BULKING BEHAVIOR OF SEEDLING TUBERS DERIVED FROM TRUE POTATO SEED (*Solanum tuberosum* L.) AS AFFECTED BY ITS SIZE AND HARVESTING TIME

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TO

MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled "**Bulking Behavior of Seedling Tubers Derived from True Potato Seed (***Solanum tuberosum* L.**) as Affected by its Size and Harvesting Time**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE** in **AGRONOMY**, embodies the result of a piece of bonafide research work carried out by **Nahida Amin**, Registration number: **10-04208** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

Dated:

Dhaka, Bangladesh

Prof. Dr. A. K. M. Ruhul Amin

Supervisor

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BULKING BEHAVIOR OF SEEDLING TUBERS DERIVED FROM TRUE POTATO SEED (*Solanum tuberosum* L.) AS AFFECTED BY ITS SIZE AND HARVESTING TIME[1]

BY

NAHIDA AMIN[2]

ABSTRACT

A field experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2010 to April 2011 to investigate the effect of seed tuber size and harvesting time on morpho-physiological characters, yield attributes and yield of potato. The experiment comprised of four different size of seed tubers *viz*., 28-<45 mm, 20-<28 mm, 10-<20 mm and <10 mm and four harvesting time *viz*., 70 (DAP), 80 DAP, 90 DAP and 100 DAP. The experiment was laid out in randomized complete block design factorial with three replications. The growth parameters such as stems hill^{-1}, leaves hill^{-1}, tuber yield plot^{-1}, marketable yield plot^{-1} and tuber yield ha^{-1} were significantly influenced by seed tuber size and harvesting time. Results revealed that in general, plant height, stems hill^{-1}, LA plant^{-1} increased with increasing seed tuber size but yield attributes and yield increased with 28-<45 mm tuber size. The highest tuber yield hectare was recorded in the tuber size of 28-<45 mm due to increased of tubers hill^{-1} and tuber yield plot^{-1}. In contrast, the lowest tuber yield ha^{-1} was recorded in the smaller seed tuber of <10 mm. Results showed that stems and leaves hill^{-1}, LA, TDM and tubers hill^{-1}, single tuber weight and tuber weight plot^{-1} increased with increasing time of harvest upto 90 DAP. The highest number of stems and leaves hill^{-1}, LA, TDM, tubers hill^{-1}, single tuber weight and tuber weight plot^{-1} were observed in the harvesting time 90 DAP and the lowest in harvesting time 70 DAP. However, the highest gross tuber yield ha^{-1} was observed in the harvesting time 90 DAP and the lowest was recorded in 70 DAP. For combined effect of seed tuber size and harvesting time, the highest gross tuber yield was observed in the treatment combination of 20-<28 mm seed tuber with the harvesting time of 90 DAP which was economically adventitious.

LIST OF ABBREVIATION

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
et al.	and others
BBS	Bangladesh Bureau of Statistics
cm	Centimeter
°C	Degree Celsius
DAP	Date After Planting
etc	Etcetera
FAO	Food and Agriculture Organization
gm	Gram
ha	Hectare
hr	Hour
kg	Kilogram
m	Meter
mm	Millimeter
MoP	Muriate of Potash
No.	Number
%	Percent
RCBD	Randomized Complete Block Design
m^2	Square meter
TSP	Triple Super Phosphate
UNDP	United Nations Development Program

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CHAPTER I

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tuber crop belonging to the family Solanceae is one of the most important vegetable crops of the world. It is originated in the Peru-Bolivian region in the Andes of South America (Grewal *et al*., 1992). The crop is widely cultivated using seed tuber propagating materials. It is the 4^{th} major crops of the world on the basis of production and consumption and used as a principal vegetable in most of the Asian countries (Rashid, 1987). In Bangladesh, potato is one of the major crops next to rice and wheat and covers an area of about 403.4 thousand hectare of land producing 5.95 million tons of potato with 14.74 tons of average yield $hectare^{-1}$ (MoA, 2009). It is a carbohydrate rich crop, and is consumed almost absolutely as a vegetable in Bangladesh. It contributes as much as 55% of the total vegetable demand in Bangladesh (BBS, 2009).

Potato has acquired great importance in rural economy in Bangladesh. It is not only a vegetable crop but also an alternative of food crop against rice and wheat. Bangladesh has a significant agro-ecological potential of growing potato. The area and production of potato in Bangladesh has been increasing during last decades but the yield per unit area remains more or less static. 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, 42.1 t ha^{-1} in Denmark and 40.0 t ha^{-1} in UK (FAO, 2009). The reasons responsible for such a low yield of potato in Bangladesh are use of low quality seed and use of suboptimal production practices. For planting one hectare of land, it requires about 1.5 to 2.5 tons of seed potato, which covers about 40-60% of the total cost of production. Available reports indicated that potato production in Bangladesh can be increased by improving cultural practices among which optimization of manure and fertilizer, planting time, harvesting time, spacing and use of optimal sized seed which greatly influences the yield of potato (Divis and Barta, 2001).

The production of potato using botanical or true potato seed (TPS) offers a good alternative to the use of traditional seed tubers. Seedling tubers produced from TPS (true potato seed) are generally an excellent basic seed which are free from most degenerative diseases and could provide small farmers with simple but cheap device of producing healthy seed tubers in their own environments. Seedling tubers have been shown the potential as propagating material alternative to costly seed tubers (Wiersema, 1984; Chaudhury and Rasul, 1995; Siddique, 1995). Siddique (1998) made a projection of the role of TPS in potato production, and has shown that, nearly 32% of the potato area under modern varieties in Bangladesh could be covered by high quality seed tubers produced from TPS within a period of only 3 years. Development of 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 10 cm × 10 cm spacing (TCRC, 2009). The weight of seedling tubers varies from 1 g to 50 g, the majority being less than 20 ± 2 g. 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 harvesting time is maintained. Siddique *et al.* (1987) reported that the tuber yields produced from large seed tubers were higher compared to small tubers. Kadian *et al.* (1988) stated that the seedling tubers of below 20 g size can successfully be used as seed tuber for next season, which gave the same potential yield as from seed tubers (30-50 g) of standard cultivars.

On the other hand, timely harvesting is an important practice in tuber production to obtain desired size and quality planting material. Growing period of potato in Bangladesh is relatively shorter and tuber development may be influenced with the increase of growing period. Available information in respect of time of harvesting on seedling tuber production under Bangladesh conditions is also lacking. Mehta ad Kaul (2003) found that the respiration rate one day after harvest was highest in immature tubers harvested at 60 DAP, and the rates decreased as the harvest was delayed.

In view of the above situation, the present study was undertaken with the following objectives:

i. To find out the effect of tuber size on growth and yield of potato;

ii. To find out the optimum harvesting time in order to get a higher yield of good quality tubers; and

iii. To study the combined effect of tuber size and harvesting time on growth, yield and economic return of potato.

CHAPTER II

REVIW OF LITERATURE

Potato is one of the important vegetable crop in Bangladesh and as well as many countries of the world. For increasing the growth and yield of potato abundant studies were conducted in the country and abroad. But a very few studies on the related to growth and tuber production due to tuber size and harvesting time have been carried out in our country as well as many other countries of the world. On the other way, the research work so far done in Bangladesh and is not adequate and conclusive. Nevertheless, some of the important and informative works and research findings related to the effects of tuber size and harvesting time on growth and tuber production of potato have been reviewed in this chapter under the following headings-

2.1 Effect of tuber size on growth and yield of potato

Wiersema (1982) suggested that for the production of ware potato from seedling tuber of 1-5 g size the spacing should be 50 cm × 10-15 cm. He also found that the multiplication rate (yield planting rate^{-1}) 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. The yield of plants grown from small (5-20 g) seedling tubers was similar to that of plants grown from clonal seed tubers when planted at equivalent weight rates (CIP, 1982).

Wiersema (1984) reported that plants in small sized (1-5 g) seedling tubers develop more slowly mature later and produce a larger proportion of tubers smaller than 45mm than plants from larger tubers. It would, therefore, appear that the management of relatively small seedling tubers should aim at promoting early plant growth by close plant spacing. He also stated that small tubers tend to produce small tubers, a tendency likely to be more pronounced in a shorter growing period. He also reported that early plant growth, rate of ground cover, number of above ground stems as well as number and yield of tubers increased with increasing seedling tuber size. The advantage of small tubers specially small seedling tubers over larger ones would seem to be their high multiplication rate. The high multiplication rate of small tubers and their tendency to produce small tubers would make them particularly suitable for the production of seed potato rather than ware potato production.

Hussain (1985) concluded that tuber yield increased with the increase in seed- size and it was primarily due to high food reserve in large seeds. Wiersema and Cabello (1986) found that although final emergence of plants derived from different sized seedling tubers was similar, but plants from 1-5 g seedling tubers required an average of 4 days more to reach 90% emergence than plants from larger seedling tubers. They also concluded that 1-5 g tubers are more suitable for seed tuber (28-45 mm) production than for the production of ware sized tubers.

Siddique *et al.* (1987) reported that the tuber yields produced from large seed tubers were higher compared to small tubers. Rashid (1987) conducted a trial at TCRC, BARI, Joydebpur and observed increased plant emergence with larger seed tubers, but the effect was not significant. He also observed that the effect of tuber size on emergence and reported that plant emergence increased with large seed tubers than small seeds and ultimate result was higher shoots plant^{-1}. Mandala and Arora (1987) conducted an experiment with 15, 25 and 35 cm plant spacing and 45 cm row spacing, and observed that the lowest spacing gave the highest yield.

Kadian *et al.* (1988) stated that the seedling tubers of below 20 g size can successfully be used as seed tuber for next season, which gave the same potential yield as from seed tubers (30-50 g) of standard cultivars. From an experiment on seedling tuber size Hoang *et al.* (1988) stated that yield increased markedly with the increase of seedling tuber size. 2-5 g sized seedling tubers yielded 17.6 t ha^{-1}, whereas 10-15 g sized seedling tubers yielded 23.9 t ha^{-1}. From another trial, comparison between the local cultivar and TPS seedling tubers they found that the TPS progeny had superior resistance to *Phytophthora infestans*, lower virus infection and higher yield at harvest.

According to Nankar (1990) nearly 50% of the seedling tubers produced in nursery beds were of below 59 size. To assess the possibility of using <5 g seedling tubers as planting material one, two and three seedling tubers hill^{-1} were planted in the inter-cropping system. Three seedlings tubers/hill gave the highest yield. 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 10g tubers gave lower yield than 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 that for the crop raised from 20 g tubers.

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. Singh (1992) reported that with common seed rate in three seed sizes, small seed size (25 g) gave 21.1 and 46% higher yield than medium (50 g) and large (100 g) seed. The multiplication rate decreased with increase in seed size. Planting the small seeds fetched the highest net income.

The size of seed tuber influences the production of potato. The growth of young plant is directly related to the size of seed used and generally large seed tubers exhibit earlier sprout emergence, faster growth and development, more stems as well as tubers, earlier maturity and higher tuber yield than small seed (Grewal *et al.*, 1992). Batra *et al.* (1992) reported that percent emergence, plant height, tuber number/hill and tuber yield increased with increase in seedling tuber size.

Engels *et al.* (1993) reported that the rate of field emergence was faster with large (>5 g) than with small (<5 g) seedling tubers, but the final emergence was about 90% regardless of size. Initial foliage development was much faster from large than from small seedling tubers. The number of above ground stems increased with increasing seedling tuber size. However, on a per weight basis, 1-5 g tubers were about five times more effective in producing stems than tubers of >20 g. He also found that tuber yields from small seedling tubers were increased at higher planting densities. The potential of seedling tubers to produce tubers of marketable weight decreased with decreasing seedling tuber size.

The main difference between plants grown from small and large seedling tubers was the comparatively slower growth rate of those small tubers. Karle *et al.* (1997) reported that with same spacing large seedling tubers (5-10 g) produced significantly higher yield over small seed size (up to 5 g). The multiplication rate and benefit cost ratio was highest in small sized seeds. Thus planting small sized seedling tubers seems to be an attractive low investment technology for potato production, provided tubers are healthy.

To find out an optimum planting density of seedling tubers, two spacing (50 × 20 cm and 50 × 10 cm) were studied by Saikia and Rajkhowa (1998) and they found that both total and marketable yields were higher in closer spacing (50 × 10 cm) over the spacing of 50 × 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 than 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 × 15cm and 60 × 30 cm spacing respectively.

Chaudhury and Rasul (1995) reported that small (<20 mm), medium. -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.

An experiment were conducted by Garg *et al*. (2000) to know the effect of tuber size (10-15, 15-20, 20-40, 40-60 and 60-80 g) and spacing (60 × 10 cm and 60 × 15 cm) and dehaulming of potatoes (cv. Kufri jyoti) on number and yield of seed-size tubers. They reported that 40-50 g seed tubers planted at 60 × 10 cm showed the highest seed yield. The higher economic yield of seed-sized tubers could be achieved from 15-20 g of seeds at 60 × 10 cm spacing.

Gregoriou (2000) studied the effect of tuber size (30, 40, 50 and 65 mm) and row spacing (10, 20, 30 or 40 cm) on yield in potato cv. Cara and reported that seedling emergence was reduced at 10 cm spacing. Tuber yield decreased with increasing spacing. The tubers stem^{-1} and the yield per stem decreased as stem number per unit area increased. The best combination of total and baking (>65 mm) potato yield was estimated to be with a 27-cm planting distance.

Three experiments were conducted by Khalafalla (2001) to know 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 and reported that yield decreased with decrease in seed size and increase in spacing at all locations. Seed size had significant effect on marketable tubers plant^{-1}, marketable tuber weight, and stems plant^{-1}.

BongKyoon *et al*. (2001) conducted an experiment with tubers of potato (*Solanum tuberosum*) cv. Dejima weighing 10, 20, 30, 40, and 50 g were planted in plug trays with vermiculite-based root medium to determine the effects of mini-tuber size on plug seedling growth and field performance of plug seedlings. For a control, common potato tubers weighing 50 g were also planted. The authors reported that as size of seed tubers planted increased from 10 to 50 g, seedling height decreased from 24.6 to 20.0 cm while shoot number per seedling increased from 2.0 to 3.5, main stem diameter from 4.3 to 6.1 mm, and fresh weight of root + top from 9.3 to 19.4 g seedling^{-1}. At 90 days after transplanting, the total tubers plant^{-1} was increased from 3.62 to 4.72, average tuber weight from 62.9 to 72.8 g, and total tuber yield 20.5 to 23.6 t/ha with increase in seed tuber size. Plug seedlings raised from 50 g tubers was produced 22% more tubers plant^{-1} and had 21% higher >80 g tuber yield than the directly planted potatoes.

The effect of tuber size (25-30, 30-55, 55-75 and 75-85 mm) on potato growth and yield was determined by Divis and Barta (2001) in Czech Republic in 1996-98. The authors reported that increasing seed tuber size produced an increase in emergence percentage. Larger tubers produced higher stems plant^{-1}, crop growth rate as compared to small tubers which resulted in higher yield compared to small ones.

The genotype by environment interactions affecting the quantity and quality of hybrid true potato seed (TPS) were evaluated by Upadhya and Cabello (2001). Sixteen cross combinations were tested to select parental lines and cross combinations for stability for berry and TPS characteristics across environments. The effects of seed size and density strongly suggest a high correlation between seed size and yield. Therefore, in the selection of hybrid TPS combinations, parental lines that give a higher proportion of large (1.6 mm) seeds should be selected for field trials in the development of TPS for use in potato (Solanum tuberosum) production.

A three year field trial was carried out by Reust (2002) at the Swiss Federal Research Station for Plant Production of Changins [Switzerland] with different seed tuber sizes (25-35, 35-50 and 50-65 mm) to find out the effect of seed tuber size on yield in potato and reported that yields were not different between small graded seed (25-35 mm) and normal seed size (35-50 mm). The author further reported that small seed tubers had a longer dormancy and produced less stems and tubers plant^{-1} than large ones. The author opined that by using small graded seed, farmers might significantly reduce production costs.

A field experiment was carried out by Patel *et al.* (2002) during 2000 and 2001 in Kargil, Jammu and Kashmir, India, to investigate the effect of seed size [medium (25-50 g), big (50-75 g) and large (75-100 g)] and intra row spacing (20, 25 and 30 cm) on the yield of potato cv. Kufari Chandramukhi. The authors reported that growth, total yield, tubers plant^{-1} and average weight per tuber were greatly affected by seed size and spacing. Tuber yield (305.24 q ha^{-1}) and the number of tuber plant (10.40) were significantly highest with big seed size and 25 cm intra row spacing, while average weight per tuber (53.93 g) was highest with large seed size and 30 cm intra row spacing.

An experiment was conducted by MacKerron (2002) in SCRI and Terrington, UK, to test the effects of potato seed size and plant spacing in 8 combinations of seed size and plant spacing in 6 cultivars (King Edward, Marfona, Maris Piper, Pentland Dell, Pentland Squire and Shepody). Treatments comprised: the combinations of 5 seed sizes (30-35, 35-40, 40-45, 45-50, 50-55 mm) and 5 row spacings (15, 18, 25, 33 and 45 cm). The differing sensitivities of showed an inverse relation between average tuber size and stem density that provides the means of controlling tuber size distribution.

