hill^{-1}) treatment was more profitable than rest of the combination.

Table 5: Cost and return of TPS cultivation as influenced by plant spacing and number of TPS hill^{-1}

Treatment	Grade-wise seedling tubers (t ha^{-1})			Price of grade-wise seedling tubers (Tk./ha)			Gross income (Tk. /ha)	Cost of production	Net return (Tk. /ha)	Benefit Cost Ratio (BCR)
	Small	Medium	Large	Small	Medium	Large				
S_1P_1	22.65	15.94	7.51	1,35,900.00	1,27,520.00	75,100.00	3,38,520.00	1,23,559.82	2,14,960.18	2.74
S_1P_2	24.79	16.6	10.71	1,48,740.00	1,32,800.00	1,07,100.00	3,88,640.00	1,31,243.82	2,57,396.18	2.96
S_1P_3	19.78	13.62	9.06	1,18,680.00	1,08,960.00	90,600.00	3,18,240.00	1,38,927.82	1,79,312.18	2.29
S_2P_1	34.39	10.01	3.5	2,06,340.00	80,080.00	35,000.00	3,21,420.00	1,23,559.82	1,97,860.18	2.60
S_2P_2	36.12	12.55	5.23	2,16,720.00	1,00,400.00	52,300.00	3,69,420.00	1,31,243.82	2,38,176.18	2.81
S_2P_3	25.28	16.04	5.91	1,51,680.00	1,28,320.00	59,100.00	3,39,100.00	1,38,927.82	2,00,172.18	2.44
S_3P_1	31.32	9.62	3.33	1,87,920.00	76,960.00	33,300.00	2,98,180.00	1,23,559.82	1,74,620.18	2.41
S_3P_2	33.45	11.86	4.8	2,00,700.00	94,880.00	48,000.00	3,43,580.00	1,31,243.82	2,12,336.18	2.62
S_3P_3	28.46	9.39	4.24	1,70,760.00	75,120.00	42,400.00	2,88,280.00	1,38,927.82	1,49,352.18	2.08

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm and P_1 – 1 TPS hill^{-1}, P_2 – 2 TPS hill^{-1}, P_3 – 3 TPS hill^{-1}

Total cost of production was done in details according to the procedure of krishitattik Fasaler Utpadon O Unnayan (in Bengali), by Alam *et al.* (1989), pp. 231-239.

Sale of seedling tubers (small, medium and large) @ Tk. 6,000.00, 8,000.00 and 10,000.00/ton

Gross return = Marketable yield × Tk. /ton

Net income = Gross income – Total cost of production

BCR = Gross return ÷ cost of production

Discussion

The number of seedling tubers produced from TPS per unit area is an important factor, because these are the planting materials to be used to produce either ware potato or seed potato in the subsequent seasons. Seedling tubers produced per unit area is related to the plant population and spacing. According to Wiersema (1984) the optimum plant density of seedlings in nursery bed was defined as that density whereby a large number of useable seedling tubers (1g and above) are produced but whereby close plant spacing would not hinder agronomic practices.

From the results of the present experiment it was found that both foliage coverage and plant height were higher in1 TPS hill^{-1} than other treatment. Again,plant height and foliage coverage increased gradually with decrease in plant spacing form 25 cm × 6 cm to 25 cm × 4 cm. This result is in agreement with the earlier findings of Sarker and Kabir (1989). Rashid *et al.* (1990) and Zakaria*et al.* (1992) and Wiersema (1986b) also reported that increasing plant population increased the rate at which the ground was covered by foliage. The highest plant height obtained from 1 TPS hill^{-1} and closest spacing (25 cm × 4 cm) was possibly due to inter-plant combination for sun light.

The results indicated that the number and yield of seedling tuber per unit area increased gradually with the decrease in plant spacing. The higher number (734.00/m^2) and yield (8.63 kg/m^2) of seedling tubers were obtained from the closest spacing 25 cm × 4 cm, whereas widest spacing of 25 cm × 6 cm produced the lowest number and yield of seedling tubers. The result conformity with the findings of Wiersema (1984), Sarker and Kabir (1989), Rashid *et al.* (1990) and Choudhury*et al.* (1987), where the authors obtained highest yield of seedling tubers from the closest spacing. Wiersema (1986a) reported that increasing plant population due to close spacing led to a greater number of tubers and a greater total weight at maturity. A plant population of100 plants/m^2 produced significantly more tubers and higher total tuberweight than 50 plants/m^2. He also point out that plant density higher than 100 plants/m^2 were found impractical for management of the beds, especially hilling operations become rather difficult and often resulted in plant damage.

The higher (686.30v) and yield (8.22 kg/m^2) of seedling tubers were obtained from the treatment of 2 TPS hill^{-1} compared to other treatment. Martin (1988) also suggested that both tuber number and yield will be greater if clumps of seedlings are left un-thinned in beds for seedling tuber production from TPS.The average weight of seedling tuber was found to be higher in widest spacing (25 cm × 6 cm) (8.78 g) compared to closest spacing. Again, in maximum TPS per hill (3 TPS hill^{-1}) the average weight of seedling tuber was the highest (9.18 g) compared to other treatment. The average seedling tuber weight increased gradually with the increase in plant spacing and number of TPS hill^{-1}. The result is in agreement with the fining of Wiersema (1986b).

In the medium spacing (25 cm × 5 cm) and 2 TPS hill^{-1}, the proportion of small size seedling tubers (<10 g) was higher compared to other treatment. But in closest spacing (25 cm × 4 cm) and 2 TPS hill^{-1}, maximum medium and large size seedling tubers (10-20 g and <20 g) was found.

The economic analysis of the present experiment revealed that the best economic return (2.96) was obtained from the closest spacing (25 cm × 4 cm) in combination of 2 TPS hill^{-1}. The above said treatment combination, gave the highest yield of seedling tubers and also had the low production cost due to widest spacing and maximum TPS hill^{-1}.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

Chapter V

Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted that the effect of plant spacing and number of TPS per hill on growth, yield and economic return of seedling tuber derived from true potato seed (TPS) during the period from November 12, 2013 to February 03, 2014 in Rabi season. The experiment consisted of two factors such as plant spacing and number of TPS $hill^{-1}$. The treatments were as follows: factor A: Plant spacing (3 levels) viz. S_1 – 25 cm × 4 cm, S_2 - 25 cm × 5 cm, S_3 - 25 cm × 6 cm and factor B: number of TPS $hill^{-1}$ (3 levels) viz. P_1 – 1 TPS $hill^{-1}$, P_2 – 2 TPS $hill^{-1}$, P_3 – 3 TPS $hill^{-1}$. The experiment was laid out in a Randomized Complete Block Design (RCBD) with five replications thus comprised 45 plots. The planting materials comprised the TPS seedling tubers of BARI TPS-I.

