INFLUENCE OF HARVESTING DATE ON YIELD AND QUALITY OF POTATO VARIETIES

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DHAKA-1207

DECEMBER, 2014

INFLUENCE OF HARVESTING DATE ON YIELD AND QUALITY OF POTATO VARIETIES

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AThesis
Submitted to the Faculty of Agriculture,
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

AGRONOMY

SEMESTER: JULY-DECEMBER, 2014

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CERTIFICATE

*This is to certify that the thesis entitled "**INFLUENCE OF HARVESTING DATE ON YIELD AND QUALITY OF POTATO VARIETIES**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **AGRONOMY,** embodies the results of a piece of bona fide research work carried out by **MD. JANNATH CHOWDHURY,** Registration. No. **08-02813**, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated: 24.02.2016
Dhaka, Bangladesh

(Prof. Dr. Tuhin Suvra Roy)
Supervisor

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

All praises are due to the Almighty Allah, the great, the gracious, merciful and supreme ruler of the universe to complete the research work and thesis successfully for the degree of Master of Science (MS) in Agronomy.

The author expresses the deepest sense of gratitude, sincere appreciation and heartfelt indebtedness to his reverend research supervisor ***Professor. Dr. Tuhin Suvra Roy****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his scholastic guidance, innovative suggestion, constant supervision and inspiration, valuable advice and helpful criticism in carrying out the research work and preparation of his manuscript.*

The author deems it a proud privilege to acknowledge his gratefulness, boundless gratitude and best regards to his respectable co-supervisor ***Professor Dr. Md. Shahidul Islam****, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for his valuable advice, constructive criticism and factual comments in upgrading the research work and this documents.*

Special appreciation and warmest gratitude are extended to his esteemed teachers Prof. Dr. Md. Hazrat Ali, Prof. Dr. Md. Fazlul Karim, Prof. Dr. Md. Jafar Ullah, Prof. Dr. A.K.M Ruhul Amin, Assist. Prof. Mirza Hasanuzzaman, Assist. Prof. Sheikh Muhammad Masum and all other teachers, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka who provided creative suggestions, guidance and constant inspiration from the beginning to the completion of the research work. Their contribution, love and affection would persist in his memory for countless days.

The author also expresses his special thanks to Section Officer, Lab. Assistants and other office staff of the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka for their extended and heartiest helps during the research work.

The author expresses his unfathomable tributes, sincere gratitude and heartfelt indebtedness from his core of heart to his parents; whose blessings, inspiration, sacrifice, and moral support opened the gate and paved the way of his higher study. The author also expresses his indebtedness to his sisters and brother for their love and well wishing.

The Author

INFLUENCE OF HARVESTING DATE ON YIELD AND QUALITY OF POTATO VARIETIES

ABSTRACT

A field experiment was conducted at the Agronomy research field, Sher-e-Bangla Agricultural University, Dhaka from November 2013 to May 2014, to find out the effect of harvesting time on yield and some processing quality of local potato cultivar. The experiment consists of four potato varieties and four different harvesting times. Harvesting time often affects the yield, dry matter, specific gravity and color of potato tubers. Comparative study of some processing traits of three local varieties of potato ('Fata Pakri', 'Sada Pakri' and 'Rumana') harvested at 80, 90, 100 and 110 days after planting with those of True Potato Seed variety 'BARI TPS-I' is used in this study. Tuber samples were harvested after 10 days of tuber skin-curing in the soil. Potato tuber yield increased significantly up to the last date of harvest. Mature tubers exhibited significantly higher dry matter and specific gravity compared to immature ones. Tuber color was also significantly affected by time of harvest irrespective of varieties. The 'BARI TPS-I' gave the highest tuber yield. 'Fata Pakri' exhibited the highest specific gravity and dry matter content. On the basis of flesh color, 'BARI TPS-I', 'Fata Pakri' and 'Sada Pakri' were found suitable for chips. Bangladeshi potato farmers and processors will get benefited from the information generated regarding the appropriate harvesting time of local potatoes for processing industries.

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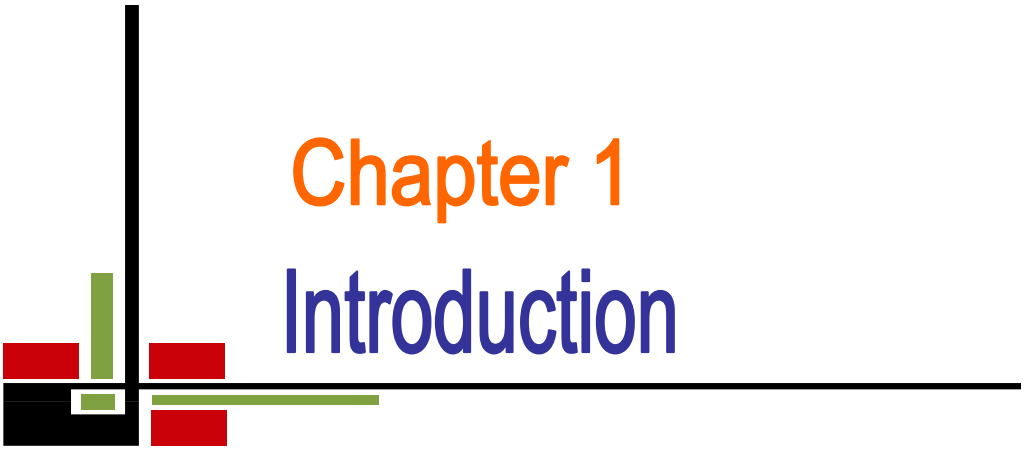
LIST OF ACRONYMS

AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
Anim.	Animal
Anon.	Anonymous
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Bd	Bangladesh
cm	Centi-meter
cm^2	Centi-meter squares
CV %	Percent Coefficient of Variance
DAP	Days After Planting
Environ	Environmental
etal.	And others
Expt.	Experemental
FAO	Food and Agriculture Organization
g	Gram (s)
mg	Milligram
$hill^{-1}$	Per hill
i.e.	*id est* (L), that is
Res.	Research
j.	Journal
Kg	Kilogram (s)
LSD	Least Significant Difference
m^2	Meter squares
M.S.	Master of Science
No.	Number
ppm	Parts per million
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
Sci	Science
SE	Standard Error
Tech.	Technology
$t\ ha^{-1}$	Ton per hectare
UNDP	United Nations Development Programme
viz	Namely
%	Percentage



Chapter 1

Introduction

CHAPTER I
INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major food crops of the world. Bangladesh was the world's seventh largest producer of potatoes with a total production of about 8.8 million tons in 2012-2013 (FAOSTAT, 2013). In Bangladesh, it ranks second after rice in production (FAOSTAT, 2013). The total area under potato crops, per ha yield and total production in Bangladesh are 444534.41 hectares, 19.35 t ha^{-1} and 8603000 metric ton respectively (BBS, 2013). The total production is increasing day by day as such consumption also rapidly increasing in Bangladesh (BBS, 2013). Potato varieties cultivated during the winter in all the districts of Bangladesh. Potato consumption as processed and fresh food is also increasing considerably in Bangladesh (Brown, 2005).

Abong *et al*. (2009) studied the storage and processing characteristics of red skinned, Kerr's pink, white skinned and Desiree potato varieties. Al though, potato product manufacturers are using High Yielding Variety (HYV), consumers in some parts of northern region of Bangladesh also prefer the local potato cultivars, because of taste, flavor, color, ambient storage ability local cultivars of potato.

Potato tuber quality is one of the most important quality attributes (Brown, 2005) for consumers and industrial demand. Potato having optimum dry matter, specific gravity, reducing sugars, starch and good color are preferred by processing industry. The specific gravity and dry matter of potato tubers is influenced by type and amount of fertilizers, dates of planting and harvesting etc., (Burton, 1966; Smith, 1968).