A study was conducted by Wadhwa *et al.* (2002) to investigate 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 spacing of 20 cm, 30 cm and 40 cm were also used. The authors reported that leaf area index (LAI) and crop growth rate (CGR) were greater in larger seeds than smaller ones. The authors further reported that yield increased with the use of heavier 'seed' tubers. On the average, yield of plants of category B 'seed' tubers was 52% higher than those obtained from 'seed' tubers of category A and 58% and 59% higher than those of categories C and D, respectively.

The effect of N rate (75, 100, 125 and 150 kg ha^{-1}), seed size (30-60 and 61-90 g) and spacing (60 ×15 and 60 × 20 cm) for the newly released potato cv. Kufri Sutlej were observed by Malik *et al*. (2002) and reported that the number of stem $hill^{-1}$, tuber yield $plant^{-1}$ and tuber yield were higher under 60 × 20 cm spacing and using 60-90 g seeds.

Shingrup *et al.* (2003) investigated the effect of row spacing (45 and 60 cm) and tuber size (6-25 g and 26-45 g) on growth, yield and yield components of potato cv. *Kufri jyoti* and reported that plant growth and development increased with increased tuber size. The tuber size of 26-45 g recorded significantly higher yield but average weight of tuber was higher in 6-25 g tuber size. Upadhya and Cabello (2001) studied the influence of seed size and density on the performance of direct seedling transplants from hybrid true potato seed and reported that seed size and density strongly suggest a high correlation between seed size and yield.

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 seed tubers size of 26-45 g recorded significantly higher tuber yield, gross monetary returns, net monetary returns and benefit-cost ratio than seed tubers of 6-25 g size.

An experiment was conducted by Sonawane and Dhoble (2004) during the winter (*robi*) 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*) and reported that the tuber yield increased with the increase in seedling tuber size. Significantly highest tuber yield was recorded by large seedling tuber size of 11-15 g over 1-5 g and 6-10 g sizes. Similarly, 6-10 g seedling tuber weight was significantly superior to 1-5 g size. Benefit: cost ratio decreased as the seedling tuber size increased from 1 to 15 g.

An experiment was conducted by Verma *et al.* (2007) at Muzaffarpur, Bihar, India, during rabi 2001-02 with 15 treatment combinations which included five seed tuberlet sizes (<10, 10-20, 20-30, 30-40 and >40 g) and three true potato seed (TPS) cultivars (92-PT-27, TPS C-3 and HPS 1/13). They reported that the seed tuberlet size of 30-40 g resulted in significantly superior tuber yield, which was at par with the tuber yield obtained from 10-20 and >40 g seed tubers in all the three TPS cultivars. Use of large seed generally results increased seed rate. However, the net yield is generally higher with seed of medium size (Bayorbor and Gumah, 2007).

Patel *et al*. (2008) conducted an experiment to evaluate the effects of physiological age (200, 375, 750 and 1125 degree days) and seed size (31-59 g and 51-70 g) on the growth (percent emergence, percent ground cover and number of stems hill^{-1}) and tuber yield of potato on loamy sand soils and observed that better growth and yield could be achieved by planting 51-70 g seed tubers with a physiological age of 375 degree days.

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 early potato were studied by Gulluoglu and Aroglu (2009) in Adana, Turkey and reported that planting larger seeds positively affected all growth and yield components. Tuber yield hectare^{-1} was increased up to certain stem density and then was started to decline at all seed sizes. However, the optimum stem density for the maximum tuber yield hectare^{-1} markedly differed depending on size of seed tubers. The optimum stem density increased with increasing seed size .The authors indicated that size of seed tuber has further importance for growth of potato plant as well as competition aspect in early potato production in the mediterranean-type environments. The author concluded that using larger tubers had an advantage for vigorous early growth and for obtain high tuber yield in early potato production in the mediterranean-type environments. Seed size should be considered during recommendation for planting density in potato production.

Field performances of minitubers obtained from in vitro plantlets and tubers obtained from microtubers from 6 potato genotypes (Nif, Clone 122, Agria, Resy, Marfona and Granola) were compared by Ozturk Yldrm (2010). In vitro plantlets and microtubers were obtained by using meristem culture technics in the laboratory and at seedbeds. Initially, in vitro plantlets (IP) and microtubers (MT) were grown at seedbeds and they were evaluated for morphological and yield characteristics. The IP and the MT plants were not significantly different for plant height, stem number, branch number and leaf number. The high means were obtained from the IP plants such as leaf area, tuber number, single tuber weight, tuber yield, tuber width and length. Genotype Nif had the highest means for the majority of characteristics. In the first and second years of field production, the MT group were found to have higher means for plant height, stem number, branch number and leaf number. But the IP and MT tubers were not significantly different in terms of yield characteristics except tuber number. The high values for yield and related traits were obtained for Clone 122 and Nif.

The split block design was used in mini-potato reproduction of Zhongshu 3 in autumn to study the effects of mini-potato weight and planting density on yield and yield characters by Wu *et al*. (2010). The results showed that the optimum planting density of mini-potato which weighed 1-5 g and more than 5 g were 8500-9000 plants/667 m^2 and 6500-7000 plants/667 m^2 respectively.

The experiments were conducted by Khan *et al*. (2010) to determine the suitable planting geometry for better yield from TPS mini tubers during autumn 2006-2007 and 2007-2008. It was revealed that even small size (5-20 g, 20-30 g) tubers planted at closer row and plant spacing (60 cm × 15 cm, 70 cm × 15 cm) produced

31.00%, 31.33% and 28.33%, 32.33% medium size tubers (35-55 mm size). Whereas wider spacing (70 cm × 20 cm, 50 cm × 20 cm) produced relatively higher number of large size tubers.

2.2 Effect harvesting time on the growth and yield of potato

Peterson *et al.* (1981) observed that respiration rates of Potato tubers were high immediately after harvest, and declined to an equilibrium level after about 7 days. Weight loss during storage ranged from 8.3 to 3.7% in the early and late harvested samples.

Kundzicz (1985) stated that the influence of harvest date on the storage loss was considerable. The highest losses occurred at late harvest dates during the storage of cv. Sokol and Sowa. At early harvest dates the differences in the amount of damage were remarkable.

Ezekiel and Rakesh (1988) illustrated that the sprouting of potato cv. Kufri Candramukhi increased with the increase in age of seed tubers. Physiologically older tubers were reported to have higher sprouting. It was also reported that, endogenous content of IAA could be related to rate of sprout elongation in potato. According to Frydecka and Zgorska (1988) the losses of dry matter, starch and total tuber weight in storage decreased as harvesting time was delayed. Somani *et al.* (1988) stated that potatoes in cold storage after harvesting in January and February showed higher sprouting than those harvested in March.

Chaurasia and Singh (1992) conducted an experiment at Uttar Prodesh of India on potato cv. Kufri Bahar and Kufri Lalmia. Haulms were cut 80, 90, 100, 110 and 120 days after planting. Tubers were harvested 10 days after stem cutting, and stored for 30, 60 and 90 days. They observed that the percentage of tuber weight loss, sprouting and rotting decreased with the delay in haulm cutting date.

According to Okwuowulu and Asiegbu (2000) the harvesting age significantly ($p<0.05$) affected the storability of potato; tubers harvested early (3 months after planting) exhibited the greatest deterioration as a results of sprouting and weight loss, but were characterized by lowest rot incidence.

Mehta ad Kaul (2003) evaluated the storability and processing quality of two potato cultivars cv. Kufri Chandramukhi and Kufri Lauvkar in India and found that the respiration rate one day after harvest was highest in immature tubers harvested at 60 DAP, and the rates decreased as the harvest was delayed. The weight loss in stored potatoes was affected by harvest date with more physiologically immature tubers.

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.

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^{-1}) 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^{-1} supplementation. Tuber weight was highest with 60 cm row spacing, 18 June planting and 150 kg N ha^{-1} 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.

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 agro-climatic regions of the country by Dua *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^{-1}, 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^{-1}) 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^{-1}) and dehaulming at 80 days after planting.

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.

From the above review it is regarded that potato yield can be optimized with the use of ideal seed size with optimum harvesting time during potato cultivation.

CHAPTER III

MATERIALS AND METHODS

The field experiment was conducted during the period from November, 2010 to April, 2011 to find out the bulking behavior of seedling tubers derived from true potato seed as affected by its size and harvesting time. In this chapter the details of different materials and methodologies used followed during the experimental period have seen presented under the following heads:

3.1 Experimental location

The experiment was conducted at the Agronomy Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the *Rabi* season of November 2010 to April, 2011.

3.2 Description of the experimental site

The experimental site is geographically situated at $23^{0}41'$N latitude and $90^{0}22'$E longitude at an altitude of 8.6 meter above sea level. For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix I.

3.3 Climate

The experimental site under the sub-tropical climate that is characterized by cold temperature and minimum rainfall are the main features of the Rabi season. The weather conditions during experimentation such as monthly rainfall (mm), mean temperature (^{0}C), sunshine hours and humidity (%) have seen presented in Appendix II.

3.4 Soil

The soil of the experimental field belongs to the general soil type, Shallow Red Brown Terrace Soils under Brahmaputra Madhupur Tract. The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0-15 cm depth were collected from the experimental field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The physicochemical properties of the soil have been presented in Appendix III.

3.5 Treatments of the experiment

The experiment comprised of two factors:

Factor A: Seedling tuber size (4 levels)

i. S_1: 28-<45 mm

ii. S_2: 20-<28 mm

iii. S_3: 10-<20 mm

iv. S_4: <10 mm

Factor B: Harvesting time (4 levels)

i. D_1: 70 Days after planting (DAP) harvest

ii. D_2: 80 DAP harvest

iii. D_3: 90 DAP harvest

iv. D_4: 100 DAP harvest

There were on the whole 16 (4 × 4) treatment combinations such as S_1D_1, S_1D_2, S_1D_3, S_1D_4, S_2D_1, S_2D_2, S_2D_3, S_2D_4, S_3D_1, S_3D_2, S_3D_3, S_3D_4, S_4D_1, S_4D_2, S_4D_3 and S_4D_4.

3.6 Planting material

The first generation TPS seedling tubers of BARI TPS-1 were collected from the Tuber Research Centre, Bangladesh Agricultural Research Institute, joydebpur ,Gazipur.

3.7. Preparation of the experimental field

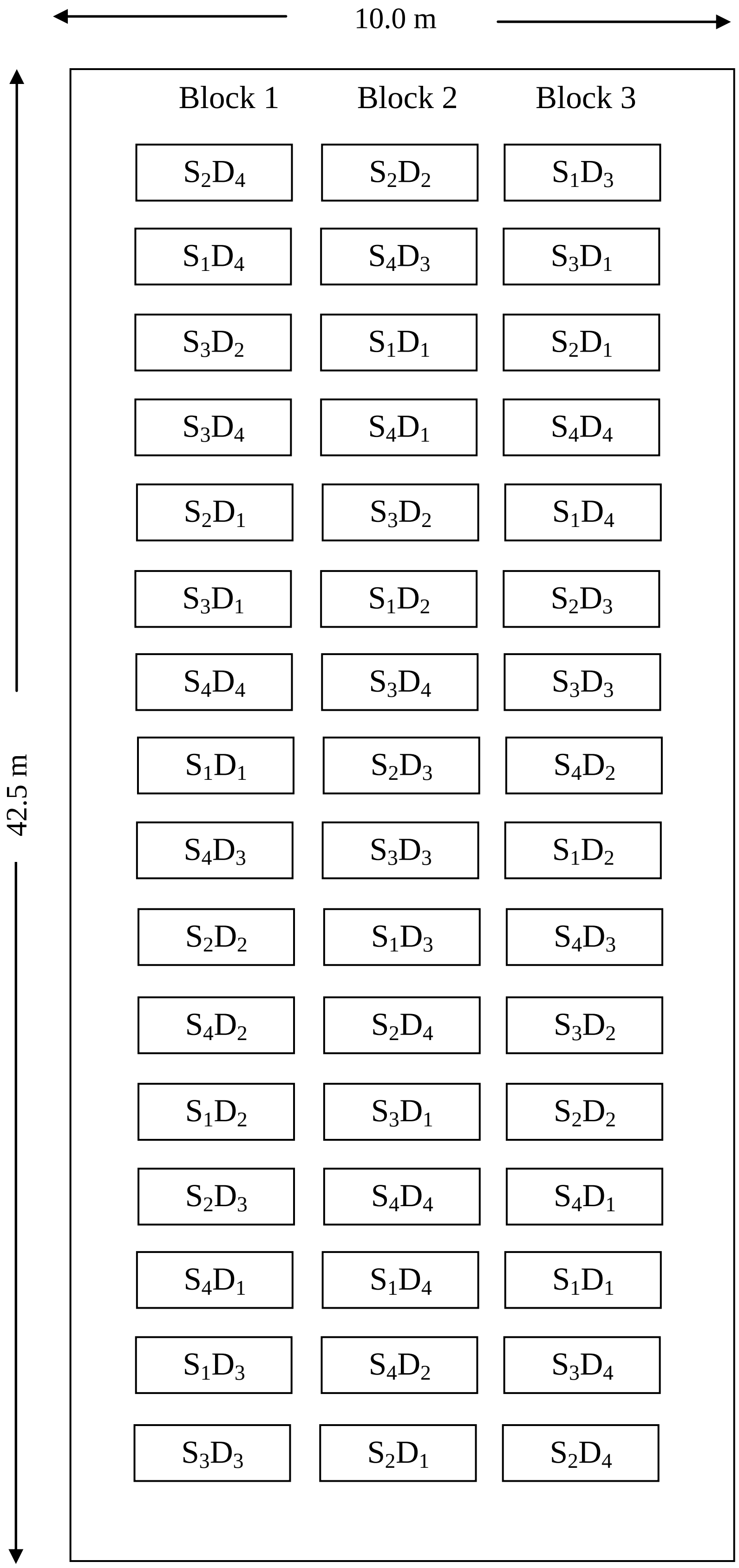
The selected field for growing the TPS seedling tubers was first opened at last week of October with a power tiller and was exposed to the sun for a week. Then the land was prepared to obtain good tilth by several ploughing, cross ploughing and laddering. Subsequent operations were done with harrow, spade and hammer etc. Weeds and stubbles were removed; larger clods were broken into small particles. The land was finally prepared on 05 November 2010 into a desirable tilth to ensure proper germination conditions. The plot was partitioned into the unit plots according to the experimental design as mentioned in section 3.8. Recommended doses of well decomposed cowdung and chemical fertilizers, as indicated in section 3.9 were applied and well mixed with the soil of each plot. Proper irrigation and drainage channels were also prepared around the plots. Each unit plot was well prepared keeping height of the plot about 15 cm from the drains. The soil was treated with Furadan 5G @ 15 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cutworm. The bed soil was made friable and the surface of the beds was leveled.

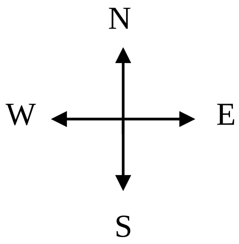
3.8 Experimental design and layout

The two factor experiment was laid out in a randomized complete block design (factorial) with three replications. The size of unit plot was 4 m × 2.5 m. Distances between block to block and plot to plot were 1.0 m and 0.50 m, respectively. Treatments were randomly distributed within the blocks. The layout of the experiment is shown in Figure 1.

3.9 Manure and fertilizer application

The crop was fertilized as per recommendation of TCRC (2009). Urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum, zinc oxide and boric acid were used as sources of nitrogen, phosphorus, potassium, sulphur, zinc and boron, respectively. The doses of fertilizers were 320, 232, 285, 120, 10 and 10 kg ha^{-1} for urea, TSP, MoP, gypsum, zinc oxide and boric acid, respectively. Rotten cowdung @ 10,000 kg ha^{-1} was applied 10 days before final land preparation. Total amount of TSP, gypsum, ZnO, boric acid and half of urea and MoP were applied as basal dose during final land preparation. The remaining 50% urea and MoP was side dressed in two equal splits at 25 and 45 days after planting (DAP) during first and second earthing up.





Plot size = 4.0 m × 2.5 m

Plot to plot: 0.5 m

Replication to replication: 1.0 m

Factor A: Seedling tuber size (4 levels)

i. S_1: 28 - <45 mm

ii. S_2: 20 - <28 mm

iii. S_3: 10 - <20 mm

iv. S_4: <10 mm

Factor B: Harvesting time (4 levels)

i. D_1: 70 Days after planting (DAP) harvest

ii. D_2: 80 DAP harvest

iii. D_3: 90 DAP harvest

iv. D_4: 100 DAP harvest

Figure 1. Field layout of two factorial experiment in the Randomized Complete Block Design (RCBD)

3.10 Seed preparation and sowing

The seedling tubers were taken out of the cold store about three weeks before planting. The tubers were graded according to the size and kept under diffuse light conditions to have healthy and good sprouts. Planting was done on November 10, 2010. The well sprouted seed tubers were planted at a depth of 5-7 cm in furrow made 60 cm apart. Hill to hill distance was maintained for 20 cm in the experiment. After planting, the seed tubers were covered with soil.