In case of spacing, significant variation of plant height was found due to different spacing in all the studied durations. At 30, 45, 60 DAS and at harvest, the tallest plant (7.60, 18.95, 37.65 and 67.40 cm, respectively) was obtained from S_1 treatment (25 cm × 4 cm); whereas, the shortest plant (6.35, 17.80, 32.75 and 63.65 cm, respectively) was obtained from S_3 treatment (25 cm × 6 cm). Results revealed that, the foliage coverage of potato plant decreased with increased spacing at 30 and 60 DAS and at harvest (Figure 3). At 30 and 60 DAS and at harvest, the maximum foliage coverage (29.00, 51.00 and 95.50 %, respectively) was observed from S_1 treatment (25 cm × 4 cm) and the minimum foliage coverage (20.70, 35.50 and 85.00 %, respectively) was observed from S_3 treatment (25 cm × 6 cm). The maximum number of seedling tuber m^{-2} (734.00) was recorded from S_1 treatment (25 cm × 4 cm) and the minimum number of seedling tuber m^{-2} (471.00) was found from the S_3 treatment (25 cm × 6 cm). The maximum average weight of seedling tuber (8.78 g) was recorded from S_3 treatment (25 cm × 6 cm), whereas; the minimum average weight of seedling tuber (7.60 g) was obtained from S_1 treatment (25 cm × 4 cm). The highest yield (8.63 kg m^{-2}) was recorded from S_2 treatment (25 cm × 5 cm) and the lowest yield (7.26 kg m^{-2}) was recorded from S_3 treatment (25 cm × 6 cm). The highest yield (52.23 t ha^{-1}) was recorded from S_2 treatment (25 cm × 5 cm) and the lowest yield (43.95 t ha^{-1}) was recorded from S_3 treatment (25 cm × 6 cm). The maximum yield of seedling tuber from <1–5 g tuber (13.42 t ha^{-1}) was recorded from S_1 treatment (25 cm × 4 cm) and the minimum yield (8.20 t ha^{-1}) was produced by S_3 treatment (25 cm × 6 cm). The highest yield from >5–10 g, >10–20 g and >20 g of tuber (19.77, 13.67 and 6.91 t ha^{-1}, respectively) was recorded from S_2 treatment (25 cm × 5 cm), whereas; the lowest yield (16.03, 11.86 and 4.78 t ha^{-1}, respectively) was obtained from S_1 treatment (25 cm × 4 cm).

In case of number of TPS $hill^{-1}$, the height of plant was significantly influenced by different number of TPS $hill^{-1}$ at 60 DAS and at harvest but was non-significant at 30 and 45 DAS. At 30 DAS, P_1 treatment (1 TPS $hill^{-1}$) showed the tallest plant (7.03 cm) and the shortest plant (7.00 cm) was found from P_3 treatment (3 TPS $hill^{-1}$) which was statistically insignificant. At 45 DAS, P_3 treatment (3 TPS $hill^{-1}$) gave the highest plant height (18.43 cm) and the lowest height was recorded from P_1 treatment (1 TPS $hill^{-1}$) (18.33 cm) which was statistically insignificant. At 60 DAS, P_3 treatment (3 TPS $hill^{-1}$) gave the highest plant height (35.33 cm) which was statistically similar (35.02 cm) with P_2 treatment (2 TPS $hill^{-1}$), whereas; the lowest height (34.70 cm) was recorded from P_1

treatment (1 TPS $hill^{-1}$). At harvest, the tallest plant (67.00cm) was recorded from P_3 treatment (3 TPS $hill^{-1}$), whereas; the shortest plant (63.57 cm) was obtained from P_1 treatment (1 TPS $hill^{-1}$). Number of TPS $hill^{-1}$ significantly influenced foliage coverage of potato plant at 30 and 60 DAS and at harvest. At 30, 60 DAS and at harvest, the highest foliage coverage (27.13, 47.67 and 94.60 %, respectively) was found in P_3 treatment (3 TPS $hill^{-1}$) and the lowest foliage coverage (23.67, 36.67 and 85.67 %, respectively) was found in P_1 treatment (1 TPS $hill^{-1}$). The highest number of seedling tuber m^{-2} (686.30) was recorded from P_2 treatment (2 TPS $hill^{-1}$) and the lowest number of seedling tuber m^{-2} (535.00) was found from the P_3 treatment (3 TPS $hill^{-1}$). The maximum average weight of seedling tuber (9.18 g) was recorded from P_1 treatment (1 TPS $hill^{-1}$), whereas; the minimum average weight of seedling tuber (7.08 g) was obtained from P_3 treatment (3 TPS $hill^{-1}$).The highest yield (8.22 kg m^{-2}) was recorded from P_2 treatment (2 TPS $hill^{-1}$) and the lowest yield (7.53 kg m^{-2}) was recorded from P_3 treatment (3 TPS $hill^{-1}$). The highest yield (49.71 t ha^{-1}) was obtained from P_2 treatment (2 TPS $hill^{-1}$) and the lowest yield (45.63 t ha^{-1}) was recorded from P_3 treatment (3 TPS $hill^{-1}$). The maximum yield of seedling tuber from <1–5 g and >5–10 g of tuber (12.75 and 19.18 t ha^{-1}, respectively) was recorded from P_2 treatment (2 TPS $hill^{-1}$) and the minimum yield (8.23 and 14.21 t ha^{-1}, respectively) was produced by P_1 treatment (1 TPS $hill^{-1}$). The highest yield from >10–20 g and >20 g of tuber (15.39 and 9.09 t ha^{-1}, respectively) was recorded from P_1 treatment (1 TPS $hill^{-1}$), whereas; the lowest yield (10.29 and 4.12 t ha^{-1}, respectively) was obtained from P_3 treatment (3 TPS $hill^{-1}$).