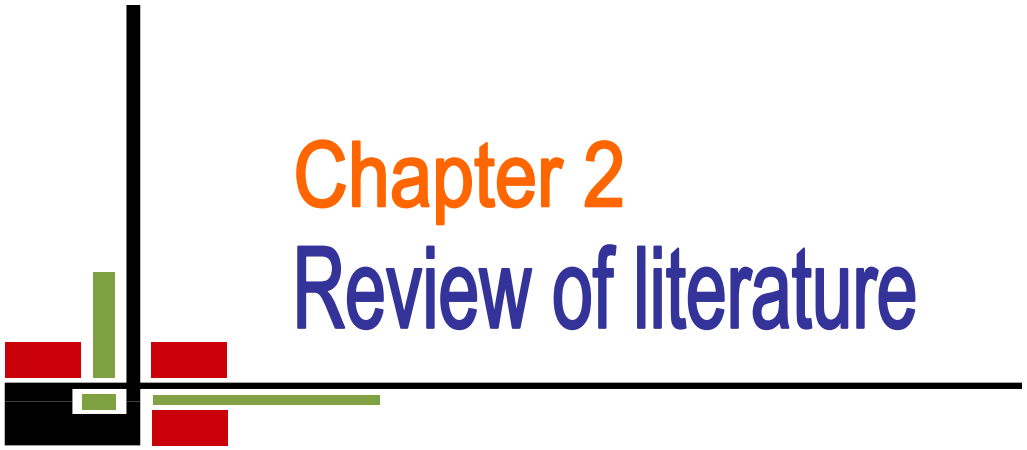
Harvesting time can influence the biomass accumulation in potato tuber. The location, cultivar, date of harvest and tuber curing influences the physical and biochemical changes in the structural components of potato tissue during

processing are influenced by Marwaha *et al*. (2005). Early harvesting of tuber gives economic support to the farmers but it affects the quality. Tuber harvested at full maturity stage contains maximum dry matter and protein content and have higher specific gravities than immature ones (Misra *et al*., 1993). Specific gravity is an important factor for maintaining quality tuber and is directly associated with the dry matter content. High specific gravity potatoes are better suited for baking, frying, mashing and chipping (Haase, 2003; Pedreschi and Moyano, 2005). Potato product manufacturers prefer tubers of higher specific gravity than potatoes with lower specific gravity to get more chips (Haase, 2003). Color is also an important quality attribute which influences the acceptability of fried products (Nourian *et al*., 2003). Golden yellow color is considered to be the best for high quality potato chips (De Freitas *et al*., 2012). Specific gravity is positively correlated to dry matter and starch content in several researches.

In Bangladesh, a local potato farmer has been lacking information on appropriate potato harvesting time and quality aspects. The study in Bangladesh on to determine the optimum harvesting time and correlating with dry matter accumulation, color and specific gravity of local potato cultivars.

With keeping in view the increasing demand for quality of local potatoes current research was conducted with following objective -

1. To study the effect of harvesting time on yield, specific gravity, dry matter content and color of different local potato varieties along with TPS cultivar.
2. To select the most suitable harvesting time for better quality potato cultivars.



Chapter 2
Review of literature

CHAPTER II

REVIEW 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, tuber production and quality of tuber due to 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 harvesting time on growth, yield and quality of tuber have been reviewed in this chapter-

2.1 Harvesting time effect

Rymuza *et al.* (2015) set a field experiment to find out the effect of ridge height and harvest date, determined based on soil temperature, on edible potato tuber quality. Starch and dry matter contents were affected by the study years, cultivar and harvest date, the highest levels being found for cv Romula tubers as well as tubers harvested at the soil temperature of 12°C.

Bhattacharjee *et al.* (2014) set a laboratory experiment was conducted at the Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March to August 2013 to study the influence of variety and date of harvesting on post harvest losses of potato derived from TPS at ambient storage condition. Due to the interaction effect of different variety and time of harvest at before storage and 20, 40, 60, 80, 100 days after storage (DAS), the maximum dry matter in flesh (13.99, 17.75, 18.80, 19.93, 21.71 and 22.57%) was observed from BARI TPS-1 and harvest at 110 days after planting and the lowest from BARI TPS-1 and harvest at 80 days after planting.

Bhattacharjee *et al.* (2014) conducted a Laboratory experiment at of at the Agronomy Department, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during March to August 2013 to study the influence of variety and date of harvesting on changes of sugar and starch levels of potato derived from TPS at ambient storage condition. Potato variety and time of harvest had significant effect on nutritional aspects. Reducing sugar, total sugar increased with advancing storage period, whereas specific gravity, non-reducing sugar and starch content decreased with increasing storage period. At harvest and 100 days after storage, the highest total sugar (0.61% and 0.82%) was observed from Lady Rosetta and harvest at 110 days after planting, while the lowest total sugar from HPS-364/67 and harvest at 80 days after planting. The results revealed that HPS 364/67 showed superior nutritional quality than other varieties when harvested at 100 days after planting.

Elfnesh *et al*. (2011) reported that specific gravity and DM content increased with the maturity of tuber and crops grown usually have more time to mature those produce tubers with high specific gravity and DM content.

Mehta *et al*. (2011) studied on four Indian processing and one exotic potato variety harvested directly at 10 day interval between 70 and 100 days after planting and at 120 days after 20 days of tuber skin curing in the soil following dehaulming, were evaluated for French fry quality. Tuber dry matter increased with maturity and was >20% at 90 days after planting in Kufri Chipsona-1, Kufri Chipsona-3 and Kufri Frysona and at 100 days in Kufri Surya. Reducing sugar content was low (<100 mg/100g fresh weight), except in Kennebec (172 mg/100 g fresh weight) harvested at 100 days after planting. Sucrose content decreased significantly towards crop maturity and curing.

Khan *et al.* (2011) studied on a field trial to optimize the sowing date and crop growth period of potato at the Agricultural Research Institute, Dera Ismail Khan,

NWFP during 2004-05. The tubers were planted on four dates with one-week interval starting from September 24 in 2004 and found that total number of tubers, percent larger and medium sized tubers, tuber yield and plant dry bio-mass increased with the delay in harvesting. However, dry matter in tuber was found higher at earlier harvestings.

Muli and Agili (2010), demonstrated that the number of marketable roots per plant, percentage of marketable roots and percent dry matter increased as more time was allowed for tuber development, before harvesting.

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 centers, 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.

Lisińska (2006) reported that the delayed harvest results in increased dry matter contents of potato.

According to Rytel (2004) delayed harvest results in increased dry matter contents of potato but the rate of their accumulation depends on cultivar and growing conditions.

Ali *et al.* (2003) reported that dry matter content and specific gravity increased when harvesting was delayed to the optimum time. The variety '9620' was at the top by producing maximum number of marketable tubers. The varieties like Hateema, Adora and 9619 were also close to 9620 in producing higher number of marketable tubers.

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.

Waterer (2002) studied the influence of planting and harvest dates on yields and grade-out due to tuber damage by common scab (*Streptomyces* spp.) over three cropping seasons using two cultivars of potato grown on land heavily infested with pathogenic *Streptomyces* species. Early planting and delaying the harvest enhanced yields in both cultivars, but also increased tuber grade-out dueto excessive levels of scab. Delaying the harvest reduced marketable yields more than did early planting. The longer harvest was delayed after top-kill, the greater was the grade out due to scab. He demonstrated that common scab of potato may be managed by minimizing the period of the crop in the ground, but this method of disease management is achieved at the expense of yields. Early planting coupled with timely harvesting after kill-down of the tops appears to be an effective compromise between the objectives of maximizing yields while avoiding excessive grade-out due to common scab.

Garayo and Moreira, (2002) found in their experiment that a higher L* value indicates a lighter color, which is desirable in potato chips.

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.

Moreira *et al*. (1999) reported that low reducing sugar content (below 0.25% and preferably below 0.1% is desired for the production of potato chips.

Marwaha (1998) also observed an increase in the specific gravity of tubers with the increase in harvesting time.

Walter *et al*. (1997) found a positive correlation between specific gravity and dry matter of tubers was observed earlier.