3.11 Intercultural operations

The seedlings were always kept under care and observation. After emergence of seedlings, the following intercultural operations were accomplished for their better growth and development:

3.11.1 Irrigation

The crop was irrigated with a watering can as and when needed depending on the moisture status of the soil and requirement of plants.

3.11.2 Thinning and gap filling

The seedlings were first thinned out from all the holes at 20 DAS. They were again thinned out at 30 DAS keeping only one healthy seedling per hill. On the contrary, gap filling was done when necessary.

3.11.3 Weeding and mulching

Weeding and mulching were necessary to keep the plots free from weeds, ease of aeration and conserve soil moisture. The newly emerged weeds were uprooted carefully after complete emergence of TPS seedlings and afterwards when necessary. Mulching was done by breaking the surface crust as and when needed.

3.11.4 Earthing up and top dressing

The remaining dose of urea (50%) and MoP (50%) were mixed with the required quantity of bed soil in 2 installments. Then that was applied to the beds uniformly. The practice was a combination of earthing up and top dressing, and was done twice after 25 and 45 DAP.

3.11.5 Plant protection measures

Furadan 5G @ 20 kg ha^{-1} was applied during final preparation of the main field to prevent the crops and tubers from the soil insects. Sevin dust was used after sowing the seeds to prevent them from insect attack. Fungicide, Ridomil (0.25%) was sprayed at an interval of 10 days, commencing at 40 DAP as a preventive measure against late blight, Kenalux 0.1% was also sprayed in addition to Ridomil to protect the crop from the attack of virus disseminating aphid.

3.12 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action for normal plant growth.

3.13 Harvesting

Harvesting of the crop was started at 70 DAP, and continued up to 100 DAP as per the harvest treatment having an interval of 10 days. The harvested plants were tagged separately plot wise. Ten sample plants were randomly selected from each plot and tagged for recording necessary data and then the whole plot was harvested with the help of spade. The yield of tuber was taken plot wise and converted into ton ha^{-1}. Care was taken to avoid injury of seedling tubers during harvesting.

3.14 Data recording

In order to study the effects of the treatments on yield components and yield of seedling tubers, data in respect of the following parameters were collected during the growth of plants and at harvesting time of the crop. During the plant growth, 10 plants were selected randomly from each unit plot for collection of data. The sampling was done in such a way that the border effects were completely avoided. For this purpose, the outer two lines and the extreme end of the middle rows were excluded.

3.14.1 Plant height

The height of the sample plants was measured from each plot in centimeter from the ground level to the tip of the longest shoot at 40, 50, 60 and 70 DAP (days after planting).

3.14.2 Number of stem hill^{-1}

The number of stem of the 10 selected plants was counted and the average number of stem hill^{-1} was calculated.

3.14.3 Number of leaves plant^{-1}

The number of leaves was counted from 10 selected plants was counted and the average number of leaves plant^{-1} was calculated of each plot after every 10 days starting from 40, 50, 60 and 70 DAP.

3.14.4 Leaf area plant^{-1}

Leaf area plant^{-1} was measured by an automatic leaf area meter (Model: LICOR 2000).

3.14.5 Dry matter plant^{-1} (g)

Collected plants including stem and leaves were oven dried at 70^0C for 72 hours then transferred into desiceator and allowed to cool down to the room temperature and final weight was taken and converted into dry matter content plant^{-1}.

3.14.6 Estimated growth parameter

Using the data on the leaf area and dry matter, the following growth parameters were derived .

Crop Growth Rate (CGR)

Crop growth rate was calculated using the following formula:

$$CGR = \frac{1}{GA} \times \frac{W_2-W_1}{T_2-T_1} \quad g\ m^{-2}\ day^{-1}$$

Where,

GA = Ground area (m^2)

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

Relative Growth Rate (RGR)

Relative growth rate was calculated using the following formula:

$$RGR = \frac{LnW_2 - LnW_1}{T_2-T_1} \quad g\ g^{-1}\ day^{-1}$$

Where,

W_1 = Total dry weight at previous sampling date

W_2 = Total dry weight at current sampling date

T_1 = Date of previous sampling

T_2 = Date of current sampling

Ln = Natural logarithm

3.14.7 Number of tubers hill^{-1}

The number of tubers hill^{-1} was recorded after harvesting of 10 samples plant from each unit plot and the average number of tubers was calculated.

3.14.8 Weight of tubers hill^{-1}

The weight of tubers hill^{-1} was calculated from the average of 10 selected plants from each unit plot at harvest.

3.14.9 Gross yield of tubers plot^{-1} and hectare^{-1}

The yield plot^{-1} was recorded from harvested tubers of all plants including sample plants of a unit plot and expressed as kg and converted into hectare and expressed in ton per hectare.

3.14.10 Marketable yield of tubers plot^{-1} and hectare^{-1}

The marketable yield of tubers plot^{-1} was the weight of potato were discarding the potatoes damaged by insect attack, rotting and injury from the gross yield of potato plot^{-1} and expressed as kg. The marketable yield of tubers plot^{-1} converted into tubers hectare^{-1} and expressed as ton per hectare.

3.14.11 Grade of tubers

Tubers harvested from 10 selected sample plants of each plot were graded by number and by weight. The following four grades on the basis of diameter and converted to percentage

>55 mm in diameter

45-55 mm in diameter

28-45 mm in diameter

<28 mm in diameter

3.14.12 Seed yield

Seed yield was calculated by adding 45-55 mm and 28-45 mm in diameter size and expressed in percentage.

3.14.13 Non seed yield

Non-seed yield was calculated by adding >55 mm and <28 mm in diameter and expressed in percentage.

3.15 Benefit-cost analysis

The cost of production was analyzed with a view to finding out the most profitable treatment combination. In this case, all the non-material and material input costs were considered for calculating the cost of production. The benefit cost ratio was calculated by the following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

3.16 Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

CHAPTER IV

RESULTS AND DISCUSSION

The results of the study regarding the effect of seedling tuber size and different harvesting time on growth characters yield and yield related traits of potato have been presented and possible interpretations have been made in this chapter.

4.1 Plant height (cm)

Plant height was significantly influenced by seed tuber size at 4 growth stages (40, 50, 60 and 70 DAP) of potato (Appendix IV). Result showed that plant height increased with increasing tuber size (Figure 2). The tallest plant was recorded in tuber size of 28-<45 mm (26.81 cm, 38.14 cm, 53.33 cm and 60.70 cm at 40, 50, 60 and 70 DAP, respectively) followed by tuber size of 20-<28 mm (26.24 cm, 37.80 cm, 51.49 cm and 57.26 cm 40, 50, 60 and 70 DAP, respectively) at all growth stages. In contrast, the tuber size of <10 mm had the shortest plant height at all growth stages (23.78 cm, 31.52 cm, 43.28 cm and 50.17 cm at 40, 50, 60 and 70 DAP, respectively). The plant height was higher in larger tubers size because of larger seedling tuber had huge stored food material that supported increased vegetative growth of the plants. This result is consistent with different scientists (Garg *et al*., 2000; Khalafalla, 2001; Reust, 2002; Yenagi *et al.*, 2005; Kumar *et al.*, 2009) in potato who reported that plant height of potato increased with increasing seed tuber size.

Considering plant height at different harvesting time, there was no significant variation was observed (Appendix IV). At 40 and 50 DAP, the tallest plant (25.51 cm and 36.28 cm, respectively) was recorded at 70 DAP harvest but 48.98 cm for 80 DAP harvest in case of data recorded for 60 DAP and 55.92 cm for 70 DAP harvest in case of data recorded for 90 DAP. On the other hand the shortest plant (25.03 cm, 35.02 cm and 48.27 cm) was recorded for 90 DAP harvest, respectively for 40, 50 and 60 DAP but at 70 DAP it was shortest (55.10 cm) for 100 DAP harvest (Figure 3).

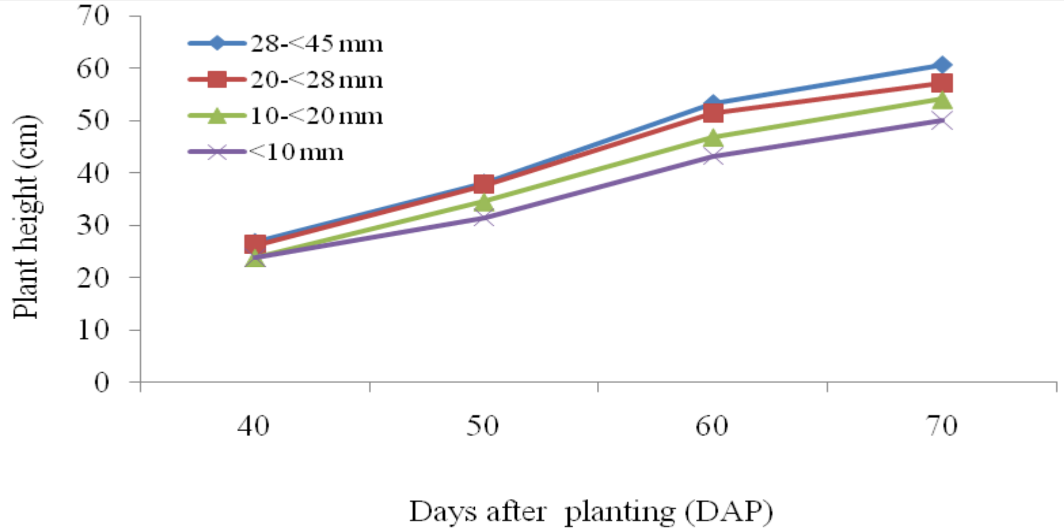


Figure 2. Effect of seedling tuber size on plant height of potato (Sx = 0.663, 0.688, 1.200 and 0.837 for 40, 50, 60 and 70 DAP, respectively)

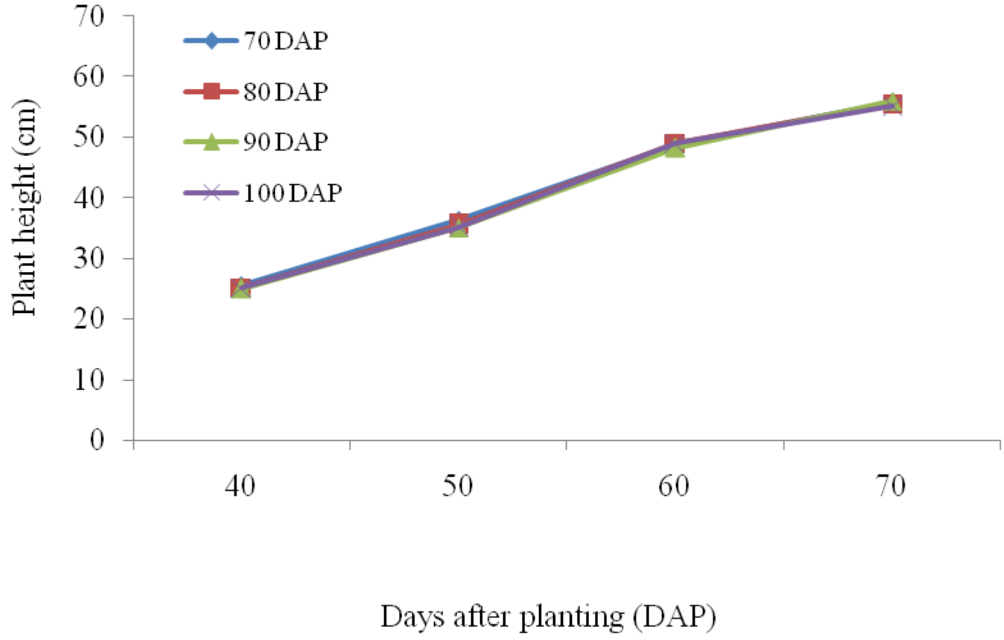


Figure 3. Effect of harvesting time on plant height of potato (Sx = 0.663, 0.688, 1.200 and 0.837 for 40, 50, 60 and 70 DAP, respectively)

The interaction effect of seed tuber size and harvesting time had significant effect on plant height at four growth stages of 40, 50, 60 and 70 DAP in potato (Appendix IV). The highest plant height was recorded in the treatment combination of 28-<45 mm tuber size with 70 DAP harvesting time (29.05 cm, 41.95 cm, 57.37 cm and 64.43 cm at 40, 50, 60 and 70 DAP, respectively) and the lowest was recorded in the treatment combination of <10 mm tuber with 70 DAP harvest (21.76 cm, 28.04 cm, 35.79 cm and 43.85 cm at 40, 50, 60 and 70 DAP, respectively) (Table 1).

4.2 Stem hill^{-1} (no)

Seed tuber size exerted significant effect on stem hill^{-1} in potato at 40, 50, 60 and 70 DAP (Appendix V). Result revealed that stem hill^{-1} increased with increasing seed tuber size. The maximum stems hill^{-1} was observed in the tuber size of 28-<45 mm (4.99, 6.27, 9.14 and 13.17 at 40, 50, 60 and 70 DAP, respectively) followed by tuber size of 20-<28 mm (4.93, 6.14, 9.01 and 12.96 at 40, 50, 60 and 70 DAP, respectively). In contrast, the lowest stems hill^{-1} was recorded in the tuber size of <10 mm (4.11, 5.68, 7.67 and 11.23 at 40, 50, 60 and 70 DAP, respectively) (Figure 4). The increase of stem hill^{-1} obtained from the large seed tuber might be due to the higher number of potential eyes present per tuber which led to production of higher stem hill^{-1}. The findings of the present study also supported by Gulluoglu and Aroglu (2009) who observed that stem hill^{-1} of potato increased with increasing seed tuber weight.

In harvesting time, stem hill^{-1} varied non significantly under the present trial (Appendix V). Result showed that stems hill^{-1} increased with delayed harvesting. The highest stems hill^{-1} (4.68, 6.07, 8.80 and 12.75) was recorded in harvesting time of 70, 90, 70 and 90 DAP at 40, 50, 60 and 70 days recorded data, respectively (Figure 5). The lowest stems hill^{-1} (4.57, 6.02, 8.47 and 12.08) was recorded in harvesting time 80 DAP and 100 DAP as data recorded for 40, 50, 60 and 70 DAP, respectively.

Table 1. Interaction effect of seed tuber size and harvesting time on plant height of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Plant height (cm) at			
	40 DAP	50 DAP	60 DAP	70 DAP
28-<45 mm				
× 70 DAP	29.05 ab	41.95 a	57.37 a	64.43 a
× 80 DAP	26.41 a-c	36.62 b-d	50.52 a-c	57.90 b-d
× 90 DAP	24.60 cd	35.47 b-e	51.65 a-c	60.60 ab
× 100 DAP	27.17 a-c	38.50 a-c	53.78 ab	59.89 a-c
20-<28 mm				
× 70 DAP	26.51 a-c	39.07 a-c	54.44 ab	60.01 a-c
× 80 DAP	23.95 cd	35.31 c-e	49.54 a-c	56.03 b-f
× 90 DAP	29.64 a	39.97 ab	51.96 a-c	57.78 b-e
× 100 DAP	24.88 b-d	36.84 b-d	50.00 a-c	55.23 b-f
10-<20 mm				
× 70 DAP	24.74 b-d	36.04 b-e	47.58 bc	54.48 c-f
× 80 DAP	23.78 cd	34.61 c-f	48.30 bc	55.11 b-f
× 90 DAP	23.04 cd	32.86 d-f	44.00 c	52.23 ef
× 100 DAP	24.06 cd	34.78 c-e	47.74 bc	54.60 c-f
<10 mm				
× 70 DAP	21.76 d	28.04 g	35.79 d	43.85 g
× 80 DAP	26.24 a-d	35.88 b-e	47.55 bc	53.06 d-f
× 90 DAP	22.83 cd	31.78 e-g	45.48 c	53.08 d-f
× 100 DAP	24.28 cd	30.36 fg	44.28 c	50.68 f
SE	**1.326**	**1.376**	**2.400**	**1.674**
Significant level	**0.05**	**0.01**	**0.05**	**0.01**
CV(%)	**9.12**	**6.71**	**8.53**	**5.22**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

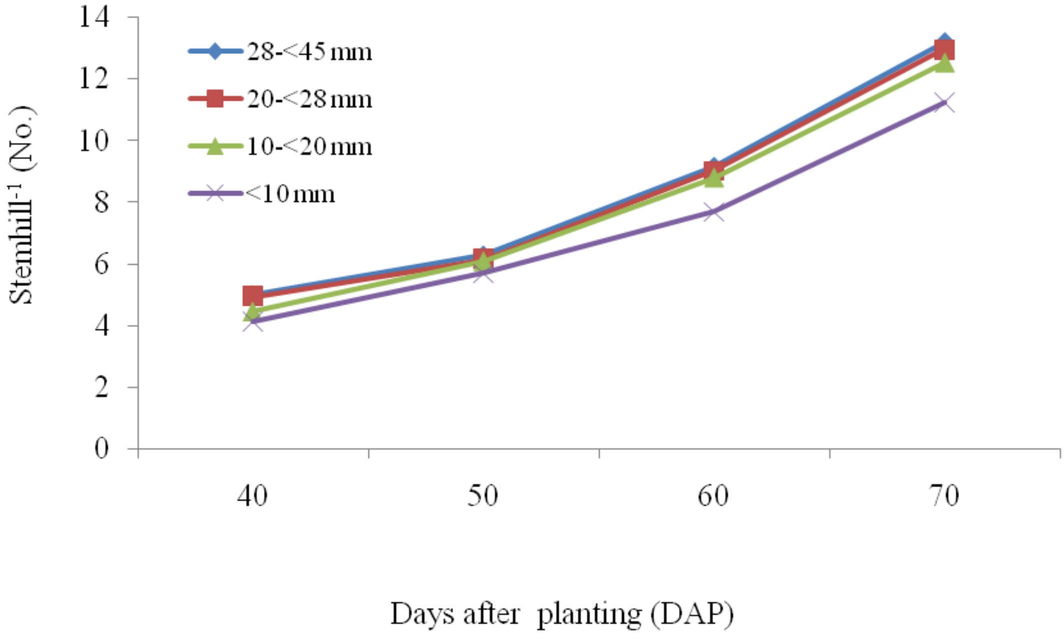


Figure 4. Effect of seedling tuber size on number of stem hill^{-1} of potato (Sx = 0.068, 0.067, 0.115 and 0.113 for 40, 50, 60 and 70 DAP, respectively)