Significant interaction effects of spacing and number of TPS $hill^{-1}$ on plant height was observed at 30, 45, 60 DAS and at harvest. At 30 DAS, the tallest plant (7.70 cm) was obtained from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$) and the shortest plant (6.20 cm) was obtained from the S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$). At 45 DAS, the highest plant height (19.20 cm) was observed from the S_1P_1 treatment combination (25 cm × 4 cm spacing with 1 TPS $hill^{-1}$) whereas; the lowest plant height (17.50 cm) was obtained from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$). The tallest plant at 60 DAS (37.80 cm) was produced from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$). On the other hand, the shortest plant at 60 DAS (31.50 cm) was recorded from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$). At harvest, the maximum height of plant (70.10 cm) was obtained from the S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$) and the minimum height of plant (62.20 cm) was obtained from the S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$).There was significant variation observed due to the interaction of spacing and number of seed $hill^{-1}$ on the foliage coverage of true potato seed at 30 and 60 DAS and at harvest. At 30 and 60 DAS and at harvest, the maximum coverage of foliage (31.00, 57.00 and 98.00 %, respectively) was recorded from the combination of S_3P_1 treatment (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$). On the other hand, the minimum coverage of foliage at 30 and 60 DAS and at harvest (19.00, 31.00 and 79.00 % respectively) was obtained in the combination of S_1P_3 treatment (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$). The maximum number of seedling tuber m^{-2} (837.00) was recorded from the combination of S_2P_1 treatment (25 cm × 5 cm spacing with 1 TPS $hill^{-1}$), whereas; the minimum number of seedling tuber m^{-2} (415.00) was obtained at the combination of S_3P_3 treatment (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$). The highest average weight of seedling tuber (9.73 g) was recorded from

S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$), whereas; the lowest average weight of seedling tuber (6.64 g) was recorded from S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$). Yield (kg m^{-2}) was significantly influenced by the interaction effects of spacing and number of seed $hill^{-1}$. Among the treatments, the maximum yield (8.93 kg m^{-2}) was observed in S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$) whereas, the minimum yield (6.95 kg m^{-2}) was found from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$). Among the treatments, the highest yield (53.93 t ha^{-1}) was observed in S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$), whereas; the lowest yield (42.11 t ha^{-1}) was found from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$). The highest yield with <1–5 g of tuber (15.87 t ha^{-1}) was recorded from S_2P_1 treatment combination (25 cm × 5 cm spacing with 1 TPS $hill^{-1}$), whereas; the lowest yield (5.90 t ha^{-1}) was produced by S_1P_3 treatment combination (25 cm × 4 cm spacing with 3 TPS $hill^{-1}$). In case of >5–10 g tuber, the highest yield (22.13 t ha^{-1}) was observed from S_2P_2 treatment combination (25 cm × 5 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (12.48 t ha^{-1}) was obtained from S_1P_1 treatment combination (25 cm × 4 cm spacing with 1 TPS $hill^{-1}$). Again, in case of>10–20 g tuber, the highest yield (16.60 t ha^{-1}) was observed from S_1P_2 treatment combination (25 cm × 4 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (9.39 t ha^{-1}) was obtained from S_3P_3 treatment combination (25 cm × 6 cm spacing with 3 TPS $hill^{-1}$). In case of large sized tuber (>20 g), the highest yield (10.71 t ha^{-1}) was observed from S_1P_2 treatment combination (25 cm × 4 cm spacing with 2 TPS $hill^{-1}$) and the lowest yield (3.33 t ha^{-1}) was obtained from S_3P_1 treatment combination (25 cm × 6 cm spacing with 1 TPS $hill^{-1}$).

Based on the experimental results, it may be concluded that-

i) The effect of spacing and number of TPS hill^{-1} had positive effect on morphological and growth characters, yield attributes and economic return in seedling tubers.

ii) 25 cm × 4 cm spacing and 2 TPS hill^{-1} seemed to be more suitable for getting higher seedling tuber yield.

RECOMMENDATION

Considering the above observation of the present study further investigation in the following areas may be suggested.

1. Further study may be needed for ensuring the different spacing and number of TPS hill^{-1} in relation to growth, yield and economic return in different agro-ecological zones (AEZ) of Bangladesh for regional adaptability.

2. Closer treatments of spacing and other TPS variety may be needed to include for future study as sole or different combination.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

References

REFERENCES

Accatino, P. (1979). Agronomic management in the utilization of true potato seed, preliminary results. In: CIP Report of the planning conference on the production of potatoes from true potato seed. Manila, Philippines. pp. 61-69.

Accatina, P. and Malagamba, P. (1983). Growing potatoes from TPS. Current agronomic knowledge and future prospects. In: W.J. Hooker (ed.) 'Research for the potato in the year 2000', CIP, Lima, Peru. pp. 61-62.

Ahire, N.R., Bhoi, P.G. and Solanke, A.V. (2000). Effect of row spacing and planting system on growth and yield of potato under surface and drip irrigation. *J. Indian Potato Assoc.* **27**(1/2): 59-60.

Alam, M.S. (1999). Growth and yield of TPS seedling tubers as influenced by cowdung manure and chemical fertilizers. MS thesis, Department of Horticulture, BAU, Mymensingh. p. 63.

Anonymous. (1997). Annual report 1996-1997. Breeders seed production centre (BSPC), Bangladesh Agricultural institute (BARI), Joydebpur, GAzipur.

Anonymous. (1989). Research report 1994-1995. Tuber Crops research Centre (TCRC), Bangladesh Agricultural institute (BARI), Joydebpur, GAzipur.

Anonymous. (1988a). The yearbook of production. FAO, Rome, Italy.

Anonymous. (1988b). Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2. Agroecological Regions of Bangladesh, UNDP and FAO. pp. 472-496.

Anonymous. (1986). Research Report 1985-1986. Tuber Crops research Centre (TCRC), Bangladesh Agricultural institute (BARI), Joydebpur, GAzipur.

Batra, V.K., Malik, Y.S., Pandita, M.L. and Khurana, S.C. (1992). Effect of seedling tuber size, spacing and method of planting on potato production. *J. Indian Potato Assoc.* **19**(3-4): 166-170.

Bayorbor, T.B. and Gumah, A.Y. (2007). Effects of 'seed' tuber weight and spacing on the yield of Frafra potato (*Solenostemon rotundifolius*). *Ghana J. Hort.* **6**: 41-48.

BBS (Bangladesh Bureau of Statistics). (2013). Monthly statistical year book. Ministry of Planning, Govt. People's Repub. Bangladesh. p. 64.

BBS (Bangladesh Bureau of Statistics). (2010). Monthly statistical year book. Ministry of Planning, Govt. People's Repub. Bangladesh. p. 89.

Bhuyun, H.A.M. (2003). Effect of mulch and crop management practices on growth and yield of potato. MS thesis, Dept. of Hort., BAU, Mymensingh.