Jeong *et al*. (1996) reported gradual increase in specific gravity until 100 days after planting, and showed a decrease thereafter.

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.

Sinha *et al.* (1992) grew potato cvs. Atlantic, Eramosa, Kanona, Norchip, Onaway and Saginaw Gold, and selections MS 700-70, MS 700-83 (Spartan Pearl), MS 716-15 and W-855 (Snowden) on a sandy loam in Michigan. In year 1988, average yields were 46.9 t ha^{-1} at 98 days and 54.7 t ha^{-1} at 138 days; corresponding yields in 1989 were 43.1 and 52.3 t ha^{-1}. Increase in yield between the two harvest dates ranged from 0-19.6 t ha^{-1}. Tuber yield after 138 days was highest for 'MS-700-83' (62.3 t ha^{-1}) in 1988 and 'MS-700-70' (59.4 t ha^{-1}) in 1989 and lowest in 'Eramosa' in both years (41.2 and 43.0 t ha^{-1} in 1988 and 1989, respectively). Two of the selections ‘Onaway’ and ‘Eramosa’ were the earliest maturing, contained low specific gravities, high concentrations of glucose, and resulted into dark colored chips. Specific gravities of the tubers were 1.079-1.088 in Atlantic, MS 700-70, MS 716-15 and W-855, 1.071-1.076 in Norchip, Kanona and Saginaw Gold and 1.056-1.068 in Eramosa and Onaway; harvest dates did not affect specific gravity.

De-Buchananne and Lawson (1991) studied the effect of plant population and harvest timing on potato yield and chipping quality at Muscatine and Whiting. They planted cultivars: Atlantic and Nor Chip at in-row spacing of 15, 31, and 46

cm and harvested approximately 12, 14 and 16 week after planting. They obtained greater yield and greater specific gravity for both cultivars at final harvesting at both the locations. But chip color was not significantly affected at Muscatine by harvest date while each successive date of harvest resulted in lighter colored chips at Whiting. They further reported that higher plant population increased the yield but smaller increase in specific gravity was noted for both the cultivars. However chip color was not significantly influenced by the plant population. Cultivar 'Atlantic' produced lower yield having lower specific gravity as compared to 'Nor-Chip' throughout the season in the final harvest.

Simon Jewel and Richard Stanley (1989) conducted an experiment to find the effect of four dates of defoliation (0, +10, +20, +30 days) and three days intervals to harvest (0, +10, +20 days) on yield, tuber size, dry matter, reducing sugar, fry test color and finish fried sensory quality for two cultivars (Pentland Dell, Maris Piper). Dry matter content and yield of tuber were influenced by all factors in the trail. Later date of defoliation gave lowest reducing sugar levels. Increase the interval from defoliation to harvest reduced dry matter and raised yield.

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.

Santerre *et al*. (1986) studied the influence of cultivars, harvest dates and soil nitrogen on sucrose, specific gravity and storage stability of potatoes grown in Michigan. They planted potato cultivars: Atlantic, Belchip, Denali, Monona, Nor chip, and Russet Burbank and harvested them at weekly intervals from early August to early October. They obtained sucrose rating (mg sucrose/g of fresh tuber) below 1 by 145 days of growth. Higher nitrogen levels reduced the total yield for early harvests, but had no significant effect for latter harvest. Changes in

sucrose levels as tubers matured were helpful in evaluating the chemical maturity of more recently developed cultivars in relation to established chipping varieties.

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.

Workman and Harrison (1982) studied the influence of harvest date on yield, early blight tuber infection and chipping characteristics of potatoes grown with sprinkler irrigation. Potato tuber yield was increased by late harvesting. Decreased tuber infection by *Alternaria solani* was attributed to maturation of the tuber periderm.

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.

2.2 Varietal effect

Rojoni *et al.* (2014) found on an experiment which was conducted at the Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh, during the period from November 2010 to March 2011. They found BARI TPS-1 produced gross tuber yield 27.67 tha^{-1}.

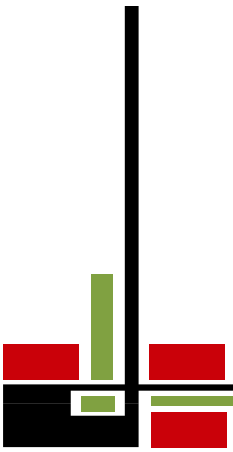
Mihovilovich *et al*. (2014) found that the potential tuber number that can be successfully produced by a plant varies with the genotype and most cultivars having a consistent number of tubers on each stem.

Sohail *et al*. (2013) reported that the local varieties consisted thick juice than HYV varieties like TPS which can be an indication of using the local varieties for ready to drink juice along with other materials like malt and flavours.

Mahmood (2005) was carried out an experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to investigate the effect of planting method and spacing on the yield of potato using Cv. BARI TPS-1. He found highest yield (32.5 t ha^{-1}) from BARI TPS-1.

Rytel (2004) reported that the rate of dry matter and starch accumulation depends on cultivar and growing conditions.

Pandey *et al*. (2002) reported that the variety BARI TPS-1' attained higher yield due to its hybrid vigor in its first clonal generation.



Chapter 3

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Agronomy field laboratory, Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November, 2013 to April, 2014.

3.1 Site description

3.1.1 Geographical location

The experimental area was situated at $23^0$77′ N latitude and $90^0$33′ E longitude at an altitude of 8.6 meter above the sea level (UNDP - FAO, 1988).

3.1.2 Agro-Ecological Region

The experimental site belongs to the Agro-ecological zone of "The Modhupur Tract", AEZ-28 (Anon., 1988). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988).

3.1.3 Climate

Experimental site was located in the subtropical monsoon climatic zone, set aparted by winter during the months from November to April (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh.

3.2 Details of the Experiment

3.2.1 Treatments

Two sets of treatments included in the experiment were as follows:

A. Variety 4:

1. V_1 – Fata Pakri
2. V_2 – Sada Pakri
3. V_3 – Rumana
4. V_4 – BARI TPS-1

B. Time of Harvest: 4

1. H_1 – Harvested at 80 Days after planting (DAP)
2. H_2 – Harvested at 90 DAP
3. H_3 – Harvested at 100 DAP
4. H_4 – Harvested at 110 DAP

Treatment combinations were as:

V_1H_1, V_1H_2, V_1H_3, V_1H_4, V_2H_1, V_2H_2, V_2H_3, V_2H_4, V_3H_1, V_3H_2, V_3H_3, V_3H_4, V_4H_1, V_4H_2, V_4H_3 and V_4H_4.

3.2.2 Experimental design

Experiment was provoked in Randomized Complete Block Design (RCBD) with three replications and thus the number of plots came to 48. The size of unit plot was 4m × 3m where the tubers were planted at 50 cm × 25 cm spacing. The distances between plot to plot and replication to replication were 1 m and 1.5 m, respectively. The layout of the experiment has been shown in Appendix I.

3.3 Planting material

The planting materials comprised three local varieties of potato and one True Potato Seed (TPS) cultivar 'BARI TPS-1'. The varieties were Fata Pakri (V_1), Sada Pakri (V_2), Romana (V_3) and BARI TPS-1 (V_4).