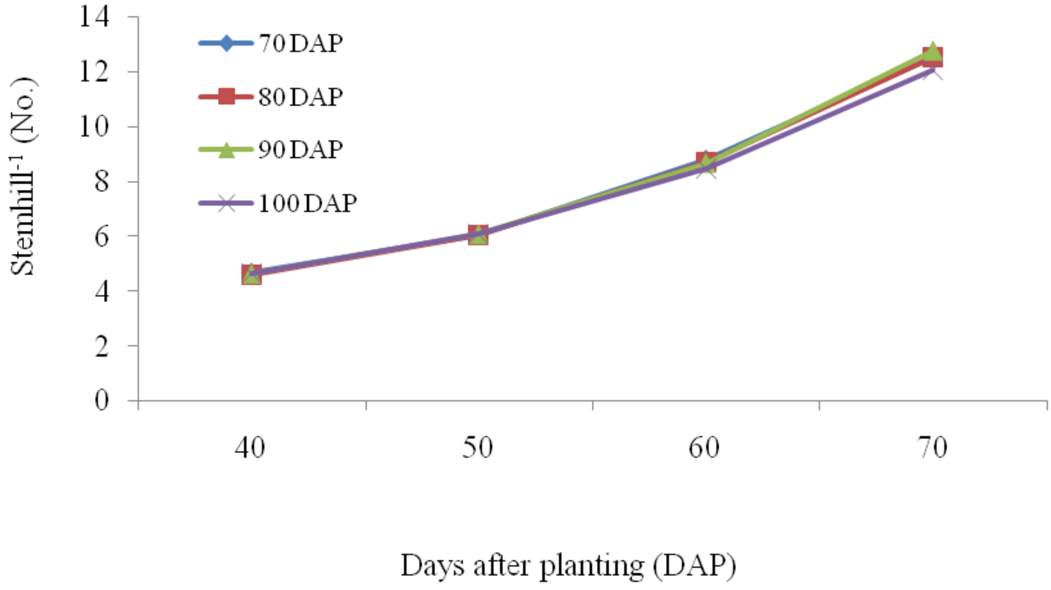


Figure 5. Effect of harvesting time on number of stem hill^{-1} of potato (Sx = 0.068, 0.067, 0.115 and 0.113 for 40, 50, 60 and 70 DAP, respectively)

The interaction effect between seed tuber size and harvesting time had significant effect on stems hill^{-1} (Appendix V). The highest stems hill^{-1} (5.10, 6.43, 9.53 and 13.37 at 40, 50, 60 and 70 DAP, respectively) was observed in treatment combination of 28-<45 mm and 90 DAP harvest and the lowest stems hill^{-1} (3.80, 5.33, 7.17 and 11.00 at 40, 50, 60 and 70 DAP, respectively) was recorded in the treatment combination of <10 mm 70 DAP harvest (Table 2).

4.3 Number of leaves hill^{-1}

The effect of seed tuber size on number of leaves hill^{-1} was statistically significant at 4 growth stages (Appendix VI). The highest leaves hill^{-1} was observed in 28-<45 mm tuber (24.49, 40.06, 52.72 and 61.75 at 40, 50, 60 and 70 DAP, respectively) and the lowest leaf number was recorded in <10 mm seed tuber (20.88, 32.46, 45.82 and 54.64 hill^{-1} at 40, 50, 60 and 70 DAP, respectively) (Figure 6). Increased leaf number in larger tuber might be due to increased stems hill^{-1}. The result is consistent with the findings of Gulluoglu and Aroglu (2009) in potato who reported that leaf number in potato decreased with decreasing tuber size.

Number of leaves hill^{-1} showed no significant differences among harvesting time (Appendix VI). The highest leaves hill^{-1} 23.44 at 40 DAP, 37.57 at 50 DAP, 50.10 at 60 DAP and 58.62 at 70 DAP was recorded for harvesting time 70, 90 and 70 DAP (Figure 7).

The interaction effect of seed tuber size and harvesting time had significant effect on number of leaves hill^{-1} (Appendix VI). The highest leaves hill^{-1} (26.20, 41.87, 55.70 and 64.77 at 40, 50, 60 and 70 DAP, respectively) was observed in the treatment combination 28-<45 mm and 70 DAP harvest. The lowest leaves hill^{-1} (19.30, 28.50, 41.67 and 50.47 at 40, 50, 60 and 70 DAP, respectively) was recorded in the treatment combination of <10 mm 70 DAP harvest (Table 3).

Table 2. Interaction effect of seed tuber size and harvesting time on number of stem hill^{-1} of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Number of stem hill^{-1}			
	40 DAP	**50 DAP**	**60 DAP**	**70 DAP**
28-< 45 mm				
× 70 DAP	5.10 a	6.43 a	9.53 a	13.37 ab
× 80 DAP	4.87 ab	6.20 a-c	9.07 a-c	13.13 a-d
× 90 DAP	4.93 a	6.10 a-c	8.97 a-c	13.53 a
× 100 DAP	5.07 a	6.33 ab	9.00 a-c	12.67 b-e
20-< 28 mm				
× 70 DAP	5.00 a	6.13 a-c	9.37 a	13.13 a-d
× 80 DAP	4.70 a-d	6.03 a-d	8.93 a-c	13.20 a-c
× 90 DAP	5.07 a	6.23 a-c	8.93 a-c	13.10 a-d
× 100 DAP	4.97 a	6.17 a-c	8.80 a-c	12.40 de
10-< 20 mm				
× 70 DAP	4.80 a-c	6.23 a-c	9.13 ab	12.63 b-e
× 80 DAP	4.43 c-e	6.03 a-d	8.90 a-c	12.70 b-e
× 90 DAP	4.17 e-g	6.00 a-d	8.43 b-d	12.34 e
× 100 DAP	4.47 b-e	6.13 a-c	8.77 a-c	12.47 c-e
< 10 mm				
× 70 DAP	3.80 g	5.33 e	7.17 e	11.00 f
× 80 DAP	4.30 d-f	5.80 cd	7.87 de	11.07 f
× 90 DAP	4.34 d-f	5.93 b-d	8.30 cd	12.03 e
× 100 DAP	4.00 fg	5.63 de	7.33 e	10.80 f
SE	**0.135**	**0.135**	**0.231**	**0.225**
Significant level	**0.01**	**0.05**	**0.05**	**0.05**
CV(%)	**5.09**	**8.88**	**4.62**	**7.13**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

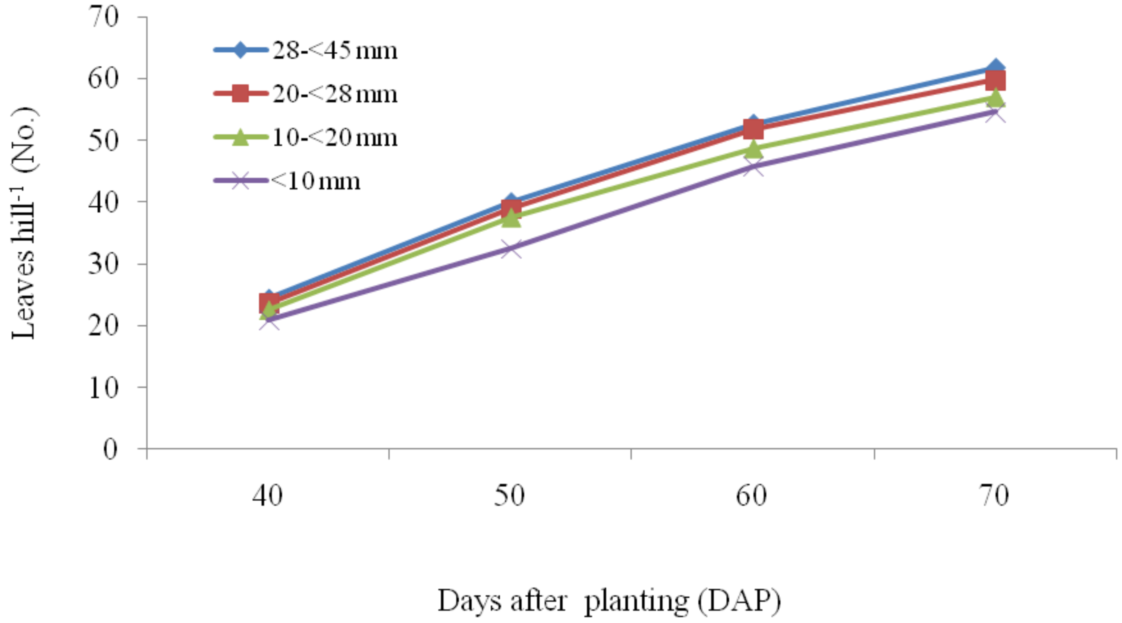


Figure 6. Effect of seedling tuber size on number of leaves hill^{-1} of potato (Sx = 0.358, 0.696, 0.573 and 0.590 for 40, 50, 60 and 70 DAP, respectively)

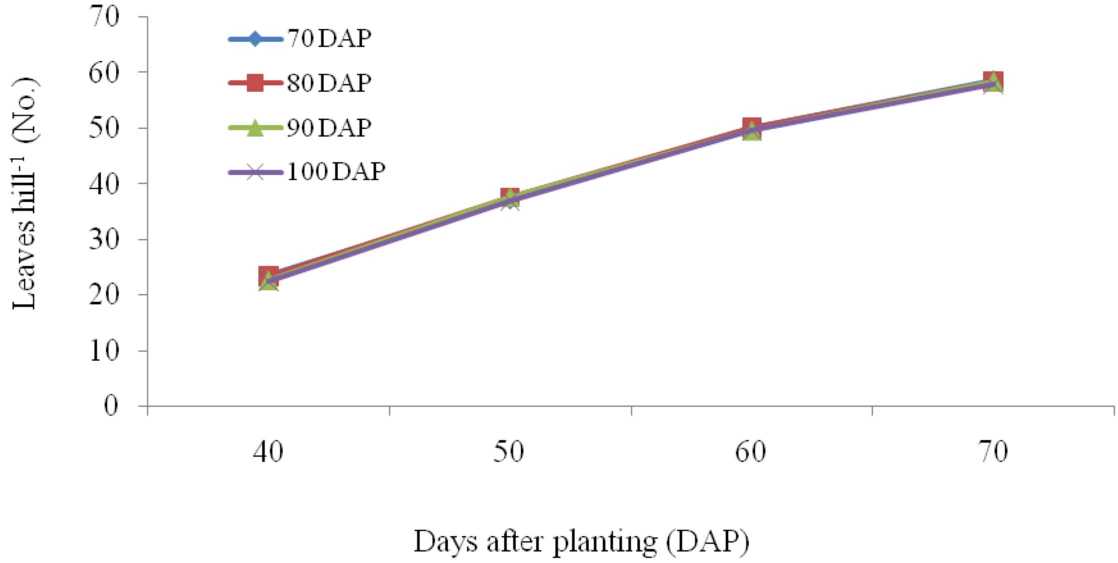


Figure 7. Effect of harvesting time on number of leaves hill^{-1} of potato (Sx = 0.358, 0.696, 0.573 and 0.590 for 40, 50, 60 and 70 DAP, respectively)

Table 3. Interaction effect of seed tuber size and harvesting time on number of leaves hill^{-1} of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Number of leaves hill^{-1} at			
	40 DAP	**50 DAP**	**60 DAP**	**70 DAP**
28-<45 mm				
× 70 DAP	26.20 a	41.87 a	55.70 a	64.77 a
× 80 DAP	24.67 ab	39.63 a-c	51.10 b-d	60.20 b-d
× 90 DAP	23.30 b-e	38.47 a-d	51.23 b-d	60.57 b-d
× 100 DAP	23.80 b-d	40.27 ab	52.83 a-c	61.47 ab
20-<28 mm				
× 70 DAP	24.77 ab	39.30 a-c	53.43 ab	61.40 a-c
× 80 DAP	23.03 b-f	37.90 a-d	50.27 b-e	58.10 b-e
× 90 DAP	24.33 a-c	40.33 ab	52.87 a-c	61.60 ab
× 100 DAP	22.50 b-f	38.33 a-d	50.73 b-e	58.10 b-e
10-<20 mm				
× 70 DAP	23.50 b-d	38.60 a-d	49.60 c-e	57.83 b-e
× 80 DAP	22.77 b-f	37.73 a-d	49.37 c-e	57.53 c-e
× 90 DAP	21.73 d-f	36.20 b-d	46.97 ef	55.63 e
× 100 DAP	22.23 c-f	37.83 a-d	49.13 c-f	57.40 de
<10 mm				
× 70 DAP	19.30 g	28.50 f	41.67 g	50.47 f
× 80 DAP	22.43 b-f	34.37 de	48.97 d-f	57.27 de
× 90 DAP	20.73 fg	35.30 c-e	47.03 ef	55.87 e
× 100 DAP	21.07 e-g	31.67 ef	45.60 f	54.97 e
SE	**0.716**	**1.392**	**1.146**	**1.180**
Significant level	**0.05**	**0.05**	**0.001**	**0.01**
CV(%)	**5.42**	**6.47**	**6.99**	**5.50**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.4 Leaf area plant^{-1} (cm^{2})

The different size of tubers had significant effect on leaf area plant^{-1} (Appendix VII). Result revealed that leaf area increased with increasing seed tuber size. The leaf production by the tuber size of 28-<45 mm was the highest at all growth stages (2021, 2256, 2590 and 3142 cm^{2} plant^{-1} at 40, 50, 60 and 70 DAP, respectively), which was statistically similar with 20-<28 mm tuber size for all growth stages except 70 DAP. The seed tuber size of <10 mm had the lowest leaf area plant^{-1} at all growth stages (1243, 1410, 1651 and 2014 cm^{2} plant^{-1} at 40, 50, 60 and 70 DAP, respectively) (Table 4). The variation in leaf area might occur due to the variation in stems plant^{-1} as well as leaves. The results are also supported by the result of Gulluoglu and Aroglu (2009) in potato.

The effect of harvesting time on leaf area plant^{-1} at 4 growth stages was statistically significant (Appendix VII). The highest leaf area plant^{-1} was observed in 90 DAP harvest (1826, 2001, 2322 and 2780 cm^{2} plant^{-1} at 40, 50, 60 and 70 DAP, respectively) followed by 100 DAP harvest (1820, 1982, 2202 and 2752 cm^{2} plant^{-1} at 40, 50, 60 and 70 DAP, respectively) with same statistical rank. The lowest leaf area was recorded in the 70 DAP harvest (1511, 1732, 2078 and 2282 cm^{2} plant^{1} at 40, 50, 60 and 70 DAP, respectively) (Table 4). The result is consistent with the findings of Yenagi *et al.* (2004) who reported that leaf area plant^{-1} decreased with time of harvesting in potato.

The interaction effect of seed tuber size and harvesting time had significant effect on leaf area plant^{-1} at all growth stages (Appendix VII). The highest leaf area plant^{-1} was observed in treatment combination 28-<45 mm and 90 DAP harvest (2212, 2420, 2753 and 3463 cm^{2} plant^{-1} at 40, 50, 60 and 70 DAP, respectively). The lowest leaf area plant^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (1131, 1320, 1600 and 1910 cm^{2} hill^{-1} at 40, 50, 60 and 70 DAP, respectively) (Table 5).