Bishop, J.G. and Wright, D.N. (1959). The effect of size and spacing of seed piece on the yield and grades of white rose potatoes in Korn country, California. *Am Potato J.* **36**: 235-240.

BongKyoon, K. YoungKil, K. and MiRa, K. (2001). Effect of seed potato size on plug seedling growth and field performance. *Korean J. Crop Sci.* **46**(2): 121-124.

Chaudhury, A.J.M.E.H. (1989). Potential for using true potato seed (TPS) for potato production in Bangladesh. Ph.D. thesis, department of Agronomy, BAU, Mymensingh. p. 91.

Chaudhury, E.H. and Rasul, M.G. (1995). True potato seed (TPS) research and development in Bangladesh. Proc. Workshop on National programme for true potato seed (TPS) in Bnaladesh. BARC, Dhaka. pp. 28-37.

Chaudhury, E.H., Sarker, M.H. and Rasul, M.G. (1995). Agronomic management for potato production from true potato seed (TPS) in Bangladesh. PRC, BARI, Jydobpur, gazipur. pp.18-28.

Chilver, A., Walker, T., Khatana, V., Fano, H., Suherman, R. and Rizk, A. (1999). On-farm profitability of true potato seed (TPS) utilization technologies working paper series, CIP, *Soc. Sci. Dep.* **99**(3): 41.

Choudhury, M.Z.H. (1997). Effect of plant spacing on the production of potato seedling tubers. MS thesis, Department of Horticulture, BAU, Mymensingh. p. 97.

CIP. (1981). Annual Report 1981. International Potato center (CIP), Lima, Peru.

CIP. (1982). Annual Report 1982. International Potato center (CIP), Lima, Peru.

CIP. (1984). Annual Report 1984. International Potato center (CIP), Lima, Peru.

CIP. (1989). Annual Report 1989. International Potato center (CIP), Lima, Peru.

CIP. (1992). Annual Report 1992. International Potato center (CIP), Lima, Peru.

Cloete, G.S. and Els, D.L. (1982). The effect of seed size and within row spacing on seed tuber production of potato cultivar BP-I. Agroplantae. **14**(1): 1-4.

Conley, S.P., Binning, L.K., and Connell, T.R. (2001). Effect of cultivar, row spacing, and weed management on weed biomass, potato yield, and net crop value. *American J. Pot Res*. **78**(1): 31-37.

Divis, J. and Barta, J. (2001). Influence of the seed-tuber size on yield and yield parameters in potatoes. *Rostlinna Vyroba.* **47**(6): 271-275.

Eddowes, M. (1975). Effect of sed size and spacing on total and marketable yield of main crop potato. In: Abstract of conference papers, 6th Triennial conference of European Associatation for potato research, Wageningen, The Netherlands. pp. 130-131.

Elias, S.M., Hossain, A.B.S. and Islam, M.R. (1997). Production of potato from True Potato Seed (folder in Bangla). TCRC, BARI, Jydebpur, Gazipur.

Engels, C., Bedewy, R.E. and Sattelmacher, B. (1993). Effects of weight and planting density of tubers derived from true potato seed on growth and yield of potato crops in Egypt. *Field Crops research.* **35**: 129-170.

FAO (Food And Agricultural Organization). (2013). Production Year Book No. 65. Food and Agriculture Organization FAO, Rome, Italy. p. 97.

Garg, V.K., Singh, S., Raj, D. and Kumar, A. (2000). Effect of physio-agronomical manipulations on the number and yield of seed tubers in breeders seed in the hills. Potato, global research and development: Proc. of the Global Conf. on Potato, Dec.6-11, 1999. Vol-1. New Delhi, India, pp. 413-418.

Ghosh, S.C., Asanuma, K., Kusutani, A. and Toyota, M. (2002). Effects of shading on dry matter production, yield and nitrate reductase activity of potato under two levels of spacing. *Environ. Cont. Biol.* **40**(3): 259-268.

Gojski, B. (1979). The effects of planting density for seed potatoes of different sizes on the yield of potato cv. Krokus and pierwiosunek. *Bunletyn Instytutu Ziemniaka.* **24**: 77-93.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedure for agricultural research. Second Edn. Intl. Rice Res. Inst., John Wiley and Sons. New York. pp. 1-340.

Gary, D. (1979). Field drilling and other methods for sowing seeds with potential for the true potato seeds. In: CIP Report of the planning conference on the production of potatoes from true seed. Manila, the Philippines. pp. 117-131.

Gregoriou, S. (2000). The effect of row spacing on yield and tuber size distribution of the potato cv. Cara. Tech. Bull. *Cyprus Agric. Res. Ins.* **207**:1-10.

Gulluoglu, L. and Aroglu, H. (2009). Effects of seed size and row spacing on growth and yield of early potato in a mediterranean-type environment in Turkey. *African J. Agric. Res.* **4**(5): 535-541.

Haan, H.D. (1953). Potato breeding in the Netherlands. **2**: 113-121.

Horton, D. (1987). Potatoes: Production, Marketing and Programs for Developing Countries. Westview Press, London. pp.19-24.

Hoque, M.A. (2000). Effect of mulching and plant spacing on seedling tuber production from TPs. Annual report on Tuber crops 1999-2000. Tuber Crops Research Sub-centre, BARI, Munshihonj. p. 15.

Hossain, M.M., Sarker, P.K. and Habib, M.A. and Hossain, A.E. (1992). Studies on degeneration of seedling tubers derived from true potato seed. *Bangladesh Hort.* **20**(1): 69-72.

Hossain, M.M.,Sarker, P.K. and Mondal, M.A.A. (1994). Production and utilization of seedling tubers derived from true potato seed (TPS) in farmers field. *J. Bio. Sci.* **2**: 83-88.

Hussain, M.M. (2000). Export potential of potatoes from Bangladesh. Paper presented in the first conference of BPC, BARC, Dhaka.

Islam, F. (1992). Effect of seedling tuber size and plant spacing on the growth and yield of potato. M.Sc.(Ag.) thesis, department of Hortculture, BAU, Mymensingh. p. 43.

Jones, R.A.C. (1982). Test for transmission of four viruses through potato true seed. Annals of Applied Biology. 100: 315-320.

Kabir, M.H. (2001). Effect of plant spacing and time of harvesting on growth and yield of potato seedling tubers raised from TPS. MS thesis. Department of Horticulture, BAU, Mymensingh. p. 86.

Kadian, M.S., Pande, P.C. and Upadhya, M.D. (1990). TPS as propagating material for north-western Indo-Gangetic plains. Central Potato research Institute, Shimla, India. pp. 40-44.