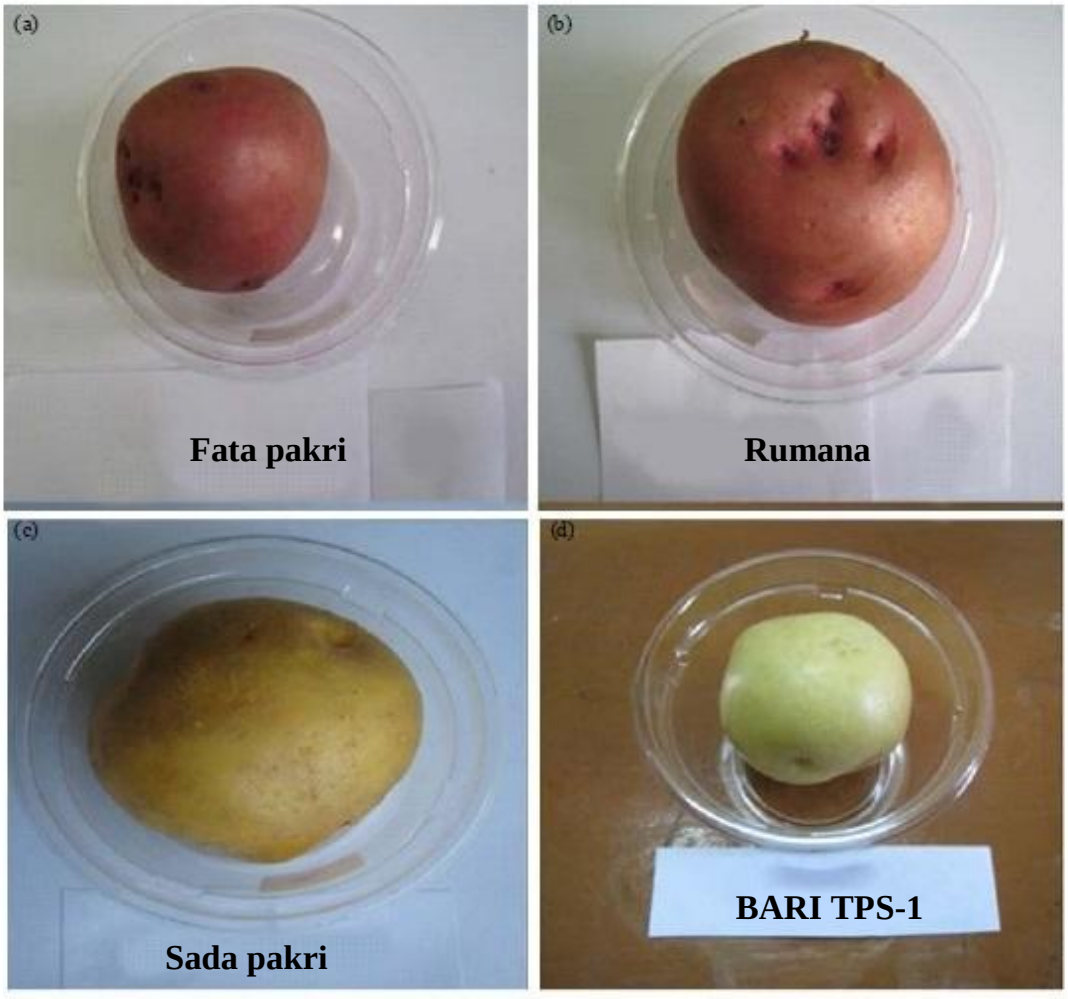


Plate 1. Different potato varieties of Bangladesh used in the experiments, (a) Fata pakri, (b) Rumana, (c) Sada parki and (d) BARI TPS-1

3.4 Crop management

3.4.1 Seed collection

The local variety was collected from different district of Bangladesh and BARI TPS-1 variety was collected from Bangladesh Agriculture Research Institute (BARI), Joydebpur, Gazipur. Average individual weight of seed potato was 50 to 60 g and average size of each potato seed was 45 to 50 mm.

3.4.2 Seed preparation

Collected seed tubers were kept in room temperature to facilitate sprouting. Finally sprouted potato tubers were used as a planting material.

3.4.3 Land preparation

The land was first opened with a tractor one week before planting. Then it was exposed to the sunshine for 7 days prior to the next ploughing. Then it was prepared by repeated ploughing and cross ploughing followed by breaking of clods and laddering to attain a good tilth. The stubbles were removed properly to clean the land. In order to avoid water logging due to rainfall during the study period, drainage channel were made around the land. The soil was treated with insecticide when the plot was finally ploughed. Finally the land was evenly leveled and the soil particles were pulverized.

3.4.4 Fertilizer application

The experimental plots were fertilized with a basal dose of 60 kg N as urea 80 kg P_2O_5 as Triple Superphosphate and 150 kg K_2O ha^{-1} as Muriate of Potash was applied at planting time and an additional 60 kg N was top dressed as urea three weeks after planting (Roy *et al.*, 2009).

3.4.5 Planting of seed tuber

The well sprouted healthy and uniform sized (45-50 mm) potato tubers were planted according to treatment and a whole potato was used as a seed potato. Tubers were planted in such a way that tuber does not go much under soil or does not remain in shallow. On an average the tubers were planted at a depth of 5-8 cm furrow as schedule of spacing on 15th November 2013.

3.4.6 Tagging

Tagging was done after planting the tubers as per treatments on 15th November 2013 using card.

3.4.7 Intercultural operations

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

3.4.7.1 Irrigation

Just after full emergence the crop was irrigated by flooding so that uniform growth and development of the crop was occurred and also moisture status of soil retain as per requirement of plants. In total four time irrigation were applied throughout the whole cropping period by four times.

3.4.7.2 Weeding and mulching

Weeding and mulching were necessary to keep the plots free from weeds and to conserve soil moisture. The newly emerged weed were uprooted carefully after complete emergence of sprouts and afterwards when necessary. Mulching was done for breaking the surface crust as and when needed.

3.4.7.3 Earthing up

The earthing up was done three times during the growing period. The first was done during planting of tuber and the remaining two were done at 30 and 50 days after plantings just after top dressing of fertilizers.

3.4.7.4 Disease and pest management

Furadan 3G @ 20 kg ha^{-1} was applied at final preparation of the main field to prevent the crops and tubers from the soil insects. Ripcord and Diathan M-45 (mixed) were applied at 30 DAP as a preventive measure for controlling virus and fungal infects. Ridomil (0.25%) was sprayed at 45 DAP to protect the crop from late blight disease.

3.4.7.5 Haulm cutting

Haulm cutting was done as per treatments. After haulm cutting the tubers were kept under the soil for 10 days for tuber skin curing. The cut haulm samples were collected, bagged and tagged separately for further data collection.

3.4.7.6 Harvesting of tubers

The tubers were harvested at 80, 90, 100 and 110 DAP, respectively. The tubers of each treatment were separately harvested, bagged and tagged and brought to the laboratory. Harvesting was done manually by hand.

3.4.8 Recording of data

Experimental data were determined from germination of tuber and continued until processing of tubers. Data on the following parameters were recorded from the five randomly selected plants during the course of the experiment. However, the yield of all the plants of the plot was considered to obtain the per plot yield. Dry matter content of different plant parts and different quality parameters were collected after harvesting of tubers. The followings data were recorded during the experiment.

A. Growth characters
    i. Plant height (cm)
    ii. Number of leaves plant^{-1}
    iii. Number of stem hill^{-1}

B. Yield and yield components
    iv. Number of tubers hill^{-1}
    v. Weight of tuber hill^{-1} (g)
    vi. Yield of tuber (t ha^{-1})
    vii. Average tuber weight (g)
    viii. Tuber dry matter content (%)

C. Quality characters
    ix. Specific gravity
    x. Total Soluble Solids (TSS, °brix)
    xi. Skin colour of tuber
    xii. Flesh colour of tuber

3.4.9 Detailed procedures of recording data

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

A. Crop growth characters

i. Plant height (cm)

The height of the potato plants was recorded at 80 DAP, beginning from the ground level up to tip of the longest stem was counted as plant height. The average height of five plants was considered as the height of the plant for each plot.

ii. Number of leaves plant^{-1}

Number of leaves plant^{-1} was counted at 80 DAP. Leaves number plant^{-1} were recorded by counting all leaves from each plant from randomly selected five plants. The average number of leaves of five plants was considered as the number of leaves plant^{-1} for each plot.

iii. Number of stems hill^{-1}

Number of stems hill^{-1} was counted at 80 DAP. Stem numbers hill^{-1} was recorded by counting all stem from randomly selected five plants. The average stem numbers of five plants were considered as the number of stems hill^{-1} for each plot.