Table 4. Effect of tuber size and harvesting time on leaf area plant^{-1} of potato at different days after planting

Treatments	Leaf area plant^{-1} (cm^2)			
	40 DAP	50 DAP	60 DAP	70 DAP
Seed tuber size				
28-<45 mm	2021 a	2256 a	2590 a	3142 a
20-<28 mm	1925 a	2152 a	2490 a	2905 b
10-<20 mm	1508 b	1716 b	2231 b	2526 c
<10 mm	1243 c	1410 c	1651 c	2014 d
SE	**29.52**	**43.21**	**41.68**	**75.55**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**
Harvesting time				
70 DAP	1511 c	1732 c	2078 c	2282 c
80 DAP	1653 b	1862 b	2251 ab	2433 b
90 DAP	1826 a	2001 a	2322 a	2780 a
100 DAP	1820 a	1982 a	2205a	2752 a
SE	**29.52**	**43.21**	**41.68**	**75.55**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**4.92**	**6.93**	**5.58**	**8.64**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 5. Interaction effect of tuber size and harvesting time on leaf area plant^{-1} of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Leaf area plant^{-1} (cm^2)			
	40 DAP	**50 DAP**	**60 DAP**	**70 DAP**
28-<45 mm				
× 70 DAP	1852 cd	2055 cd	2186 cd	2688 cd
× 80 DAP	2108 ab	2300 ab	2255 cd	2740 cd
× 90 DAP	2212 a	2420 a	2753 a	3463 a
× 100 DAP	1672 de	1876 de	2623 ab	3228 ab
20-<28 mm				
× 70 DAP	2132 ab	2340 ab	2588 a-c	3080 b
× 80 DAP	1955 b	2160 b	2510 bc	2940 bc
× 90 DAP	1756 cd	1950 c-e	2380 cd	2700 cd
× 100 DAP	1671 cd	1880 cd	2366 cd	2675 cd
10-<20 mm				
× 70 DAP	1636 df	1835 d-f	2270 de	2670 cd
× 80 DAP	1502 ef	1700 ef	2280 de	2500 d
× 90 DAP	1418 fg	1620 fg	2145 e	2410 de
× 100 DAP	1376 fg	1570 fg	2085 e	2350 de
<10 mm				
× 70 DAP	1131 h	1320 h	1600 f	1910 f
× 80 DAP	1266 gh	1462 gh	1688 f	2012 ef
× 90 DAP	1228 gh	1410 gh	1670 f	2050 ef
× 100 DAP	1153 h	1360 h	1626 f	1990 f
SE	**64.52**	**74.85**	**72.19**	**130.86**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**4.92**	**6.93**	**5.58**	**8.64**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.5 Total dry mass

A significant variation plant^{-1} and m^{-2}(g) was observed in total dry mass (TDM) production plant^{-1} and total dry mass m^{-2} at 40, 50, 60 and 70 DAP due to seed tuber weight (Table 6). Result showed that total dry mass plant^{-1} and total dry mass m^{-2} increased with increasing tuber size. The highest TDM plant^{-1} and TDM m^{-2} was recorded in tuber size of 28-<45 mm (44.25, 53.84, 101.87 and 118.75 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively, and 454.1, 476.2, 895.6 and 1059.5 g m^{-2} at 40, 50, 60 and 70 DAP, respectively and 408.0, 430.0, 836.4 and 1002. 0 g m^{2} at 40, 50, 60 and 70 DAP, respectively followed by tuber size of 20-<28 mm(38.12, 47.13, 94.32 and 109.07 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively) at all growth stages. In contrast, the tuber size of <10 mm had the lowest TDM plant^{-1} and TDM m^{-2} at all growth stages (18.17, 25.37, 44.25 and 55.08 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively and 179.4, 190.0, 369.7 and 468.0 g m^{-2} at 40, 50, 60 and 70 DAP, respectively). The TDM was higher in larger tubers because of larger tuber seedling had huge stored food material that promoted increased vegetative growth of the plants. This result is consistent with several workers (Garg *et al*., 2000; Khalafalla, 2001; Reust, 2002; Yenagi *et al.,* 2005; Kumar *et al.,* 2009) in potato who reported that TDM increased with increasing seed tuber size.

The effect of harvesting time on TDM production both per plant and per square meter on 40, 50, 60 and 70 DAP was significant (Table 6). The highest TDM plant^{-1} was observed in the 90 DAP harvest (39.81, 45.16, 81.48 and 99.32 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively and 388.3 365.5, 676.1 and 841.1 g m^{-2} at 40, 50, 60 and 70 DAP, respectively) followed by at 100 DAP harvest (35.62, 42.78, 77.93 and 95.11 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively and 376.2, 358.8, 670.3 and 833.8 g m^{-2} at 40, 50, 60 and 70 DAP, respectively). The lowest TDM plant^{-1} was recorded at 70 DAP harvest (27.36, 35.8, 45.3 and 50.9 cm at 40, 50, 60 and 70 DAP, respectively and 268.7, 343.3, 658.9 and 814.3 g m^{-2} at 40, 50, 60 and 70 DAP, respectively).

Table 6. Effect of tuber size and harvesting time on total dry mass production of potato at different days after planting

Treatments	Total dry mass plant^{-1} (g)				Total dry mass m^{-2} (g)			
	40DAP	50 DAP	60DAP	70 DAP	40DAP	50DAP	60DAP	70DAP
Seed tuber size								
28-<45 mm	44.25 a	53.84 a	101.87 a	118.75 a	454.1 a	476.2 a	895.6 a	1059.5 a
20-<28 mm	38.12 b	47.13 b	94.32 b	109.07 b	408.0 b	430.0 b	836.4 b	1002.0 b
10-<20 mm	28.24 c	36.95 c	65.69 c	88.70 c	300.3 c	324.6 c	569.3 c	786.4 c
<10 mm	18.17 d	25.37 d	44.25 d	55.08 d	179.4 d	190.0 d	369.7 d	468.0 d
SE	**0.33**	**0.13**	**0.18**	**0.51**	**7.154**	**2.22**	**3.66**	**2.82**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Harvesting time								
70 DAP	27.36 d	35.87 d	71.46 d	86.32 d	268.7 d	343.3 d	659.0 d	814.3 d
80 DAP	32.28 c	39.47 c	75.26 c	90.85 c	341.8 c	353.0 c	665.7 c	826.8 c
90 DAP	39.81 a	45.16 a	81.48 a	99.32 a	388.3 a	365.5 a	676.1 a	841.1 a
100 DAP	35.62 b	42.78 ab	77.93 b	95.11 b	376.2 b	358.8 b	670.3 b	833.8 b
SE	**0.33**	**0.13**	**0.18**	**0.51**	**1.154**	**2.22**	**3.66**	**2.82**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**3.89**	**2.93**	**2.70**	**2.31**	**5.93**	**3.22**	**2.17**	**2.52**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

The interaction effect of seed tuber size and harvesting time had significant effect on TDM plant^{-1} and TDM m^{-2} at 4 growth stages of 40, 50, 60 and 70 DAP in potato (Table 7). The highest TDM plant^{-1} was recorded in the treatment combination of 28-<45 mm and 90 DAP harvest (50.62, 58.80, 107.80 and 125.83 at 40, 50, 60 and 70 DAP, respectively and 465.3, 485.5, 899.5 and 1073.2 g m^{-2} at 40, 50, 60 and 70 DAP, respectively) and that of lowest was recorded in the treatment combination of <10 mm and 70 DAP harvest (13.88, 20.46, 40.50 and 49.63 g plant^{-1} at 40, 50, 60 and 70 DAP, respectively and 161.2, 179.3, 355.4 and 458.0 g m^{-2} at 40, 50, 60 and 70 DAP, respectively).

4.6 Crop growth rate

Crop growth rate (CGR) was significantly influenced by seed tuber size at 40-50, 50-60 and 60-70 DAP (Table 8). Results showed that at 60-70 DAP, the CGR increased with increasing tuber size. At 60-70 DAP, the highest CGR was recorded in tuber size of 28-<45 mm (30.28 g m^{-1}d^{-1}) followed by the tuber size of 20-<28 mm (26.89 g m^{-1}d^{-1}). In contrast, the lowest CGR both at 40-50, 50-60 and 60-70 DAP was observed in <10 mm tuber (8.5, 17.63 and 20.21 g m^{-2} d^{-1}, respectively). The CGR was higher in larger tuber might be due to increased TDM plant^{-1}. This result corroborates with the findings of Divis and Barta (2001) that larger tuber produced higher number of stem plant^{-1}, crop growth rate as compared to small tubers which resulted in higher yield compared to small ones.

The effect of harvesting time on CGR at 40-50, 50-60 and 60-70 DAP was significant (Table 8). The highest CGR was observed in 90 DAP harvesting time (11.46, 23.57 and 26.26 g m^{-2} d^{-1} at 40-50, 50-60 and 60-70 DAP, respectively). The lowest was recorded in 70 DAP harvest (23.88 g m^{-2} d^{-1}, 21.40 and 9.33 g m^{-2} d^{-1} at 60-70, 50-60 and 40-50 DAP, respectively).

Table 7. Interaction effect of tuber size and harvesting time on total dry mass production of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Total dry mass plant^{-1} (g)				Total dry mass m^{-2} (g)			
	40DAP	**50 DAP**	**60 DAP**	**70 DAP**	**40DAP**	**50 DAP**	**60 DAP**	**70 DAP**
28-< 45 mm								
× 70 DAP	41.22 cd	48.86 cd	94.73 cd	109.93 cd	446.8 c	465.8 c	886.7 c	1042.1 c
× 80 DAP	44.32 bc	52.30 bc	100.60 bc	116.10 bc	455.2 bc	474.4 bc	892.4 bc	1056.3 bc
× 90 DAP	50.62 a	58.80 a	107.80 a	125.83 a	465.9 a	485.5 a	903.9 a	1073.2 a
× 100 DAP	47.88 ab	55.40 ab	104.36 ab	123.13 ab	450.3 ab	479.0 ab	899.5 ab	1066.6 ab
20-< 28 mm								
× 70 DAP	35.25 de	42.66 de	89.60 cd	103.60 cd	397.1 cd	415.6 cd	820.6 cd	986.1 cd
× 80 DAP	39.44 d	46.36 d	93.40 d	107.50 d	419.9 d	428.4 d	838.6 d	998.0 d
× 90 DAP	43.11 c	50.70 c	99.06 c	115.26 c	421.2 cd	440.6 cd	845.5 cd	1017.5 cd
× 100 DAP	40.88 d	48.80 d	95.23 d	109.93 d	415.9 d	434.9 d	840.8 d	1006.4 d
10-< 20 mm								
× 70 DAP	24.78 f	31.50 f	61.03 f	82.13 f	393.3 f	312.6 f	555.9 f	771.2 f
× 80 DAP	28.63 c-e	35.46 c-e	64.70 c-e	86.26 c-e	302.1 c-e	320.2 c-e	568.4 c-e	785.1 c-e
× 90 DAP	34.55 de	41.70 de	70.80 de	95.36 de	318.6 de	337.0 de	578.5 de	797.2 de
× 100 DAP	32.12 ef	39.13 ef	66.23 ef	91.06 ef	310.1 ef	328.6 ef	574.3 ef	792.3 ef
< 10 mm								
× 70 DAP	13.88 g	20.46 g	40.50 g	49.63 g	161.2 g	179.3 g	355.4 g	458.0 g
× 80 DAP	16.22 fg	23.76 fg	42.36 fg	53.53 fg	170.2 fg	188.9 fg	369.0 fg	467.6 fg
× 90 DAP	22.14 e	29.46 e	48.26 e	60.83 e	179.9 e	198.9 e	381.0 e	476.5 e
× 100 DAP	20.28 ef	27.80 ef	45.90 ef	56.33 ef	173.9 ef	192.8 ef	373.6 ef	469.9 ef
SE	**0.42**	**1.615**	**2.157**	**4.935**	**1.52**	**0.99**	**8.957**	**1.20**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**3.89**	**7.08**	**5.00**	**9.21**	**5.93**	**6.93**	**4.70**	**5.31**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 8. Effect of tuber size and harvesting time on growth of potato at different days after planting

Treatment	Crop growth rate (g m^{-2} d^{-1})			Relative growth rate (mg g^{-1} d^{-1})		
	40-50 DAP	**50-60 DAP**	**60-70 DAP**	**40-50 DAP**	**50-60 DAP**	**60-70 DAP**
Seed tuber size						
28-<45 mm	13.17 a	27.53 a	30.28 a	21.92 a	45.25 a	48.88 a
20-<28 mm	11.89 b	24.31 b	26.89 b	15.82 b	44.65 a	48.12 a
10-<20 mm	9.96 c	20.03 c	22.82 c	11.98 c	43.10 b	46.11 b
<10 mm	8.50 d	17.63 d	20.21 d	11.18 c	38.61 c	42.12 c
SE	**0.279**	**0.515**	**0.58**	**0.471**	**0.981**	**0.82**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Harvesting time						
70 DAP	9.33 c	21.40 c	23.88 b	14.72 b	42.41 b	45.22 b
80 DAP	10.69 b	22.10 b	24.66 b	15.22 a	42.51 b	45.92 b
90 DAP	11.46 a	23.57 a	26.26 a	15.54 a	43.58 a	47.88 a
100 DAP	10.04 b	23.22 a	25.99 a	15.42 a	42.37 b	46.92 a
SE	**0.279**	**0.515**	**0.58**	**0.471**	**0.981**	**0.82**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**1.75**	**2.39**	**3.84**	**1.36**	**1.93**	**4.52**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

The interaction effect of seed tuber size and harvesting time on CGR was significant at 40-50, 50-60 and 60-70DAP (Table 9). The highest CGR was recorded in the treatment combination of 28-<45 mm and 90 DAP (32.88, 28.46 and 12.36 g m^{-2} d^{-1} at 40-50, 50-60 and 60-70 DAP, respectively) and the lowest in <10 mm and 70 DAP harvesting (18.22, 16.76 g m^{-2} $d^{-1}$and 7.80 g m^{-2} d^{-1}) at 60-70, 50-60 and 40-50 DAP, respectively.

4.7 Relative growth rate

The effect of tuber size on relative growth rate (RGR) at 40-50, 50-60 and 60-70 DAP was significant (Table 8). The result showed that largest tuber size (28-<45 mm) showed its superiority in producing highest RGR for all stages of growth (21.92, 45.25 and 48.88 mg g^{-1} d^{-1} at 40-50, 50-60 and 60-70 DAP, respectively. It can also be interned from the result that RGR showed a decreasing trend with the reduced tuber size. However, the smallest tuber (<10 mm) showed the lowest RGR for all growth stages. Result showed that the lowest (11.18 mg g^{-1} d^{-1}) RGR was observed in 10-<20 mm tuber size at 40-50 DAP while at 60-70 DAP, the highest CGR (48.88 mg g^{-1} d^{-1}) was observed.

The effect of harvesting time on RGR at 40-50, 50-60 and 60-70 DAP was significant (Table 8). The highest RGR was observed in 90 DAP harvest (47.88, 43.58 and 15.54 mg g^{-1} d^{-1} at 60-70, 50-60 and 40-50 DAP, respectively) and the lowest was recorded in 70 DAP harvest (45.22, 42.41, 14.72 mg g^{-1} d^{-1} at 60-70, 50-60 and 40-50 DAP, respectively).

RGR was significantly influenced at 40-50, 50-60 and 60-70 DAP by the interaction effect of seed tuber size and harvesting time (Table 9). At 50-60 and 60-70 DAP there had no variation in RGR in treatment combinations at 40-50 DAP showed high variation. At 40-50 DAP, the highest RGR was recorded in the treatment combination of 28-<45 mm and 90 DAP (48.90 mg g^{-1} d^{-1}) and the lowest in <10 mm and 70 DAP harvest (10.80 mg g^{-1} d^{-1}).

Table 9. Interaction effect of tuber size and harvesting time on growth of potato at different days after planting

Treatment combination (Tuber size × harvesting time)	Crop growth rate (g $m^{-2}d^{-1}$)			Relative growth rate (mg $g^{-1}d^{-1}$)		
	40-50 DAP	**50-60 DAP**	**60-70 DAP**	**40-50 DAP**	**50-60 DAP**	**60-70 DAP**
28-< 45 mm						
× 70 DAP	12.20 b	26.46 b	29.22 b	21.20 b	42.30 cd	45.12 cd
× 80 DAP	11.80 b	27.23 b	30.11 b	21.90 b	42.73 cd	45.89 cd
× 90 DAP	14.13 a	28.46 a	32.88 a	22.50 a	45.90 a	48.92 a
× 100 DAP	11.20 c	27.96 a	30.88 b	22.10 a	45.20 a	47.14 a
20-< 28 mm						
× 70 DAP	10.50 cd	23.40 de	26.12 cd	15.20 cd	44.20 b	46.25 b
× 80 DAP	9.90 e	24.00 c	27.12 c	15.80 c	43.20 c	46.52 b
× 90 DAP	12.37 b	24.73 d	28.39 cd	16.30 c	44.80 b	47.26 a
× 100 DAP	10.16 cd	25.13 d	28.11 cd	16.00 c	45.10 a	46.88 b
10-< 20 mm						
× 70 DAP	9.30 e	19.00 e	23.12 de	11.70 d	38.46 d	42.11 d
× 80 DAP	13.73 a	19.80 e	24.12 d	12.10 de	44.10 b	46.12 b
× 90 DAP	12.96 b	20.40 de	24.96 d	11.83 d	44.50 b	46.56 b
× 100 DAP	11.86 b	20.93 de	24.35 d	12.30 d	45.20 a	46.89 b
< 10 mm						
× 70 DAP	7.80 f	16.76 f	18.22 f	10.80 e	38.26 d	42.05 d
× 80 DAP	8.90 ef	17.40 ef	20.22 e	11.10 d	40.80 c	42.51 d
× 90 DAP	9.20 e	18.00 ef	21.89 e	11.53 d	41.53 cd	44.11 cd
× 100 DAP	8.10 ef	18.36 e	20.56 e	11.30 d	38.70 d	42.96 d
SE	**0.279**	**0.515**	**0.82**	**0.471**	**0.981**	**0.98**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**1.75**	**2.39**	**3.84**	**1.36**	**1.93**	**4.52**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.8 Number of tubers hill^{-1}

The effect of tuber size on number tubers hill^{-1} was statistically significant (Appendix VIII). Result revealed that the number of tubers hill^{-1} increased with increasing tuber size. The highest production of tubers hill^{-1} was observed in the tuber size of 28-<45 mm (9.21) which was statistically similar with tuber size 20-<28 mm (8.98). In contrast, the lowest tubers hill^{-1} was recorded in the tuber size <10 mm (8.01). Reduction in the tubers hill^{-1} under smaller size seed tuber might be due to lesser stems hill^{1} (Figure 8). This result is confirmed by with different workers (Rashid, 1987; Garg *et al*., 2000; Khalafalla, 2001; BongKyoon *et al*., 2001; Shingrup *et al.,* 2003; Verma *et al.,* 2007) who reported that tuber number hill^{-1} increased with increasing tuber size till 55 g seed tuber.