Kadian, M.S., Pande, P.C. and Upadhya, M.D. (1992). Seedling tubers from true potato seed as planting materials for north-west Indo-Gangetic plains of India. *Crop Research.* **5**(3): 499-504.

Kadian, M.S., Pande, P.C. and Upadhya, M.D. (1987). Evaluation of TPS progenies for potato production in Deesa. *J. Indian Potato Assoc.* **14**(1&2): 57-59.

Kadly, H.J. (1972). Improvement of the technology for potato seed growing kartofel-i-Ovoshchi. **1**(2): 16-19.

Kamal, A.M.A. and Khan, I.H. (1973). Effect of variety and spacing on the yield of potato tubers. *Bangladesh Hort.* **1**(2): 52-56.

Kamaly, M.H.K. (1997). Effects of TPS seedling tuber size and plant spacing on growth and yield of potato. MS thesis, Dept. of Hort., BAU, Mymensigh. p. 108.

Sher-e-Bangla Agricultural University Library Sher-e-Bangla Nagar, Dhaka

Keeps, M.S. (1979). Production of field crops. 6th Edn. Tata Mc-Graw Hill Publishing Co. Ltd., New Delhi. p.369.

Khalafalla, A.M. (2001). Effect of plant density and seed size on growth and yield of solanum potato in Khartoum State, Sudan. *African J. Crop Sci.* **9**(1): 77-82.

Khurana, S.C. and Bhutani, R.D. (2003). Effect of spacing, fertilizer dose and crop duration on the production of seed size tubers in potato (*Solanum tuberosum* L.). *Haryana J. Hort. Sci.* **32**(3/4): 259-261.

Khurana, S.C. (1990). Performance of TPS populations at Hisar. Central Potato research Institute (CPRI), shimla, India. pp. 54-61.

Kumar, V., Vyakaranahal, B.S., Basavaraj, N., Birbal, R. and Raikar, S.D. (2009). Effect of intra-row spacing and nutrient level on growth and yield of potato (*Solanum tuberosum). Indian J. Agric. Sci.* **79**(1): 61-64.

Kushwah, V.S. and Singh, S.P. (2008). Effect of intra-row spacing and date of haulm cutting on production of small size tubers. *Pot J.* **35**(1/2): 88-90.

Li, C.H. (1983). Propects for the use of true potato seed to grow potato. In: W.J. Hooker (ed.), CIP, Lima, Peru, pp. 17-18.

Li, C.H. and shen, C.P. (1979). Production of marketable and seed potatoes from botanical seed in the china. In: International Potato centre report of the planning conference on the production of potatoes from true seed. Manila, The phillippiners. pp. 21-28.

Malagamba, P. (1988). Poatao production from triue seed in tropical climates. *Hort. Sci.* **23**(3): 495-500.

Malik, Y.S., Bhatia, A.K., Singh, N., Nehra, B.K. and Khurana, S.C. (2002). Effect of nitrogen, seed size and spacing on seed potato production in cv. Kufri Sutlej. potato, global research and development. Proceedings of the Global Conf. on Potato. Dec 6-11. New Delhi, India,1999: Vol-2. pp. 861-865.

Maleque, M.A. (1997). Effects of date of seed sowing and harvesting on the growth and development of TPS seedling tubers. MS thesis, Dept. of Horticulture, BAU, Mymensingh. p. 68.

Martin, M.W. (1988). Cultural practices for using true potato seed in potato production under temperature climates. *Hort. Sci.* 23(3): 505-512.

MOA. (Ministry of Agriculture). (2013). Hand Book of Agricultural Statistics, December, 2012. Market Monitoring and Information System, Ministry of Agriculture (MOA), Govt. People's Repub. Bangladesh. p. 493.

Mondal, M.R.I., Islam, M.S., Jalil, M.A.B., Rahman, M.M., Alam, M.S. and Rahman, M.H.H. (2011). Krishi Projukti Hatboi (Handbook of Agro-technology), 5th edition. Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh, p. 307.

Nankar, J.T. (1990). Standardization of TPS agronomy and performance of TPS populations in Maharashtra. Central potato Research Institute, shimla, India. pp. 68-76.

Patel, B.T., Barad, A.V., Chaudhari, S.M., Patel, C.K. and Patel, R.N. (2002). Standardization of spacing for seed tuberlet production from TPS under nursery beds in Gujarat. *Indian J. Potato. Assoc.* **29**(3/4): 143-146.

Pande, P.C., Kadian, M.S. and Upadhya, M.D. (1990). Field performance of seedling tubers in three successive clonal genarations. *J. India Potato Assoc.* **17**(1&2): 30-33.

Rashid, M.H., Kabir, M.H., Hossain, M.M. and Rashid, M.M. (1993). Assessment of true potato seed families for tuberlet production under the climatic conditions of Bangladesh. *Asian Potato J.* **3**: 11-13.

Rashid, M.H., Kabir, M.H., Hossain, M.M. and Rashid, M.M. (1990). Effects of transplanting density of TPS seedling on the growth and yield of potato. *Bangladesh Hort.* **18**(1&2): 1-7.

Ravichandran, G. and Singh, S. (2003). Maximization of seed size tubers through size of tubers, spacing and haulm killing in the Nilgiris. *Indian J. Pot. Assoc.* **30**(1/2): 47-48.

Razzaque, S., Dejmek, P. and Oste, R. (2000). Reproducible texture analysis of potato of chips. *J. Food Sci.* **64**: 309-312.

Roy, H.C. (1997). Growth and yield of potato grown from TPS seedling tubers of different sizes. MS thesis, Departemnt of Horticultura, BAU, Mymensingh. p. 72.

Sadik, S. (1983). Potato production from true seed- present and future. In: W.J. Hooker (ed.). CIP, Lima, Peru. pp. 18-25.

Saikia, M. and Rajkhowa, D.J. (1998). Effect of of planting density and vermicompost on the yield of potato raised from seedling tubers. *J. Indian potato Assoc.* **25**(3-4): 141-142.

Salaman, R.N. (1949). The history and social influence of the potato Cambridge university Press. p. 685.

Sarker, M.H.Z. and Kabir, M.E. (1989). Effect of spacing on seedling tuber production from true potato seed. *Bangladesh Hort.* **17**(1): 11-14.

Shingrup, P.V., Giri, D.G., Jahagirdar, S.W., Barde, P.R. and Giri, M.D. (2003). Economics of potato (*Solanum tubersum* L.) cultivation as influenced by different agro techniques. *J. Soils Crops*. **13**(2): 291-293.