B. Yield and yield components

iv. Number of tubers m^{-2}

Number of tubers m^{-2} was counted at harvest. Tuber numbers m^{-2} was recorded by counting all tubers of square meter from each plot.

v. Weight of tuber $hill^{-1}$ (g)

Tubers of randomly selected five hills were collected separately from which weight of tuber $hill^{-1}$ was recorded in gram.

vi. Yield of tuber (t ha^{-1})

The yield obtained tubers of each plot were collected separately and the weight of tubers of each plot was converted into t ha^{-1}.

vii. Average tuber weight

Tubers of randomly selected five hills were collected separately from which average tuber weight was recorded in gram

viii. Tuber dry matter content (%)

For determination of tuber dry matter, five whole tubers were randomly selected from each treatment and cut into small slices (1-2 mm) and mixed thoroughly. Dry weight of samples was then determined by drying at 70°C for 72 h in a forced air oven. The following formula was used for determining DM content:

$$\text{Dry matter content, DM (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

C. Quality Characters

ix. Specific Gravity

Specific gravity was determined in the raw tubers according to weight under water method as described by Ludwig (1972).

x. Total Soluble Solids (TSS, °brix)

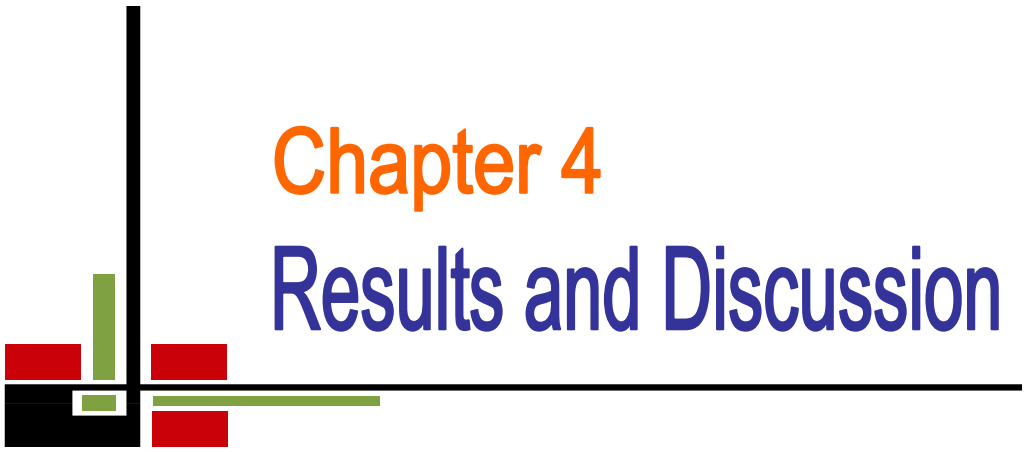
TSS was measured by portable hand refractometer (ERMA, Tokyo, Japan) at room temperature. Every single tuber was blend and juice was collected to measure (°brix). Mean was collected for each treatment.

xi. Color measurements

Color was measured with a color spectrophotometer NF333 (Nippon Denshoku, Japan) using the CIE Lab L*, a* and b* color scale. The 'L*'value is the lightness parameter indicating degree of lightness of the sample; it varies from 0 = black (dark) to 100 = white (light). The 'a*' which is the chroma tic redness parameter, whose value means tending to red color when positive (+) and green color when negative (–). The 'b*' is yellowness chromatic parameter corresponding to yellow color when it is positive (+) and blue color when it is negative (–). Each sample consisted of 10 slices, each of which was measured thrice. Hue Angle = arctg a/b and chroma = $\sqrt{a^2+b^2}$ were calculated. Higher numbers of chromaticity indicate a more vivid color, whereas lower numbers correspond to dull colors. Color measurement was done just after cutting tubers.

3.4.10 Statistical Analysis

Collected data were statistically analyzed using MSTAT-C computer package programme. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F–test (Variance Ratio). Difference between treatments was assessed by Duncan's Multiple Range Test (DMRT) at 5% level of significance (Gomez and Gomez, 1984).



Chapter 4
Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to investigate the influence of stage of maturity on growth, yield and quality of potato in Bangladesh. Some of the data have been presented and expressed in table(s) and others in figures for easy discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix. The results of each parameter have been discussed and possible interpretations where ever necessary given under following headings.

4.1 Plant height (cm)

4.1.1 Effect of variety

Significant variation was found among the varieties in case of plant height (Appendix II). Plant height of potato exposed statistically significant among 'Fata Pakri', 'Sada Pakri', 'Rumana' and 'BARI TPS-1' varieties at 80 DAP (Figure 1). The variety 'Fata Pakri' was accorded the top most result in terms of plant height (62.83 cm) which was statistically similar (58.79 cm) to 'BARI TPS-1' whereas 'Rumana' was scored as the lowest (42.84 cm) harvested at 80 DAP. The study referred that the local variety 'Fata Pakri' and the high yielding variety 'BARI TPS-1' produced maximum plant height; it may be due to varietal characters.

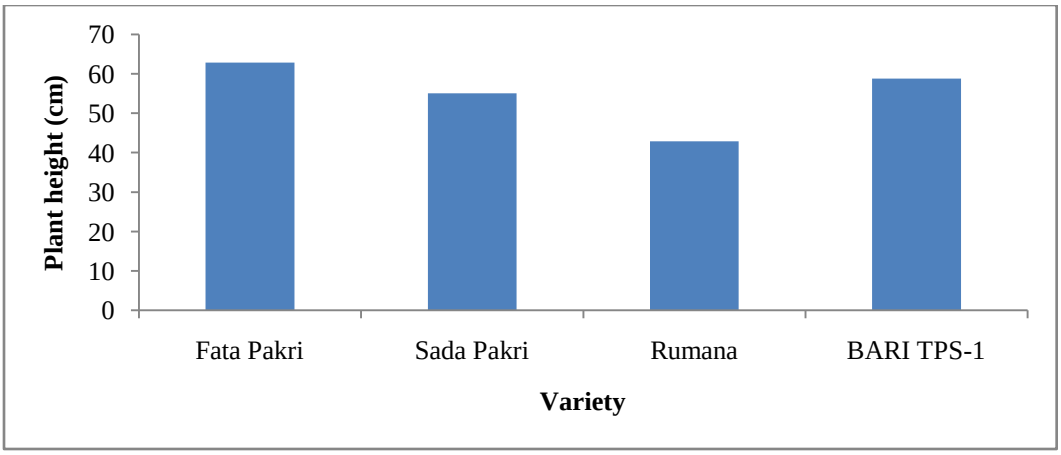


Figure 1. Varietal performance on plant height at 80 DAP

[SE value = 1.412]

4.1.2 Effect of harvesting time

Different harvesting times of potato were not significant in the case of plant height (Appendix II). Plant height of potato varieties exposed statistically non-significant among 80 DAP, 90 DAP, 100 DAP and 110 DAP at 80 DAP (Figure 2). The tallest plant (55.55 cm) was recorded from 110 DAP whereas smallest (54.0 cm) recorded from 80 DAP at 80 days after planting. The data of different harvesting time on plant height was taken in same date at 80 DAP; because harvesting date had no significant effect on plant height.