The number tubers hill^{-1} influenced significantly by different harvesting time (Appendix VIII). The highest tubers hill^{-1} (9.20) was recorded in 90 DAP harvest which was statistically similar to 80 DAP harvest (8.98). The lowest tubers hill^{-1} was recorded in 70 DAP harvest (8.13) (Figure 9).

The interaction effect between seed tuber size and harvesting time had significant effect on tubers hill^{-1} (Appendix VIII). The highest tubers hill^{-1} was observed in 10-<20 mm and 100 DAP harvesting (9.67) followed by the treatment combination of 20-<28 mm and 100 DAP harvesting (9.33) with same statistical rank. The lowest tubers hill^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (7.99) (Figure 10).

4.9 Average single tuber weight (g)

Seed tuber size significantly influenced the average single tuber weight of potato (Appendix VIII). Result revealed that single tuber weight increased with increasing seed tuber size. The highest single tuber size was observed in tuber size 28-<45 mm (65.22 g) which was statistically similar to tuber size 20-<28 mm (63.93 g). In contrast, the lowest single tuber size was recorded in the seed tuber size of <10 mm (57.80 g) (Table 10). Similar result was also reported by BongKyoon *et al*. (2001) who observed that tuber weight decreased with decreasing seed tuber size.

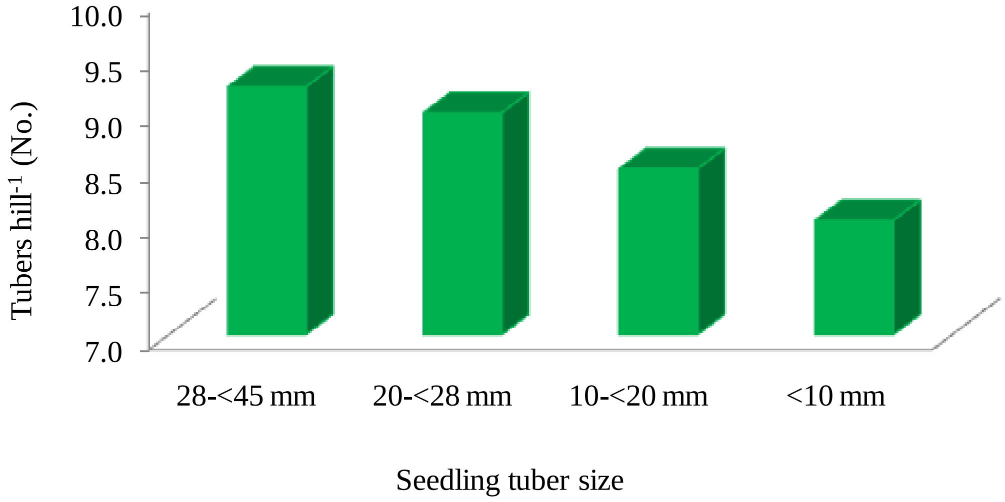


Figure 8. Effect of seedling tuber size on tubers hill^{-1} of potato (Sx = 0.167)

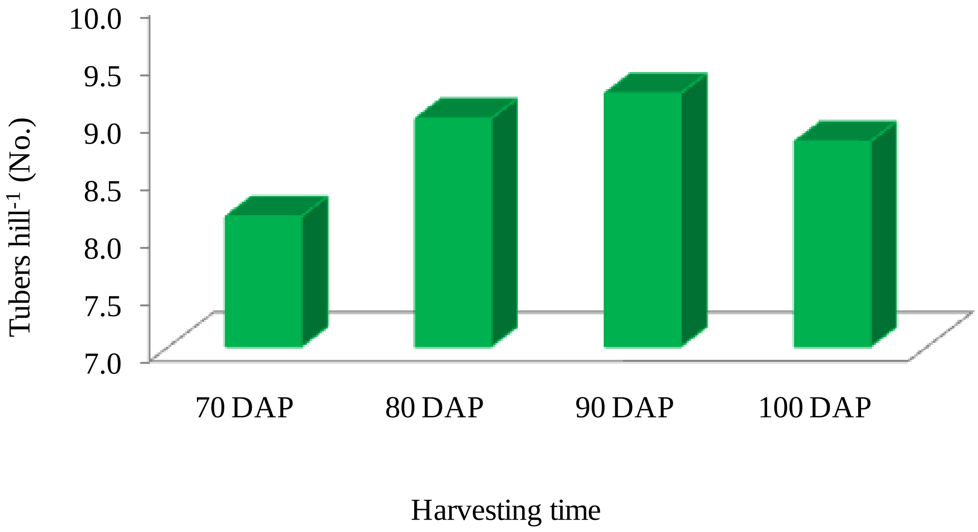


Figure 9. Effect of harvesting time on tubers hill^{-1} of potato (Sx = 0.167)

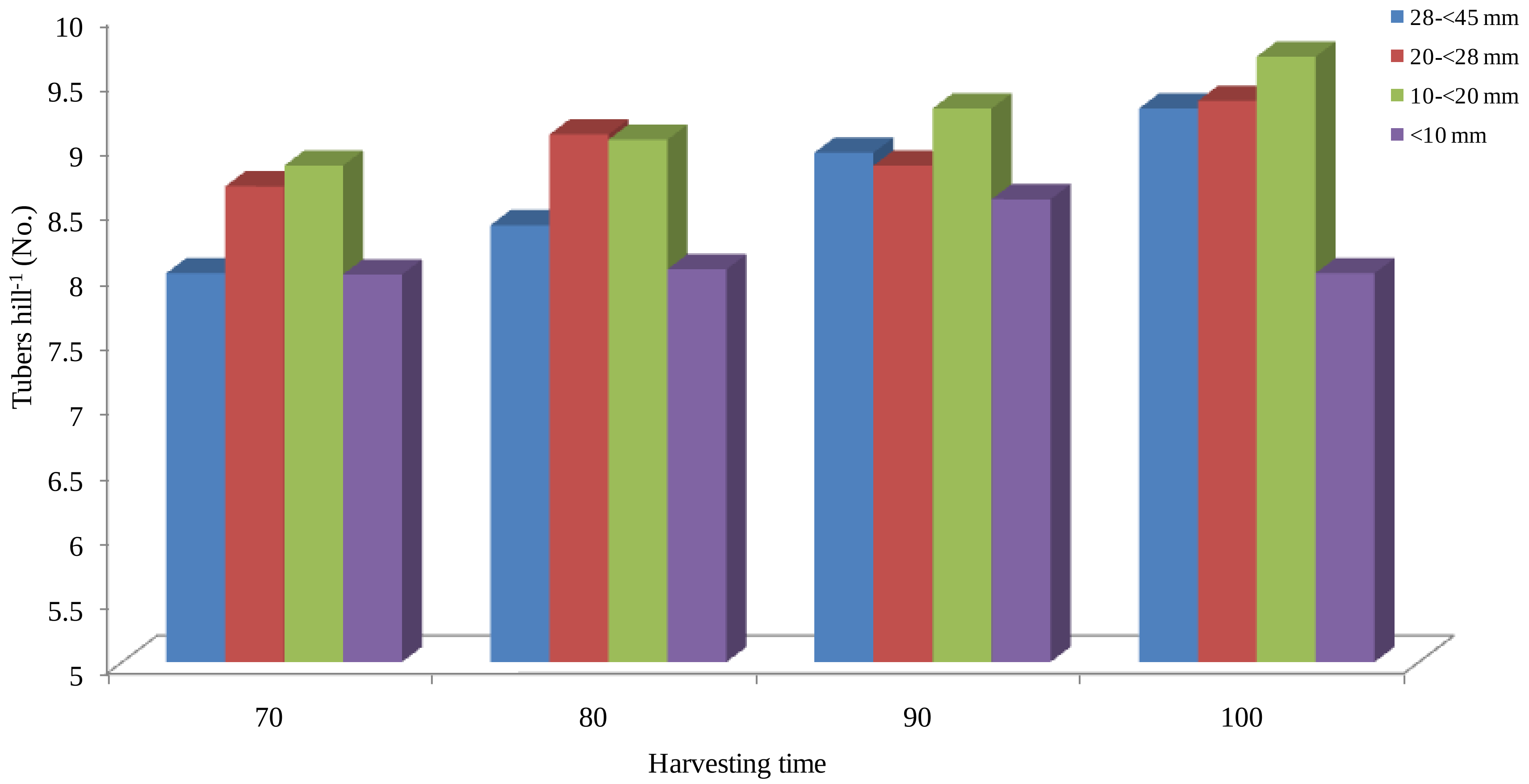


Figure 10. Interaction effect of seedling tuber size and harvesting time on tubers hill^{-1} of potato (Sx = 0.335)

Harvesting time had significant effect on single tuber size in potato (Appendix VIII). The largest tuber was observed at delayed harvest in 90 DAP (65.94 g) followed by the harvesting time 80 DAP (62.26 g). The lowest tuber size was observed in the harvesting time 70 DAP (57.93 g) (Table 10).

The interaction effect of seed tuber size and harvesting time on single tuber weight was significant (Appendix VIII). The highest single tuber weight was recorded in the treatment combination of 20-<28 mm and 90 DAP harvest (72.68 g). The lowest single tuber weight was recorded in the treatment combination of <10 mm and 70 DAP harvest (44.33 g) (Table 11).

4.10 Tuber weight hill^{-1} (g)

The effect of seed tuber size on tuber weight hill^{-1} was significant (Appendix VIII). Result revealed that tuber weight hill^{-1} increased with increasing seed tuber size upto 28-<45 mm seed tuber followed by decline trend. The highest tuber weight hill^{-1} was observed in 28-<45 mm (421.6 g hill^{-1}). In contrast, the lowest tuber weight hill^{-1} was recorded in the seed tuber size of <10 mm (385.9 g hill^{-1}) (Table 10). The lesser tuber weight in smaller size seed tuber might be due to fewer tubers hill^{-1} and smaller weight tuber. This result is consistence with the findings of Gregoriou, 2000; Reust, 2002; Malik *et al.*, 2002; Shingrup *et al.*, 2003; Bayorbor and Gumah, 2007; Verma *et al.*, 2007 and Gulluoglu and Aroglu, 2009 who observed that tuber yield decreased with decreasing seed tuber weight.

A significant variation was observed in tuber size hill^{-1} due to harvesting time (Appendix VIII). The highest tuber weight hill^{-1} was observed in delayed harvest on 90 DAP (421.7 g hill^{-1}) and the lowest tuber yield hill^{-1} was observed in 100 DAP harvest (376.4 g hill^{-1}) (Table 10).

The interaction effect of seed tuber size and harvesting time on tuber weight hill^{-1} was significant (Appendix VIII). The highest tuber weight hill^{-1} was recorded in the treatment combination of 28-<45 mm and 90 DAP harvest (442.2 g hill^{-1}) and the lowest from <10 mm and 100 DAP harvest (1346.9 g hill^{-1}) (Table 11).

Table 10. Effect of tuber size and harvesting time on single tuber weight, tuber yield $hill^{-1}$, yield $plot^{-1}$ and marketable yield ha^{-1} of potato

Treatment	Single tuber weight (g)	Tuber Yield $hill^{-1}$ (g)	Gross yield		Marketable yield	
			Kg $plot^{-1}$	Ton ha^{-1}	Kg $plot^{-1}$	Ton ha^{-1}
Seed tuber size						
28-<45 mm	65.22 a	421.62 a	11.60 a	29.00 a	10.83 a	27.08 a
20-<28 mm	63.93 ab	414.22 ab	11.32 a	28.29 a	10.73 a	26.82 a
10-<20 mm	59.22 bc	401.85 b	9.96 b	24.91 b	9.46 b	23.66 b
<10 mm	57.80 c	385.93 c	8.85 c	22.14 c	8.40 c	20.99 c
SE	**1.731**	**4.587**	**0.170**	**0.425**	**0.164**	**0.410**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
Harvesting time						
70 DAP	57.93 b	406.80 b	9.94 c	24.85 c	9.31 b	23.29 b
80 DAP	62.26 ab	418.68 ab	10.20 bc	25.50 bc	9.66 b	24.15 b
90 DAP	65.94 a	421.73 a	10.98 a	27.45 a	10.28 a	25.71 a
100 DAP	60.04 b	376.42 c	10.61 ab	26.53 ab	10.16 a	25.40 a
SE	**1.731**	**4.587**	**0.170**	**0.425**	**0.164**	**0.410**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**9.74**	**7.91**	**5.64**	**5.64**	**5.77**	**5.77**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 11. Interaction effect of tuber size and harvesting time on single tuber weight, tuber yield hill^{-1}, yield per plot and marketable yield ha^{-1} of potato

Treatment combination (Tuber size × harvesting time)		Single tuber weight (g)	Tuber yield hill^{-1} (g)	Gross yield		Marketable yield	
				Kg plot^{-1}	Ton ha^{-1}	Kg plot^{-1}	Ton ha^{-1}
28-< 45 mm							
	× 70 DAP	67.36 ab	423.95 a-d	11.63 a	29.08 a	10.83 a-c	27.07 a-c
	× 80 DAP	63.62 ab	428.67 a-c	11.44 a	28.59 a	10.79 a-c	26.98 a-c
	× 90 DAP	65.17 ab	442.24 a	11.83 a	29.57 a	11.07 ab	27.67 ab
	× 100 DAP	64.72 ab	391.62 ef	11.50 a	28.74 a	10.64 a-d	26.60 a-d
20-< 28 mm							
	× 70 DAP	62.57 ab	416.92 a-de	11.25 ab	28.12 ab	10.64 a-d	26.60 a-d
	× 80 DAP	60.86 b	431.95 ab	11.00 a-c	27.49 a-c	10.03 b-e	25.07 b-e
	× 90 DAP	72.68 a	425.63 a-d	11.91 a	29.77 a	11.34 a	28.36 a
	× 100 DAP	59.61 b	382.38 f	11.11 ab	27.78 ab	10.89 ab	27.24 ab
10-< 20 mm							
	× 70 DAP	57.48 b	401.07 c-f	9.47 d	23.69 d	9.04 ef	22.61 ef
	× 80 DAP	59.02 b	418.10 a-e	10.01 cd	25.02 cd	9.69 de	24.23 de
	× 90 DAP	61.16 ab	403.47 b-f	10.19 b-d	25.47 b-d	9.32 e	23.31 e
	× 100 DAP	59.23 b	384.75 f	10.18 b-d	25.44 b-d	9.80 c-e	24.51 c-e
< 10 mm							
	× 70 DAP	44.33 c	385.23 f	7.41 e	18.52 e	6.75 g	16.87 g
	× 80 DAP	65.53 ab	396.00 d-f	8.35 e	20.89 e	8.14 f	20.34 f
	× 90 DAP	64.74 ab	415.57 a-e	10.00 cd	24.99 cd	9.40 e	23.49 e
	× 100 DAP	56.60 b	346.93 g	9.66 d	24.14 d	9.31 e	23.27 e
SE		**3.462**	**9.174**	**0.340**	**0.849**	**0.328**	**0.820**
Significant level		**0.05**	**0.05**	**0.05**	**0.05**	**0.01**	**0.01**
CV(%)		**9.74**	**7.91**	**5.64**	**5.64**	**5.77**	**5.77**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.11 Gross yield of tuber plot^{-1} (kg)

The gross tuber yield plot^{-1} was significantly influenced by seed tuber size (Appendix VIII). Result revealed that gross tuber yield plot^{-1} increased with increasing seed tuber size upto 28-<45 mm seed tuber. The highest gross tuber yield kg plot^{-1} was observed in the seed tuber size of 28-<45 mm (11.60 kg) which was statistically similar with seed tuber size of 20-<28 mm (11.32 kg). In contrast, the lowest gross tuber yield plot^{-1} was recorded in the seed tuber size of <10 mm (8.85 kg) (Table 10). The gross tuber yield plot^{-1} was lower in smaller size seed tuber because of producing minimum tuber weight hill^{-1}. This result is supported by many workers (Malik *et al*., 2002; Shingrup *et al.,* 2003; Sonawane and Dhoble, 2004; Bayorbor and Gumah, 2007; Verma *et al.,* 2007; Gulluoglu and Aroglu, 2009) who observed that tuber yield decreased with decreasing seed tuber size.