Siddique, M.A. (1995). On-farm agronomic evaluation of true potato seed. Proc. Of the workshop on National profgramme for TPS in Bangladesh, BARC, Dhaka, pp. 44-49.

Siddique, M.A. (2001). Development of standard an dcost-effective techniques for production, post-harvest handling and storage of TPS seed, BAU, Mymensingh. p. 22.

Sikka, L.C. (1987). Review of TPS research in Bangladesh. Proc. of the workshop on true potato seed (TPS) research in bangladesh. PRC, BARI, Joydebpur, Gazipur. pp. 8-16.

Singh, A.N. (1999). True potato seed- a low-cost planting materials for small farmers. Indian Farming. 49(9): 43-47.

Singh, J.M., Khurana, C. and Mahla, C.P. (1999). Effect of seedling tuber size and crop density on tuber yield of potato. New Delhi, India. p. 256.

Singh, M.V., Singh, A.P. and Verma, S.K. (1998). Effect of nitrogen and seed size on potato grown through seedling tubers. *J. Indian Potato Assoc.* **21**(1-2): 79-80.

Sonawane, P.D. and Dhoble, M.V. (2004). Effect of spacing and seedling tuber size on potato (*Solanum tuberosum*) grown through true potato seed. *Indian J. Agron.* **49**(3): 194-197.

Song, B. (1984). Use of true potato seed in china, CIP Circular. **12**(2): 6-7.

Sultana, N. (1998). Effect of seedling tuber size and depth of plantinmg on the growth and yield of potato. MS thesis, Dept. of Horticultura, BAU, Mymensingh. p. 85.

Suman, S, Malik,Y.S. and Khurana, S.C. (2003). Effect of fertilizer, spacing and crop duration on growth and yield of potato. *J. Indian Potato Assoc*. **30**(1/2): 87-88.

TCRC (Tuber Crop Research Centre). (2004). Annual Report of 2003-04. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701. p. 13.

Tsao, S.J. and Chang, Y.M. (1982). Studies on potato production by ture seeds. Proc. of the symposium on plant bnreeding. Taichung, Taiwan. pp. 233-240.

Uddin, M.M., Hussain, M.A. and Mannaf, M.A. (2001). Potato production from TPS. Jointly organized by TCRC, BARI and CIP.

Upadhya, M.D. (1979). Potential for potato production from true potato seed under development Repotr2, FAO, Rome, Italy. p. 577.

Upadhya, M.D. and Cabello, R. (2001). Influence of seed size and density on the performance of direct seedling transplants from hybrid true potato seed. Scientist and farmer: partners in research for the 21st Century Program Report-1999-2000. pp. 207-210.

Upadhya, M.D. and Cabello, R. (1990). Influence of plant density on the performance of direct seedling transplants from hybrid true potato seed. Scientist and farmer: partners in research for the 21st Century Program Report-1999-2000. pp. 207-210.

Verma, V, Varshney, S.K., Singh, B. and Kumar, A. (2007). Effect of seedling tuberlet size on seed potato yield of TPS varieties in calcareous soils of north Bihar. *Ann. Biol.* **23**(2): 137-139.

Wadhwa, B.K., Pandita, M.L. and Khurana, S.C. (2000). Effect of spacing on ware crop of potato raised from seedlings. *J. Indian Potato Assoc.*, **27**(1/2): 45-46.

Wadhwa, B.K., Pandita, M.L. and Khurana, S.C. (2002). Effect of spacing on ware crop of potato raised from seedlings. *Haryana J. Hort. Sci.* **30**(3/&4): 280-282.

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

Wiesera, S.G. (1982). Potato seed tuber production from true seed. CIP, Lima, Peru. pp. 186-187.

Wiesera, S.G. (1986a). A method of producing seed tubers from true potato. *Potato Research.* **29**: 255-259.

Wiesera, S.G. (1986b). The effect of density on tuber yield in plants grown from true potato seed in seed beds during two contrasting season. *Potato Research.* **29**: 361-365.

Yadav, A.C., Singh, A., Brar, J. and Lal, S. (2003). Effect of irrigation and plant spacing on the growth, yield and water use efficiency of potato cv. Kufri Sutlej. *Haryana J. Hort. Sci.* **32**(1&2): 138-140.

Yenagi, B.S., Meli, S.S. and Angadi, S.S. (2005). Response of potato to spacing, planting date and nitrogen fertilization under rainfed conditions. *Karnataka J. Agric. Sci.* **18**(2): 492-493.

Yenagi, B.S., Meli, S.S., Angadi, S.S., Prabhakar, A.S.N. and Basavaraj, B. (2002). Effects of row spacing, date of planting and levels of nitrogen on yield of potato. *Karnataka J. Agric. Sci.* **15**(1): 134-135.

Yenagi, B.S., Meli, S.S. and Angadi, S.S. (2004). Effect of row spacing, planting date and nitrogen level on tuber grade, yield and economics of potato. *Karnataka J. Agric. Sci.* **17**(2): 220-223.