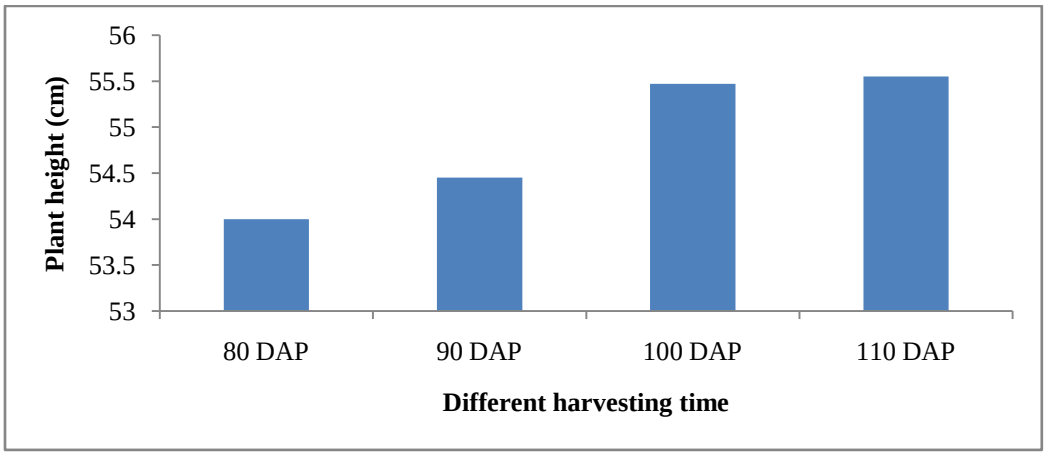


Figure 2. Effect of harvesting time on plant height at 80 DAP

[SE value = 1.39]

4.1.3 Combined effect of varieties and harvesting time

Combined effect of different potato varieties and different harvesting time in terms on plant height exposed significant variation (Appendix II). Plant height of potato varieties observed statistically significant among treatments harvested at 80 DAP (Figure 3). The tallest plant (64.03 cm) was observed in 'Fata Pakri' with 100 DAP treatment recorded, which was statistically similar to 'Fata Pakri', 'Sada Pakri' and 'BARI TPS-1' while the smallest plant (41.83 cm) was recorded in 'Rumana'.

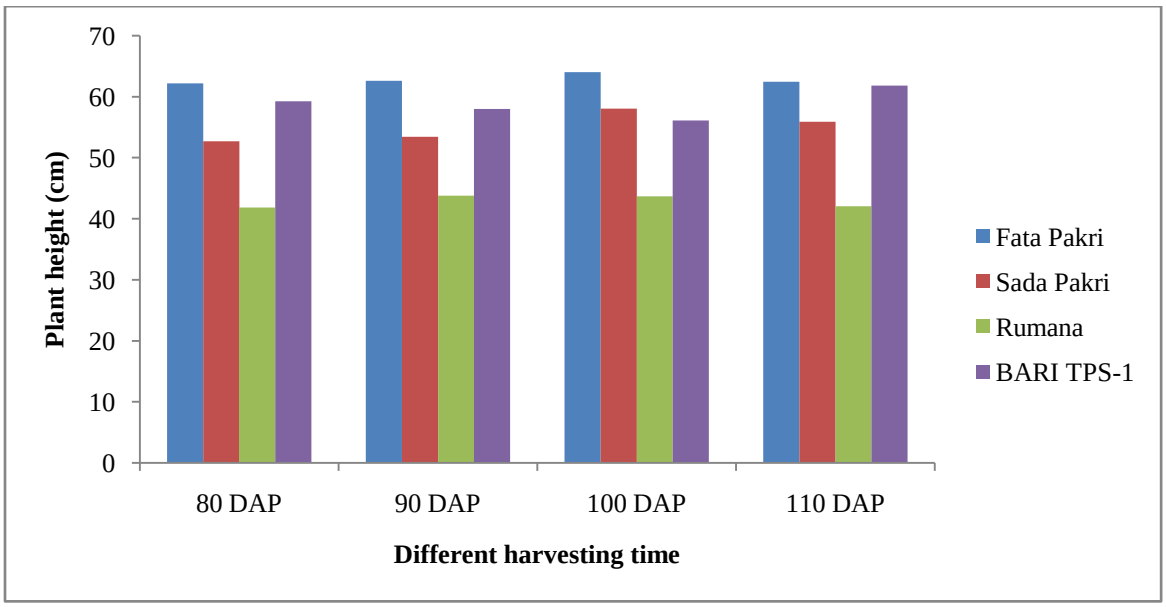


Figure 3. Combined effect of variety and different harvesting time on plant height at 80 DAP

[SE value =2.784]

4.2 Number of leaves plant^{-1}

4.2.1 Effect of variety

Significant variation was found among varieties in number of leaves plant^{-1} (Appendix II). Number of leaves plant^{-1} of potato showed statistically significant among 'Fata Pakri', 'Sada Pakri', 'Rumana' and 'BARI TPS-1' varieties (Figure 4). The maximum number of leaves plant^{-1} (26) was recorded from the variety 'BARI TPS-1' which was statistically similar (24.58) to 'Sada Pakri' whereas 'Rumana' was scored as the minimum (20.42). This study referred that the high yielding variety 'BARI TPS-1' produces maximum number of leaves than the local varieties. 'BARI TPS-1' is a high yielding variety, because of its high yielding characters it may produce maximum leaves than the local ones.

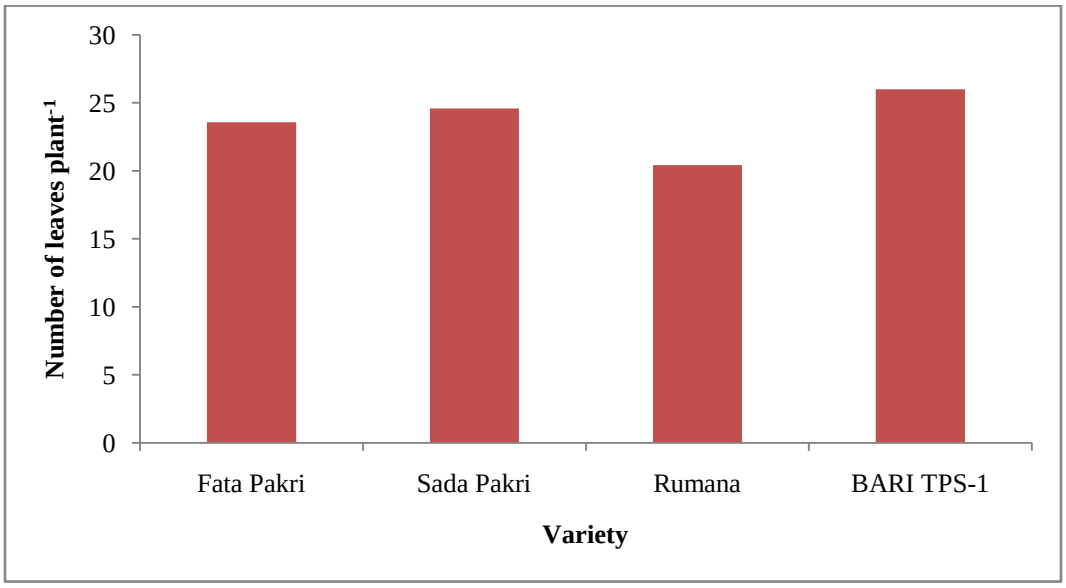


Figure 4. Varietal performance on number of leaves plant^{-1} at 80 DAP

[SE value = 0.494]

4.2.2 Effect of harvesting time

Different harvesting time of potato was not significant in case of number of leaves plant^{-1} (Appendix II). Number of leaves plant^{-1} of potato varieties exposed statistically non-significant among different harvesting times (Figure 5). The maximum number of leaves plant^{-1} (23.76) was recorded from 110 DAP whereas the minimum (23.5) recorded from 80 DAP and 90 DAP.