The effect of harvesting time on gross tuber yield plot^{-1} in potato was significant (Appendix VIII). The highest gross tuber yield plot^{-1} was observed in 90 DAP harvest (10.98 kg) which was statistically similar with 100 DAP harvest (10.61 kg). The lowest gross tuber yield plot^{-1} was recorded in 70 DAP harvest (9.94 kg) (Table 10). Again, lower tuber yield plot as well as per unit area under lower days of harvesting time was might be due to lesser amount of assimilate produced by the plants through lesser photosynthetic time plant^{-1} and nutrients uptake by the plants. This result agrees with different workers worked with potato (Yenagi *et al.,* 2005; Kushwah and Singh, 2008).

The interaction effect of seed tuber size and harvesting time on gross tuber yield plot^{-1} was significant (Appendix VIII). Results revealed that tuber yield decreased with decreasing tuber size and harvesting time. The highest gross tuber yield plot^{-1} was recorded in the treatment combination of 20-<28 mm and 90 DAP harvest (11.91 kg). The lowest gross tuber yield ha^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (7.41 kg) (Table 11).

4.12 Gross yield of tuber hectare^{-1}

The gross tuber yield hectare^{-1} was significantly influenced by seed tuber size (Appendix VIII). The result revealed that the trend of yield of tuber per ha^{-1} was the highest with the heaviest seed tuber weight (28-<45mm) and the yield reduced gradually with the decreases of tuber size. However the lowest yield was observed with the lowest tuber weight (< 10mm). This result is supported by many workers (Malik *et al*., 2002; Shingrup *et al.*, 2003; Sonawane and Dhoble, 2004; Bayorbor and Gumah, 2007; Verma *et al.*, 2007; Gulluoglu and Aroglu, 2009) who observed that tuber yield decreased with decreasing seed tuber size.

The effect of harvesting time on gross tuber yield hectare^{-1} in potato was significant (Appendix VIII). The highest gross tuber yield ha^{-1} was observed in 90 DAP harvest (27.45 ton) which was statistically similar with 100 DAP harvest (26.53 ton). The lowest gross tuber yield ha^{-1} was recorded in harvesting time 70 DAP (24.85 ton) (Table 10). Again, lower tuber yield per plant as well as per unit area under lower days of harvesting time was might be due to lesser amount of assimilate produced by the plants through lesser photosynthetic time plant^{-1} and nutrients uptake by the plants.

The interaction effect of seed tuber size and harvesting time on gross tuber yield ha^{-1} was significant (Appendix VIII). Results revealed that tuber yield decreased with decreasing tuber size and harvesting time. The highest gross tuber yield ha^{-1} was recorded in the treatment combination of 20-<28 mm and 90 DAP harvest (29.77 ton). The lowest gross tuber yield ha^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (18.52 ton) (Table 11).

4.13 Marketable yield kg plot^{-1}

The effect of seed tuber size on marketable yield of tubers plot^{-1} has been presented in (Appendix VIII). Result revealed that marketable tuber yield increased with increasing seed tuber size till highest size seed tuber. The highest marketable yield of tubers plot^{-1} was observed in the seed tuber size of 28-<45 mm (10.83 kg) followed by the seed tuber size of 20-<28 mm (10.73 kg). It was primarily due to high food reserves in large seed tubers which ultimately contributed to produce high yield through increase vegetative growth of plants and rapid development of tubers. The lowest marketable tuber yield plot^{-1} was recorded in the seed tuber size of <10 mm (8.40 kg) (Table 10). The marketable tuber yield was lower in smaller size seed tuber because of producing lower tuber weight hill^{-1}. This result is supported by many workers (Malik *et al*., 2002; Shingrup *et al.*, 2003; Sonawane and Dhoble, 2004; Bayorbor and Gumah, 2007; Verma *et al.*, 2007; Gulluoglu and Aroglu, 2009) who observed that marketable tuber yield decreased with decreasing seed tuber size.

The effect of different harvesting time on marketable yield in potato showed statistically significant differences (Appendix VIII). The figure shows that the highest marketable tuber yield plot^{-1} was observed in harvesting time of 90 DAP (10.28 kg) that was identical to 100 DAP harvest (10.16 kg). The lowest marketable tuber yield plot^{-1} was recorded in 70 DAP harvest (9.22 kg) (Table 10). Again, lower marketable tuber yield was might be due to lesser amount of assimilate produced by the plants through lesser time of planting and lesser photosynthetic time uptake by the plants.

The interaction effect of seed tuber size and harvesting time on marketable tuber yield plot^{-1} was significant (Appendix VIII). The highest marketable tuber yield kg plot^{-1} was recorded in the treatment combination of 20-<28 mm and 90 DAP harvest (11.34 kg). The lowest marketable tuber yield plot^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (6.75 kg) (Table 11).

4.14 Marketable yield of tuber hectare^{-1}

The marketable tuber yield ha^{-1} was significantly influenced by seed tuber size (Appendix VIII). Result revealed that marketable tuber yield increased with increasing seed tuber size upto 28-<45 mm seed tuber. The highest marketable tuber yield ha^{-1} was observed in the seed tuber size of 28-<45 mm (27.08 ton) which was statistically similar with the seed tuber size of 20-<28 mm (26.82 ton). On the other hand, the lowest marketable tuber yield was recorded in the seed tuber size of <10 mm (20.99 ton) (Table 10). The marketable tuber yield was lower in smaller size seed tuber because of producing minimum tuber weight hill^{-1}. Thie result corroborate with the findings of many workers (Gregoriou, 2000; Khalafalla, 2001; Reust, 2002; Malik *et al*., 2002; Shingrup *et al.,* 2003; Sonawane and Dhoble, 2004; Bayorbor and Gumah, 2007; Verma *et al.,* 2007; Gulluoglu and Aroglu, 2009) who observed that tuber yield decreased with decreasing seed tuber size.

The effect of harvesting time on marketable tuber yield in potato was significant (Appendix VIII). The highest marketable tuber yield ha^{-1} was observed in 90 DAP harvest (25.71 ton) which was similar with 100 DAP harvest (25.40 ton). The lowest tuber yield was recorded in 70 DAP harvest (23.29 ton) (Table 10). Again, lower tuber yield per hectare under lower days of harvesting time was might be due to lesser amount of assimilate produced by the plants through lesser photosynthetic time plant^{-1} and nutrients uptake by the plants. This result is consistent with many workers in potato (Yenagi *et al.,* 2005; Kushwah and Singh, 2008).

The interaction effect of seed tuber size and harvesting time on marketable tuber yield ha^{-1} was significant (Appendix VIII). The highest marketable tuber yield ha^{-1} was recorded in the treatment combination of 20-<28 mm and 90 DAP harvest (28.36 ton). The lowest marketable tuber yield ha^{-1} was recorded in the treatment combination of <10 mm and 70 DAP harvest (16.87 ton) (Table 11).

4.15 Size grade distribution of tubers

The harvested tubers were categorized into four grades according to size by number *viz*., >55 mm size, 45-55 mm, 28-45 mm and < 28 mm. It was observed that there was variation in size grade of tubers due to different seed tuber number, seed yield and non seed yield (Table 12 and 13).

In consideration of seed tuber size, for >55 mm the highest (4.27%) was recorded from 20-<28 mm size seed tuber and the lowest (3.68%) for <10 mm size. For 45-55 mm in size, the highest (18.04%) was recorded from 20-<28 mm size seed tuber and the lowest (17.02%) for <10 mm size. In case of 28-45 mm, the highest (39.62%) was recorded from <10 mm size seed tuber and the lowest (38.78%) for 20-<28 mm size. In case of <28 mm, the highest (39.74%) was recorded from <10 mm size seed tuber and the lowest (38.90%) for 20-<28 mm size. Grewal *et al*. (1992) reported that larger seed tuber produced highest number of seed tuber than smaller seed tuber which supported present experimental results.

In harvesting time, for >55 mm, the highest (4.84%) was recorded from 70 DAP harvesting time and the lowest (2.35%) for 90 DAP harvesting. In context of 45-55 mm, the highest (19.70%) was recorded from 70 DAP harvest and the lowest (13.68%) for 90 DAP harvest. Consideration 28-45 mm, the highest (43.53%) was recorded from 90 DAP harvest and the lowest (36.30%) for 100 DAP harvest. For <28 mm, the highest (40.44%) was recorded from 90 DAP harvest and the lowest (38.23%) for 80 DAP harvest.

The interaction effect of seed tuber size and harvesting time on tuber grade distribution was significant (Table 13). The highest >55 mm size potato was recorded from 28-<45 mm tuber with delay harvesting and the vise versa was observed for <10 mm size seed potato with early harvest. The distribution of seed and non-seed yield also presented in Table 12 and 13.

Table 12. Effect of tuber size and harvesting time on grade potato in number

Treatments	Grade potato in number (%)				Seed yield (%)	Non-seed yield (%)
	>55 mm	45-55 mm	28-45 mm	<28 mm		
Seed tuber size						
28-< 45 mm	4.10 b	17.76 ab	38.95 bc	39.20 ab	56.71	43.29
20-< 28 mm	4.27 a	18.04 a	38.78 c	38.90 b	56.83	43.17
10-< 20 mm	3.89 c	17.42 bc	39.36 ab	39.31 ab	56.78	43.20
< 10 mm	3.68 d	17.02 c	39.62 a	39.74 a	56.65	43.42
SE	**0.056**	**0.500**	**0.174**	**0.183**	**0.243**	**0.243**
Significant level	**0.01**	**0.01**	**0.01**	**0.05**	**NS**	**NS**
Harvesting time						
70 DAP	4.84 a	19.70 a	37.21 c	38.25 b	56.91 b	43.09 b
80 DAP	4.09 c	18.06 c	39.67 b	38.23 b	57.72 a	42.32 c
90 DAP	2.35 d	13.68 d	43.53 a	40.44 a	57.20 ab	42.79 bc
100 DAP	4.66 b	18.81 b	36.30 d	40.23 a	55.11 c	44.89 a
SE	**0.056**	**0.500**	**0.174**	**0.183**	**0.243**	**0.243**
Significant level	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
CV(%)	**4.85**	**5.41**	**4.54**	**5.61**	**6.49**	**7.52**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

Table 13. Interaction effect of tuber size and harvesting time on grade potato in number

Treatment combination (Tuber size × harvesting time)	Grade potato in number (%)				Seed yield (%)	Non-seed yield (%)
	> 55 mm	45-55 mm	28-45 mm	<28 mm		
28-< 45 mm						
× 70 DAP	4.98 ab	19.53 ab	37.51 f	37.99 cd	57.04 ab	42.97 b-e
× 80 DAP	4.15 e	18.34 cd	39.33 e	38.18 cd	57.67 ab	42.33 d-f
× 90 DAP	2.44 g	14.25 e	42.76 c	40.55 a	57.01 ab	42.99 b-e
× 100 DAP	4.82 a-c	18.91 bc	36.20 g	40.07 a	55.11 c	44.89 a
20-< 28 mm						
× 70 DAP	4.99 ab	20.36 a	37.32 fg	37.32 d	57.68 ab	42.31 d-f
× 80 DAP	4.12 e	18.63 b-d	39.69 e	37.56 d	58.32 a	41.68 f
× 90 DAP	2.84 f	14.58 e	41.67 d	40.91 a	56.25 bc	43.75 ab
× 100 DAP	5.14 a	18.60 b-d	36.45 fg	39.81 ab	55.05 c	44.95 a
10-< 20 mm						
× 70 DAP	4.63 c	19.28 a-c	37.29 fg	38.80 bc	56.57 bc	43.43 b-d
× 80 DAP	4.15 e	17.73 d	39.78 e	38.27 cd	57.51 ab	42.42 c-f
× 90 DAP	2.29 g	13.77 e	44.09 b	39.84 ab	57.86 ab	42.13 ef
× 100 DAP	4.49 cd	18.89 bc	36.28 g	40.33 a	55.17 c	44.82 a
< 10 mm						
× 70 DAP	4.76 bc	19.63 ab	36.73 fg	38.89 bc	56.36 bc	43.65 bc
× 80 DAP	3.95 e	17.53 d	39.87 e	38.91 bc	57.40 ab	42.86 b-f
× 90 DAP	1.81 h	12.10 f	45.60 a	40.48 a	57.70 ab	42.29 d-f
× 100 DAP	4.19 de	18.84 bc	36.28 g	40.70 a	55.12 c	44.89 a
SE	**0.111**	**0.346**	**0.348**	**0.365**	**0.469**	**0.380**
Significant level	**0.01**	**0.05**	**0.01**	**0.01**	**0.05**	**0.05**
CV(%)	**4.85**	**5.41**	**4.54**	**5.61**	**6.49**	**7.52**

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

4.16 Economic analysis

Economic analysis was done with a view to observing the comparative cost and benefit under different treatment combinations of seed tuber size and harvesting time of potato. For this purpose, the input cost for land preparation, seed tuber, planting, manure and fertilizer, intercultural operation and manpower required for all the operations including tubers were recorded against each treatment, which were then enumerated into cost per hectare.

Variation in cost of production was noticed due to the cost of seed tuber size and different harvesting time (Table 14). The total cost of cultivation ranged between 230,561 Tk.ha^{-1}-284,237 Tk.ha^{-1} The cultivation cost increased with increasing seed tuber size. The highest cost of production was involved when used 28-<45 mm seed tuber (Tk 284,237 ha^{-1}). The lowest cost of production was involved when used <10 mm seed tuber (230,561 Tk. ha^{-1}). The highest gross return was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (Tk. 567,200 ha^{-1}) and the lowest gross return was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (Tk. 337,400 ha^{-1}). However, highest net return was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (Tk. 299,514 ha^{-1}) and the lowest net return was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (Tk. 106,839 ha^{-1}). The maximum benefit cost ratio was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (2.12) and the minimum benefit cost ratio was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (1.46). For economic point of view, results indicated that the seed tuber size of 20-<28 mm with harvesting time 90 DAP was more profitable than the other treatment combination.

Table 14. Economic analysis in potato production as influenced by tuber size and harvesting time of potato

Treatment combination (Tuber size × harvesting time)	Cost of production (Tk. ha^{-1})	Marketable yield of Potato (t ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	Benefit cost ratio
28-<45 mm					
× 70 DAP	284,237	27.07	541,400	257,163	1.90
× 80 DAP	284,237	26.98	539,600	255,363	1.90
× 90 DAP	284,237	27.67	553,400	269,163	1.95
× 100 DAP	284,237	26.60	532,000	247,763	1.87
20-<28 mm					
× 70 DAP	267,686	26.60	532,000	264,314	1.99
× 80 DAP	267,686	25.07	501,400	233,714	1.87
× 90 DAP	267,686	28.36	567,200	299,514	2.12
× 100 DAP	267,686	27.24	544,800	277,114	2.04
10-<20 mm					
× 70 DAP	243,980	22.61	452,200	208,220	1.85
× 80 DAP	243,980	24.23	484,600	240,620	1.99
× 90 DAP	243,980	23.31	466,200	222,220	1.91
× 100 DAP	243,980	24.51	490,200	246,220	2.01
<10 mm					
× 70 DAP	230,561	16.87	337,400	106,839	1.46
× 80 DAP	230,561	20.34	406,800	176,239	1.76
× 90 DAP	230,561	23.49	469,800	239,239	2.04
× 100 DAP	230,561	23.27	465,400	234,839	2.02

Price of Potato @ Tk. 20,000 ton^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the field of Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2010 to April 2011 to investigate the effect of seed tuber size and harvesting time on morpho-physiological characters, yield attributes and yield of potato. The experiment comprised of 4 different size of seed tubers *viz*., 28-<45 mm, 20-<28 mm, 10-<20 mm and <10 mm and four harvesting time *viz*., 70 DAP (Days after planting), 80 DAP, 90 DAP and 100 DAP. The experiment was laid out in randomized complete block design (factorial) with three replications. The collected data were analyzed statistically and the means were separated by DMRT at 5% level of probability.

The morpho-physiological parameters such as stems hill^{-1}, number of leaves hill^{-1}, leaf Area (LA) plant^{-1} and Total Dry Mass (TDM) were significantly influenced by seed tuber size at different growth stages in potato. Results revealed that stems hill^{-1}, LA plant^{-1} increased significantly with increasing seed tuber size till the seed tuber size of 28-<45 mm. The highest plant height, stems and leaves hill^{-1} LA, TDM was observed in the tuber size of 28-<45 mm followed by the tuber size of 20-<28 mm. In contrast, the shortest plant height, lowest stems hill^{-1} and leaves hill^{-1}, LA plant^{-1} and TDM was observed in the smaller size seed tuber <10 mm.

The effect of seed tuber size on yield attributes such as tuber no hill^{-1}, single tuber weight, tuber weight hill^{-1} and tuber yield was significant. Results revealed that number tuber hill^{-1}, single tuber weight, tuber weight hill^{-1}, gross yield plot^{-1} and ha^{-1}, marketable yield plot $^{-1}$ and ha^{-1} increased with increasing seed tuber size till the tuber size of 28-<45 mm. The highest gross yield was observed in the tuber size of 28-<45 mm due to increased bearing of weight of tubers hill^{-1}. In contrast, the lowest tuber yield of both gross and marketable was recorded in smaller size seed tuber of <10 mm due to production of lower tuber weight hill^{-1}. There was significant variation in size grade of tubers due to different seed tuber size. The highest size grade distribution of tubers of >55 mm, 45-55 mm, 28-45 mm and <28 mm tuber was recorded in the seed tuber size of 28-<45 mm. The lowest size grade distribution of tubers of >55 mm, 45-55 mm, 28-45 mm and <28 mm tuber was recorded in the seed tuber size of <10 mm.