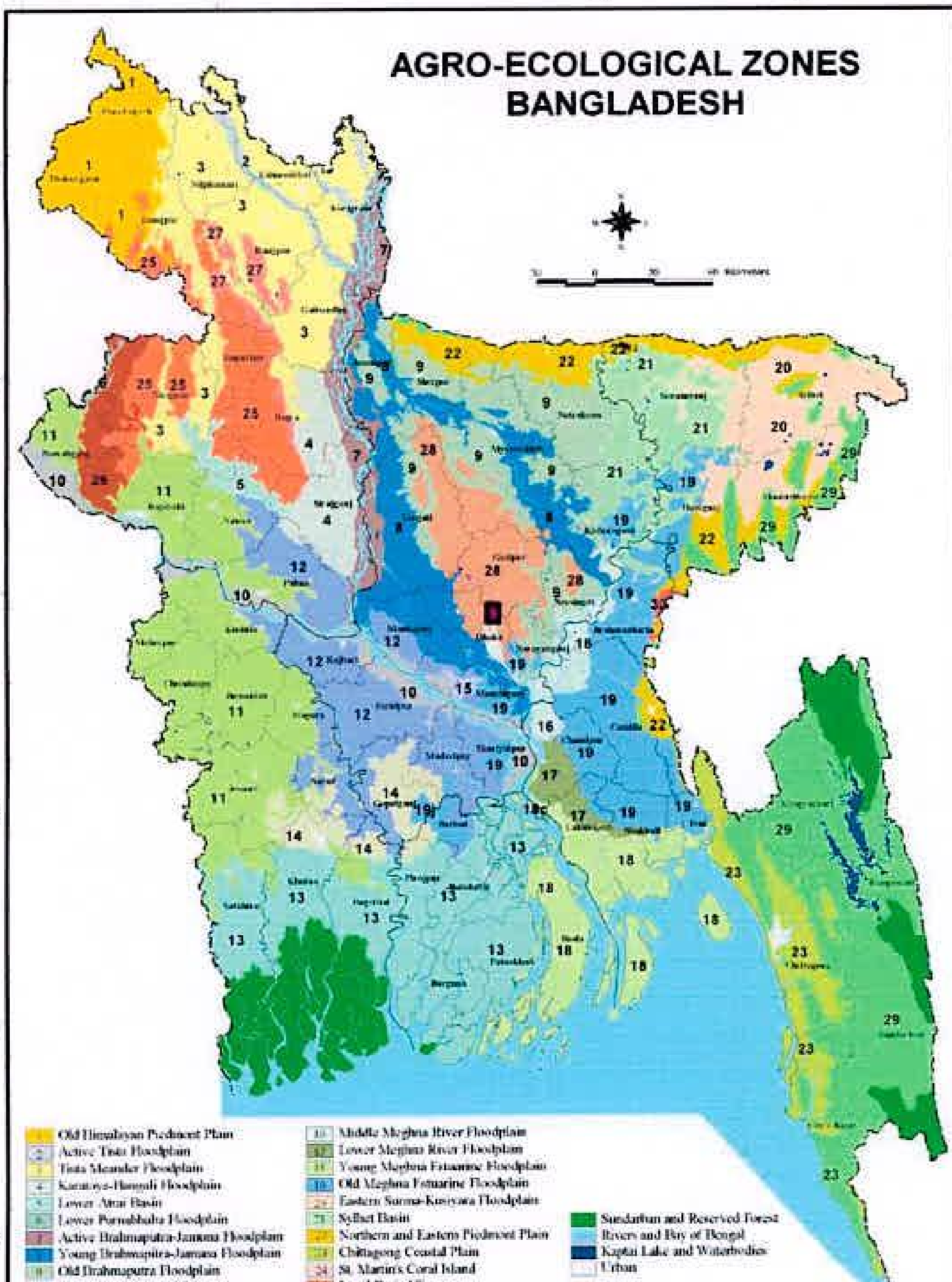
Zakaria, A.K.A., Hossian, M.M. and Uddian, M.K. (1992). Production of seedling tubers from true potato seed (TPS) as affected by different progenies and seedling number per hill. The Bangladesh rural Development Studies. **3**(1&2): 85-92.

Sher-e-Bangla Agricultural University
Library
Sher-e-Bangla Nagar, Dhaka

Appendices

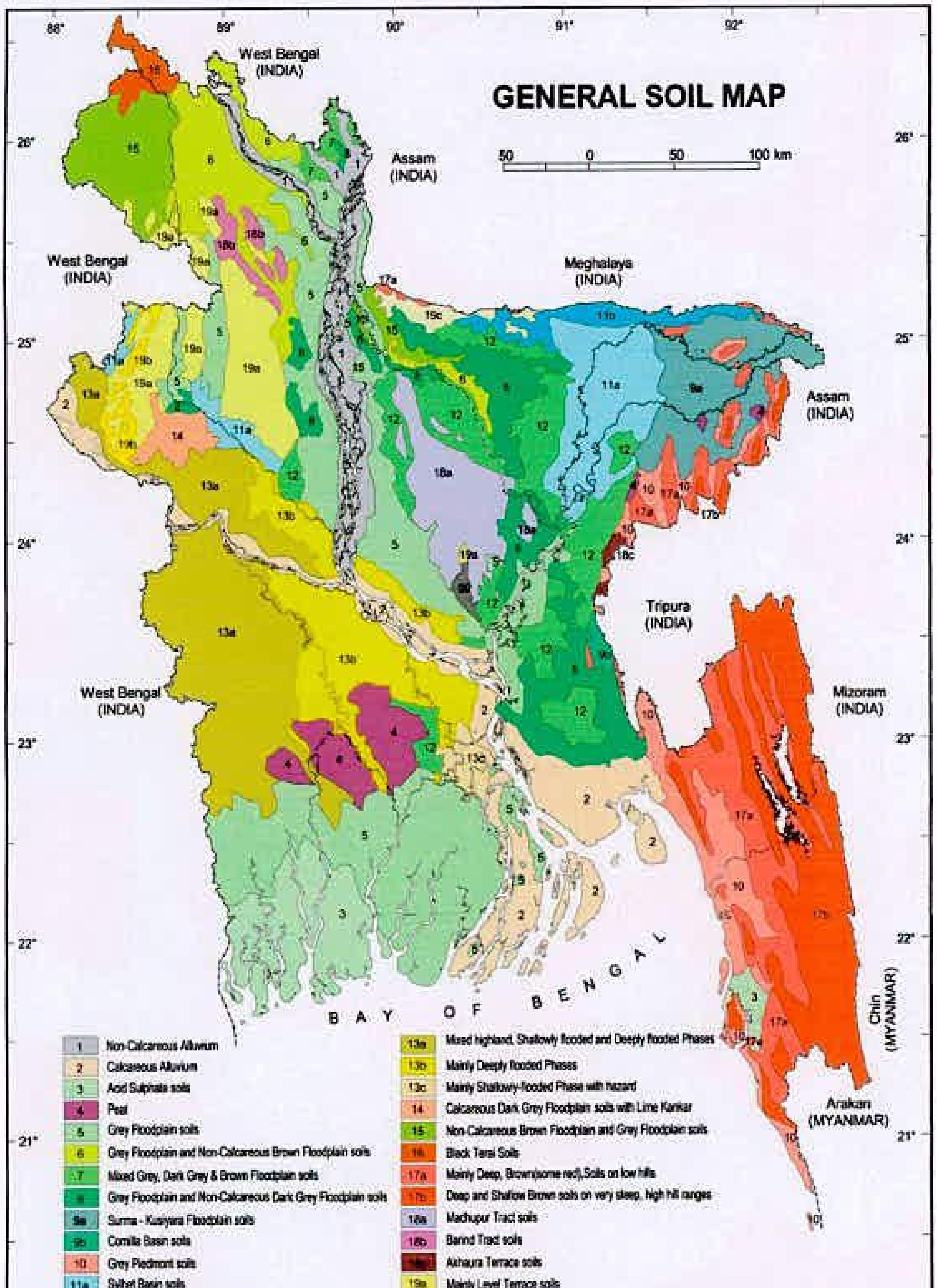
APPENDICES

Appendix I: Map showing the experimental sites under study



The experimental site under study

Appendix II: Map showing the general soil sites under study



Appendix III: Characteristics ofsoil of experimental site is analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping Pattern	Boro–Aman–Boro