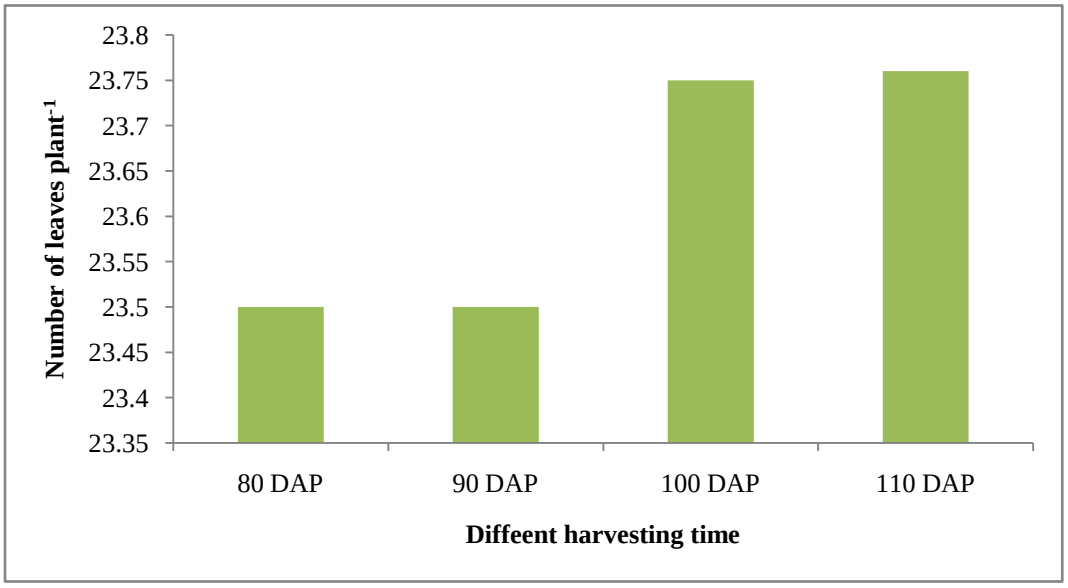


Figure 5. Effect of harvesting time on number of leaves plant^{-1} at 80 DAP

[SE value = 0.494]

4.2.3 Combined effect of varieties and harvesting time

Combined effect of different potato varieties and different harvesting time in terms of number of leaves plant^{-1} exposed significant variation (Appendix II). Number of leaves plant^{-1} of potato varieties observed statistically significant among treatments at 80 DAP (Figure 6). The maximum number of leaves plant^{-1} (27) was observed under 'BARI TPS-1' with 90 DAP treatment combination at 80 DAP which was statistically similar to same variety with different harvesting time, 'Fata Pakri' and 'Sada Pakri' with 100 DAP and 110 DAP treatment combination while the minimum (19) was recorded on 'Rumana' at harvested at 80 DAP. The study referred that the high yielding variety 'BARI TPS-1' produces maximum number of leaves than the local varieties irrespective of different harvesting time.

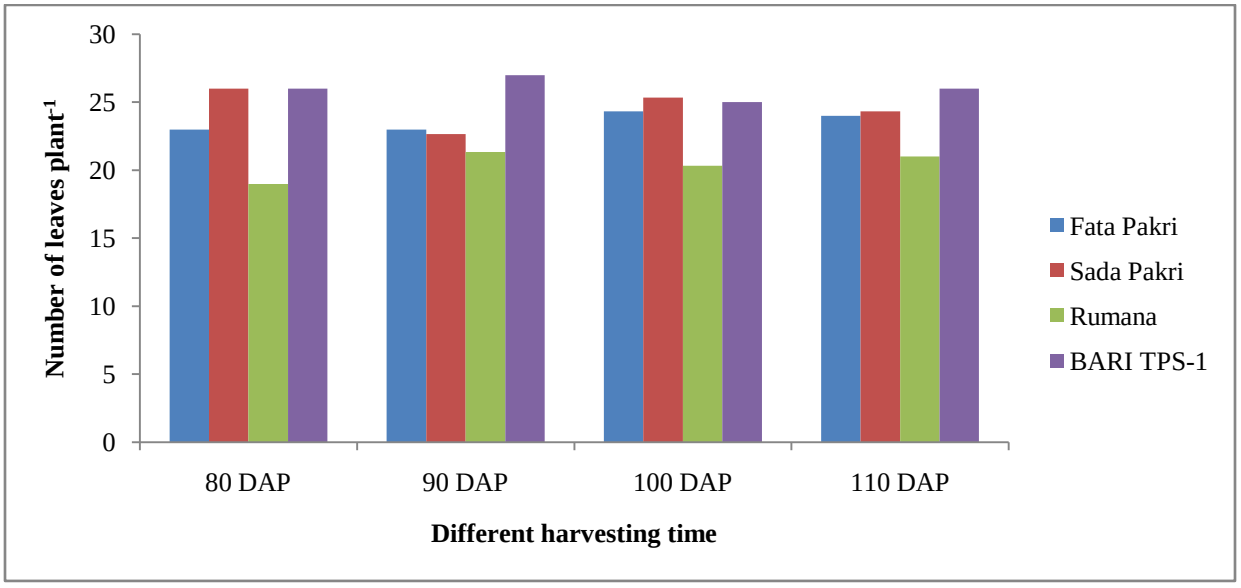


Figure 6. Combined effect of variety and different harvesting time on number of leaves plant^{-1} at 80 DAP

[SE value: 0.987]

4.3 Number of stems hill^{-1}

4.3.1 Effect of variety

Significant variation was found among the varieties on stems hill^{-1} (Appendix II). Number of stems hill^{-1} of potato exposed statistically significant among 'Fata Pakri', 'Sada Pakri', 'Rumana' and 'BARI TPS-1' varieties (Figure 7). The maximum number of stems hill^{-1} (3.67) was recorded from the variety 'Fata Pakri' which was statistically similar (3.25) to 'Sada Pakri' whereas 'BARI TPS-1' and 'Rumana' were scored minimum (2). The study referred that all local variety produced maximum number of stem hill^{-1} than the high yielding variety 'BARI TPS-1'; it might be due to varietal characters.

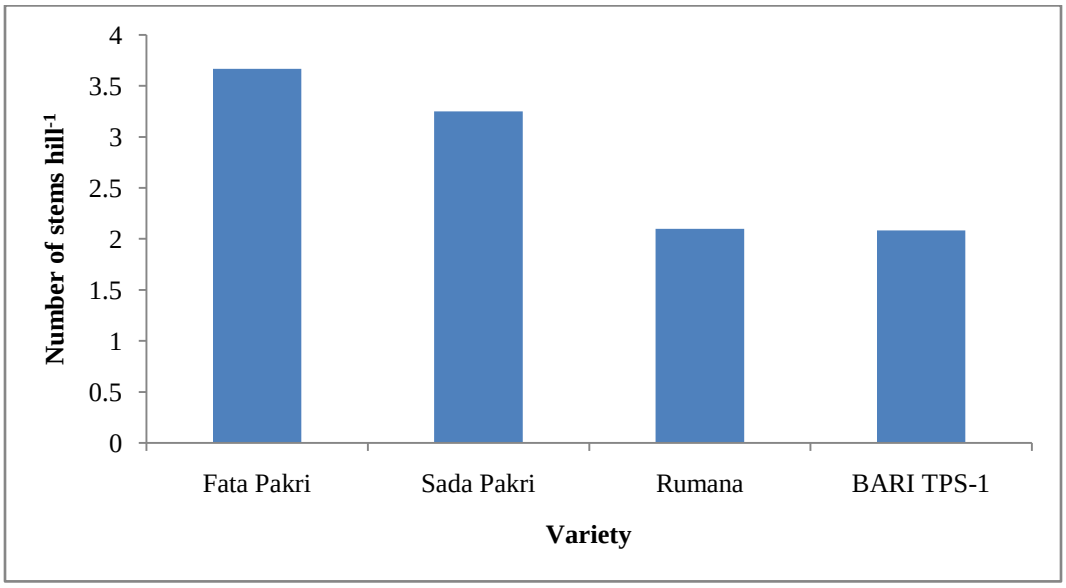


Figure 7. Varietal performance on number of stems hill^{-1} at 80 DAP

[SE value = 0.186]

4.3.2 Effect of harvesting time

Different harvesting time of potato was not significant in stems hill^{-1} (Appendix II). Number of stems hill^{-1} of potato varieties appeared non-significant among (Figure 8). However, the maximum number of stems hill^{-1} (2.76) was recorded from 110 DAP treatment whereas the minimum (2.67).