The effect of harvesting time on morpho-physiological growth, yield attributes and tuber yield was significant. Results showed that stems and leaves hill^{-1}, LA, TDM, single tuber weight, tubers hill^{-1} and tuber weight hill^{-1} increased with increasing harvesting time upto 90 DAP while reverse trend was observed in LAI. The tallest plant, the highest LAI, were recorded in 90 DAP while the lowest value were recorded in the 70 DAP. The highest stems and leaves hill^{-1}, tuber weight hill^{-1} were observed in the wider spacing of harvesting time 90 DAP and the lowest of the above parameters was observed in the harvesting time 70 DAP. The highest gross yield plot^{-1}, marketable tuber yield plot^{-1} and gross tuber yield ha^{-1} and gross marketable yield ha^{-1} was observed in the harvesting time 90 DAP and the lowest was recorded in the harvesting time 70 DAP due to lower tuber weight hill^{-1}. However, the larger tuber by size grade distribution of tuber was greater in harvesting time 90 DAP.

The combined effect of seed tuber size and harvesting time on all the studied parameters such as morpho-physiological, growth, yield attributes and yield was significant. The highest yield plot^{-1}, marketable tuber yield plot^{-1} and gross tuber yield ha^{-1} was observed in the treatment combination of 20-<28 mm seed tuber with the harvesting time 90 DAP and the lowest in the treatment combination of <10 mm seed tuber with the harvesting time 70 DAP.

Variation in cost of production was noticed due to the varied cost of seed tuber and different harvesting time. The highest gross return was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (Tk. 567,200 ha^{-1}) and the lowest gross return was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (Tk. 337,400 ha^{-1}).

However, highest net return was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (Tk. 299,514 ha^{-1}) and the lowest net return was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (Tk. 106,839 ha^{-1}). The maximum benefit cost ratio was obtained from the treatment combination of 20-<28 mm seed tuber with 90 DAP harvest (2.12) and the minimum benefit cost ratio was found from the treatment combination of <10 mm seed tuber with 70 DAP harvest (1.46). For economic point of view, results indicated that the seed tuber size of 20-<28 mm with harvesting time 90 DAP was more profitable than the other treatment combination.

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

i) The effect of seed tuber size and harvesting time had positive effect on morphological and growth characters, yield attributes and yield in potato; and

ii) The tuber size of 20-<28 mm with 90 DAP harvest seems to be more suitable for getting higher tuber yield which reflected better in economic analysis.

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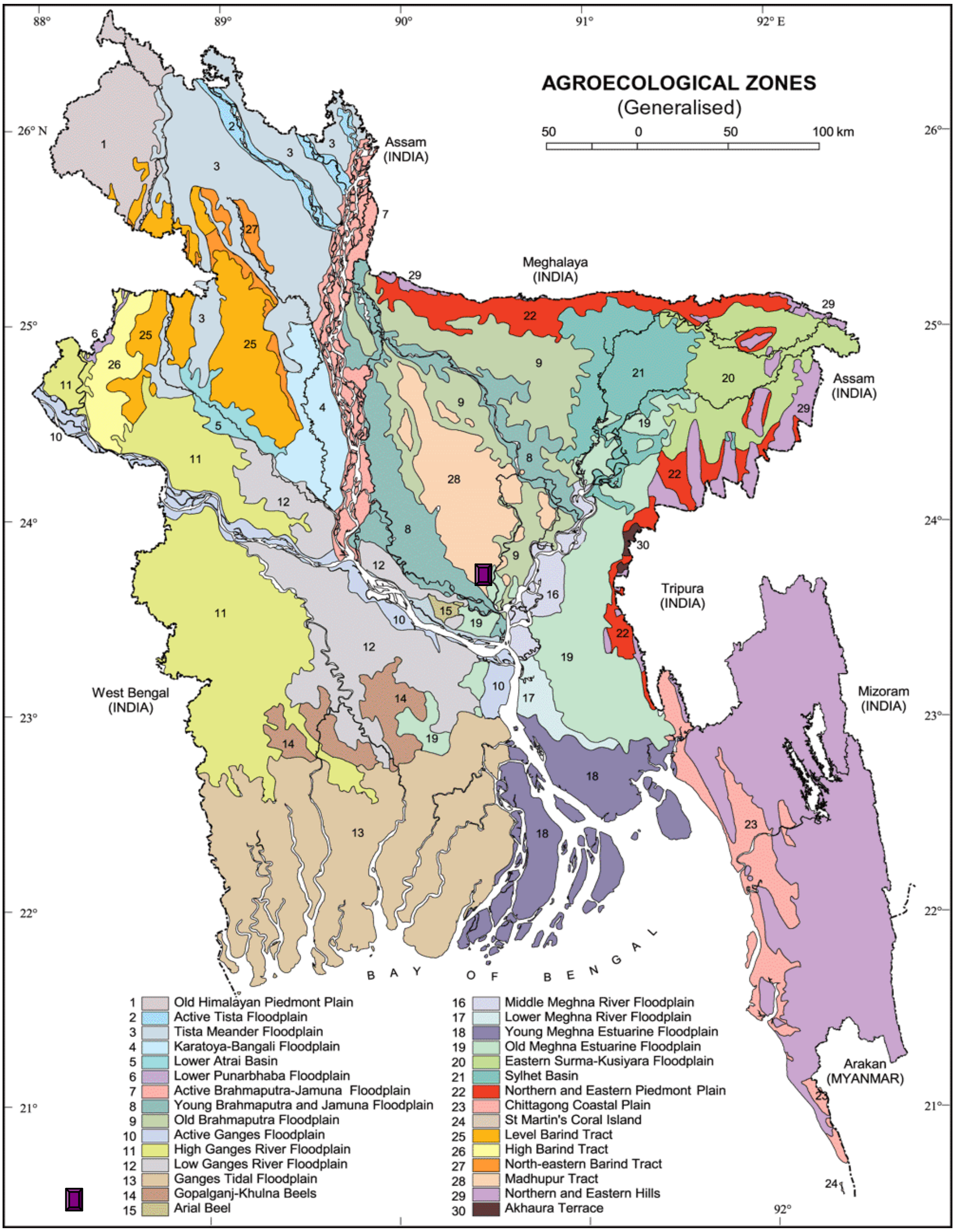
APPENDICES

Appendix I. Map showing the experimental sites under study



Appendix II. Average air temperature monthly rainfall, sunshine and relative humidity during the experimental period between November 2010 to March, 2011 at the SAU area, Dhaka

Month	Monthly average air temperature (^0C)			Averag e rainfall (mm)	Average relative humidity (%)	Average daily sunshine (hrs)
	Maximum	Minimum	Average			
October	31.27	24.14	27.71	18.0	86.2	8.65
November	29.49	19.55	24.52	00.0	84.3	8.45
December	26.52	13.19	19.85	00.0	80.8	6.67
January	23.43	12.93	18.18	00.0	78.0	7.20
February	27.34	16.41	21.87	06.6	73.9	8.18
March	29.61	20.57	25.09	13.6	80.6	7.66
April	30.56	22.14	26.35	96.6	78.57	7.42

Source: Weather Yard, SAU, Dhaka

Appendix III. Physical and chemical properties of soil of the experimental plots

A. Physical properties of soil

% sand (0.2-.02 mm)	21.75
% silt (0.02-.002 mm)	66.60
% clay (< 0.002 mm)	11.65
Textural class	Silty loam
Consistency	Granular

B. Chemical properties of soil

Soil pH	6.53
Organic carbon (%)	1.68
Organic matter (%)	1.28
Total nitrogen (%)	0.17
Available phosphorus (ppm)	8.05
Exchangeable potassium (me/100 g soil)	0.16
Available sulphur (ppm)	11.43

Appendix IV. Analysis of variance (mean square) on plant height of potato at different days after planting

Source of variation	DF	Mean square			
		Plant height (cm)			
		40 DAP	50 DAP	60 DAP	70DAP
Replication	2	0.117	2.975	8.120	3.206
Seed tuber size (A)	3	29.511**	115.83**	247.31**	242.149**
Harvesting time (B)	3	0.592	3.945NS	1.280	1.447
Interaction (A×B)	9	13.684*	23.746**	44.259*	32.125**
Error	30	5.275	5.681	17.274	8.408

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix V. Analysis of variance (mean square) on number of stem hill^{-1} of potato at different days after planting

Source of variation	DF	Mean square			
		Stem hill^{-1}			
		40 DAP	50 DAP	60 DAP	70DAP
Replication	2	0.019	0.003	0.032	0.099
Seed tuber size (A)	3	2.083**	0.793**	5.448**	9.155**
Harvesting time (B)	3	0.020	0.007	0.219	0.940**
Interaction (A×B)	9	0.164**	0.104**	0.411**	0.299**
Error	30	0.055	0.055	0.160	0.152

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VI. Analysis of variance (mean square) on number of leaves plant^{-1} of potato at different days after planting

Source of variation	DF	Mean square			
		Leaves plant^{-1} (No.)			
		40 DAP	50 DAP	60 DAP	70DAP
Replication	2	0.790	0.617	1.014	0.732
Seed tuber size (A)	3	29.166**	135.64**	118.179**	115.891**
Harvesting time (B)	3	3.160	0.853	0.921	0.851
Interaction (A×B)	9	3.929*	13.243**	17.733**	17.538**
Error	30	1.537	5.816	3.938	4.174

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VII. Analysis of variance (mean square) on leaf area plant^{-1} of potato at different days after planting

Source of variation	DF	Mean square			
		Leaf area plant^{-1} (cm^2)			
		40 DAP	50 DAP	60 DAP	70 DAP
Replication	2	2700.0	2872.3	3939.6	8025.3
Seed tuber size (A)	3	1313037.7**	1483241.2**	1598262.2**	2042814.2**
Harvesting time (B)	3	216072.2**	286142.6**	94017.0**	368269.8**
Interaction (A×B)	9	35093.9*	37346.3**	39395.0*	128547.8*
Error	30	16809.1	18092.4	15635.0	51374.4

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VIII. Analysis of variance (mean square) on total dry mass plant^{-1} of potato at different days after planting

Source of variation	DF	Mean square			
		Total dry mass plant^{-1} (g)			
		40 DAP	50 DAP	60 DAP	70 DAP
Replication	2	193.2	202.66	137.48	314.40
Seed tuber size (A)	3	4632.42**	5636.49**	8468.65**	10152.71**
Harvesting time (B)	3	54.22**	62.11**	28.710**	24.94**
Interaction (A×B)	9	3.11**	3.315**	0.328**	0.206**
Error	30	0.022	0.012	0.033	0.072

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix IX. Analysis of variance (mean square) on total dry mass m^{-2} of potato at different days after planting

Source of variation	DF	Mean square			
		Total dry mass m^{-2} (g)			
		40 DAP	50 DAP	60 DAP	70 DAP
Replication	2	3486.22	3946.95	6595.99	13749.40
Seed tuber size (A)	3	1753291.4**	193692.12**	718439.20**	864760.10**
Harvesting time (B)	3	1572.22**	176.35**	283.034**	716.204**
Interaction (A×B)	9	1.243**	1.439**	0.583**	2.277**
Error	30	14.331	19.944	18.551	23.822

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix X. Analysis of variance (mean square) on crop growth rate (CGR) of potato at different days after planting

Source of variation	DF	Mean square		
		Crop growth rate (g m^{-2} d^{-1})		
		40-50 DAP	50-60 DAP	60-70 DAP
Replication	2	15.221	17.119	4.206
Seed tuber size (A)	3	188.55**	233.38**	51.15**
Harvesting time (B)	3	6.221**	7.552**	5.152**
Interaction (A×B)	9	0.031**	0.020**	0.238**
Error	30	0.012	0.091	0.005

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XI. Analysis of variance (mean square) on crop growth rate (CGR) of potato at different days after planting

Source of variation	DF	Mean square		
		Relative growth rate (mg g^{-1} d^{-1})		
		40-50 DAP	50-60 DAP	60-70 DAP
Replication	2	3.581	3.973	4.025
Seed tuber size (A)	3	92.56**	107.90**	288.37**
Harvesting time (B)	3	2.591**	3.074**	1.561**
Interaction (A×B)	9	0.125**	0.182**	0.160**
Error	30	0.018	0.021	0.021

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XII. Analysis of variance (mean square) on yield attributes in potato

Source of variation	DF	Mean square	
		Tubers $hill^{-1}$ (No.)	Single tuber weight (g)
Replication	2	0.003	11.255
Seed tuber size (A)	3	3.411**	154.289**
Harvesting time (B)	3	2.996**	140.379*
Interaction (A×B)	9	1.489**	90.363*
Error	30	0.336	35.947

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XIII. Analysis of variance (mean square) on yield of potato

Source of variation	DF	Mean square			
		Gross yield		Marketable yield	
		Kg plot^{-1}	Ton ha^{-1}	Kg plot^{-1}	Ton ha^{-1}
Replication	2	0.104	0.650	0.126	0.788
Seed tuber size (A)	3	19.414**	121.34**	15.962**	99.760**
Harvesting time (B)	3	2.522**	15.764**	2.424**	15.150**
Interaction (A×B)	9	0.901*	5.633*	1.183**	7.396**
Error	30	0.346	2.162	0.323	2.018

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XIV. Analysis of variance (mean square) on the grade of tubers by number in potato

Source of variation	DF	Grade wise yield (number of seedling tuber)			
		>55 mm	45-55 mm	28-45 mm	<28 mm
Replication	2	0.006	0.008	0.000	0.000
Seed tuber size (A)	3	0.796**	2.313**	1.748**	1.469*
Harvesting time (B)	3	15.551**	85.931**	125.245**	17.672**
Interaction (A×B)	9	0.125**	0.942*	2.481**	2.705*
Error	30	0.037	0.359	0.363	0.400

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XV. Analysis of variance (mean square) on seed and non-seed yield in potato

Source of variation	DF	Mean square	
		Seed yield (%)	Non-seed yield (%)
Replication	2	0.302	0.012
Seed tuber size (A)	3	1.424	0.075
Harvesting time (B)	3	0.875	15.460**
Interaction (A×B)	9	1.010	1.031
Error	30	1.329	0.711

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix XVI. Per hectare production cost of potato

Treatment combination (Tuber size × harvesting time)		Labour cost	Ploughing cost	Seed Cost	Irrigation	Pesticides	Manure and fertilizers					Sub Total (A)
							Cowdung	Urea	TSP	MP	Gypsum Zn and Boron	
28-< 45 mm	70 DAP	11000.00	6000.00	116800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	192275.00
	80 DAP	11000.00	6000.00	116800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	192275.00
	90 DAP	11000.00	6000.00	116800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	192275.00
	100 DAP	11000.00	6000.00	116800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	192275.00
20-< 28 mm	70 DAP	11000.00	6000.00	102000.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	177475.00
	80 DAP	11000.00	6000.00	102000.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	177475.00
	90 DAP	11000.00	6000.00	102000.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	177475.00
	100 DAP	11000.00	6000.00	102000.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	177475.00
10-< 20 mm	70 DAP	11000.00	6000.00	80800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	156275.00
	80 DAP	11000.00	6000.00	80800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	156275.00
	90 DAP	11000.00	6000.00	80800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	156275.00
	100 DAP	11000.00	6000.00	80800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	156275.00
< 10 mm	70 DAP	11000.00	6000.00	68800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	144275.00
	80 DAP	11000.00	6000.00	68800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	144275.00
	90 DAP	11000.00	6000.00	68800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	144275.00
	100 DAP	11000.00	6000.00	68800.00	10000.00	9000.00	20000.00	6400.00	5800.00	4275.00	3000.00	144275.00

Appendix XVI. Contd.

B. Overhead cost (Tk./ha)

Treatment combination (Tuber size × harvesting time)		Cost of lease of land for 6 months (13% of value of land Tk. 10,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
28-< 45 mm	70 DAP	65,000	9,614	17,348	91,962	284,237
	80 DAP	65,000	9,614	17,348	91,962	284,237
	90 DAP	65,000	9,614	17,348	91,962	284,237
	100 DAP	65,000	9,614	17,348	91,962	284,237
20-< 28 mm	70 DAP	65,000	8,874	16,338	90,211	267,686
	80 DAP	65,000	8,874	16,338	90,211	267,686
	90 DAP	65,000	8,874	16,338	90,211	267,686
	100 DAP	65,000	8,874	16,338	90,211	267,686
10-< 20 mm	70 DAP	65,000	7,814	14,891	87,705	243,980
	80 DAP	65,000	7,814	14,891	87,705	243,980
	90 DAP	65,000	7,814	14,891	87,705	243,980
	100 DAP	65,000	7,814	14,891	87,705	243,980
< 10 mm	70 DAP	65,000	7,214	14,072	86,286	230,561
	80 DAP	65,000	7,214	14,072	86,286	230,561
	90 DAP	65,000	7,214	14,072	86,286	230,561
	100 DAP	65,000	7,214	14,072	86,286	230,561