B. Physical and chemical properties of the initial soil

Characteristics	Value
%Sand	27
%Silt	43
%clay	30
Textural class	Silty-clay
Ph	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.077
Available P (ppm)	20.00
Exchangeable K (mel 1.00 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2013

Appendix IV. Monthly record of air temperature, rainfall, relative humidity, soil temperature and Sunshine of the experimental site during the period from November 2013 to February 2014

Month	Average air temperature (°C)			Average relative humidity (%)	Total rainfall (mm)	Total Sunshine per day (hrs)
	Maximum	Minimum	Mean			
November, 2013	29.7	20.1	24.9	65	5	6.4
December, 2013	26.9	15.8	21.35	68	0	7.0
January, 2014	24.6	12.5	18.7	66	0	5.5
February, 2014	36.0	24.6	30.3	83	37	4.1

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka – 1212

Appendix V: Error mean square values for plant height of potato at different days after sowing

Source of variation	Degrees of freedom	Plant height			
		30 DAS	45 DAS	60 DAS	Harvest
Replication	4	0.512	6.929	6.929	70.355
Spacing (A)	2	61.214*	258.021*	258.021*	262.010*
No. of TPS hill^{-1} (B)	2	5.027*	121.587*	55.037**	79.470*
A × B	4	0.716**	6.669**	6.669*	3.795*
Error	32	1.949	15.077	15.077	36.725

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VI: Error mean square values for foliage coverage of potato at different days after sowing

Source of variation	Degrees of freedom	Foliage coverage		
		30 DAS	60 DAS	Harvest
Replication	4	0.008	0.612	0.401
Spacing (A)	2	3.909**	8.810*	12.801*
No. of TPS $hill^{-1}$ (B)	2	0.268*	13.934**	9.808*
A × B	4	0.087*	0.679*	0.368**
Error	32	0.185	0.350	0.481

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VII: Error mean square values for number of seedling tuber m^{-2}, average weight of seedling tuber and yield of potato

Source of variation	Degrees of freedom	Number of seedling tuber m^{-2}	Average weight of seedling tuber (g)	Yield (kg m^{-2})	Yield (t ha^{-1})
Replication	4	0.020	0.433	0.001	0.001
Spacing (A)	2	0.305*	0.135*	0.082*	0.041*
No. of TPS $hill^{-1}$ (B)	2	0.081*	0.395*	0.034*	0.026*
A × B	4	0.003*	0.641*	0.008*	0.007*
Error	32	0.006	2.839	0.003	0.002

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VIII: Error mean square values for grading wise yield of seedling tubers (t ha^{-1}) of potato

Source of variation	Degrees of freedom	Grading wise yield of seedling tuber			
		<1-5 g	>5-10 g	>10-20 g	>20 g
Replication	4	1.863	2.164	4.224	0.302
Spacing (A)	2	3.346*	6.761**	5.643**	5.362*
No. of TPS $hill^{-1}$ (B)	2	4.086**	1.107**	8.127**	1.901*
A × B	4	3.407**	1.26**	5.03**	1.60*
Error	32	0.452	1.61	3.35	4.23

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix IX: Cost of production of seedling tuber per hectare

A. Input cost (Tk/ha)

Treatments	Labor	TPS	Pesticides	Irrigation	cow dung	Fertilizer			Subtotal(A)
						Urea	TSP	MOP	
S_1P_1	1,01,100.00	2,800.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,28,814.00
S_1P_2	1,05,100.00	5,600.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,35,614.00
S_1P_3	1,09,100.00	8,400.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,42,414.00
S_2P_1	1,01,100.00	2,800.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,28,814.00
S_2P_2	1,05,100.00	5,600.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,35,614.00
S_2P_3	1,09,100.00	8,400.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,42,414.00
S_3P_1	1,01,100.00	2,800.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,28,814.00
S_3P_2	1,05,100.00	5,600.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,35,614.00
S_3P_3	1,09,100.00	8,400.00	2,500.00	3,000.00	10,000.00	1,404.00	2,760.00	5,250.00	1,42,414.00

S_1 – 25 cm × 4 cm, S_2 – 25 cm × 5 cm, S_3 – 25 cm × 6 cm
P_1 – 1 TPS $hill^{-1}$, P_2 – 2 TPS $hill^{-1}$, P_3 – 3 TPS $hill^{-1}$
True potato seed (TPS): 14 Tk./g
Labor: 350 Tk./day

Cowdung: 2 Tk./kg
Urea: 12 Tk./kg
TSP: 24 Tk./kg
MOP: 25 Tk./kg

Sher-e-Bangla Agricultural University Library, Sher-e-Bangla Nagar, Dhaka

Appendix IX: continued

B. Overhead cost (Tk/ha)

Treatments	Cost of lease of land months for 6 months (14% of value of land Tk. 4,00,000/ year)	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (16% of cost /year)	Subtotal (B)	Subtotal(A)	Total cost of production (input cost +overhead cost)
S_1P_1	28,000.00	6,440.70	10,305.12	44,745.82	78,814.00	1,23,559.82
S_1P_2	28,000.00	6,780.70	10,849.12	45,629.82	85,614.00	1,31,243.82
S_1P_3	28,000.00	7,120.70	11,393.12	46,513.82	92,414.00	1,38,927.82
S_2P_1	28,000.00	6,440.70	10,305.12	44,745.82	78,814.00	1,23,559.82
S_2P_2	28,000.00	6,780.70	10,849.12	45,629.82	85,614.00	1,31,243.82
S_2P_3	28,000.00	7,120.70	11,393.12	46,513.82	92,414.00	1,38,927.82
S_3P_1	28,000.00	6,440.70	10,305.12	44,745.82	78,814.00	1,23,559.82
S_3P_2	28,000.00	6,780.70	10,849.12	45,629.82	85,614.00	1,31,243.82
S_3P_3	28,000.00	7,120.70	11,393.12	46,513.82	92,414.00	1,38,927.82

Sher-e-Bangla Agricultural University
Library
Accession No. 39786
Sign. Date 16.11.16