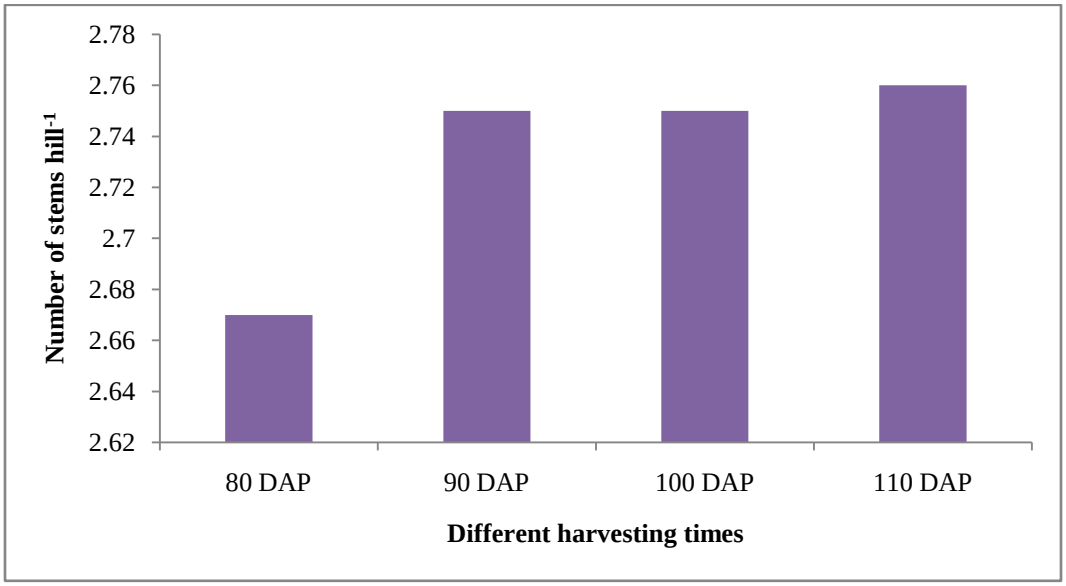


Figure 8. Effect of harvesting time on number of stems hill^{-1} at 80 DAP
[SE value = 0.186]

4.3.3 Combined effect of varieties and harvesting time

Combined effect of varieties and different harvesting time on number of stems hill^{-1} showed significant variation (Appendix II). Number of stems hill^{-1} of potato varieties observed statistically significant among treatments (Figure 9). The maximum number of stems hill^{-1} (4) was observed under 'Fata Pakri' which was statistically similar to same variety and 'Sada Pakri' at different harvesting time while the minimum (2) was recorded on 'BARI TPS-1' with different harvesting time. The study showed that all local variety produced maximum number of stems hill^{-1} than the high yielding variety 'BARI TPS-1' irrespective of harvesting time; it may be due to varietal characters.

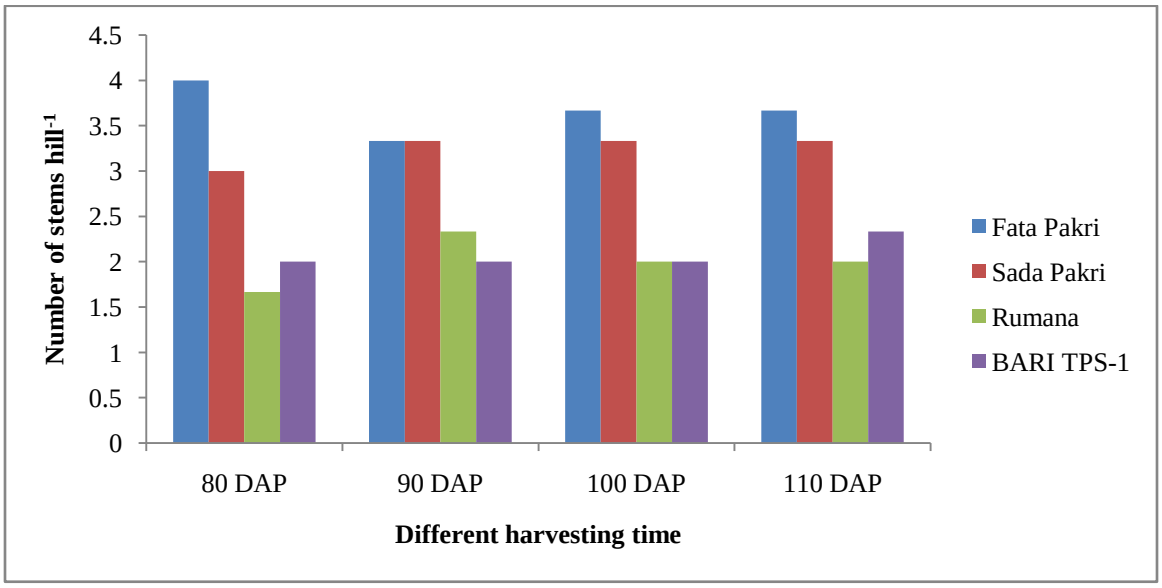


Figure 9. Combined effect of variety and different harvesting time on number of stems hill^{-1} at 80 DAP
[SE value: 0.371]

4.4 Number of tubers m^{-2}

4.4.1 Effect of variety

Number of tubers m^{-2} appeared significant with potato varieties (Appendix III). The maximum number of tubers m^{-2} (583.3) was recorded in 'Sada Pakri' whereas the minimum (195) was in 'BARI TPS-1' as of Figure 10. The study showed that all local varieties except 'Rumana' produced maximum number of tubers m^{-2} than 'BARI TPS-1'. The potential tuber number that can be successfully produced by a plant varies with the genotype and most cultivars having a consistent number of tubers on each stem (Mihovilovich *et al.*, 2014).

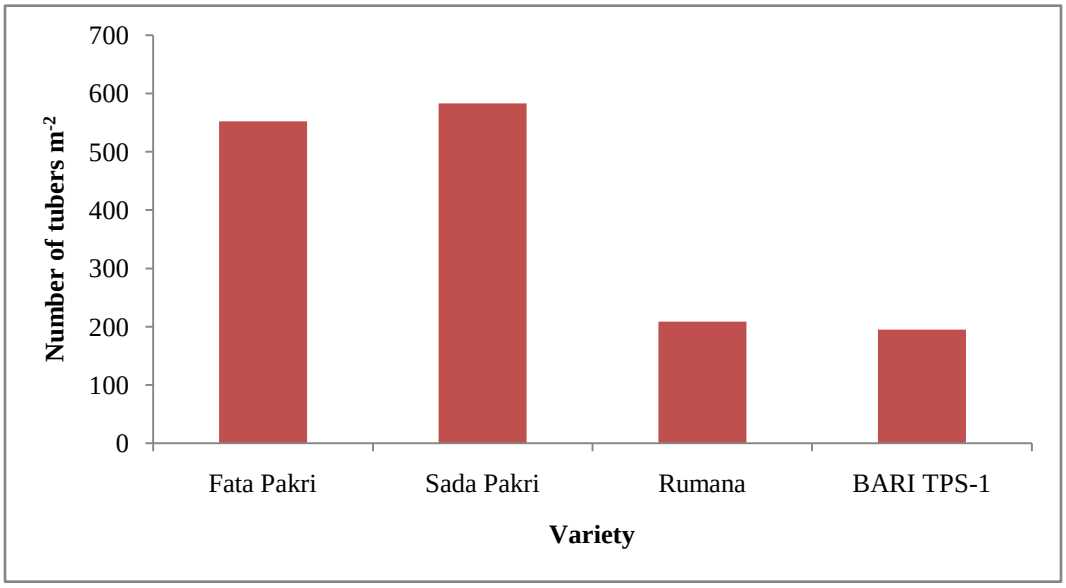


Figure 10. Varietal performance on number of tubers m^{-2}

[SE value = 7.442]

4.4.2 Effect of harvesting time

Different harvesting time significantly influenced the number of tubers m^{-2} (Appendix III). Harvesting at 110 DAP gave the maximum number of tubers m^{-2} (405.6) which was statistically similar to harvesting at 100 DAP and 90 DAP while the minimum (329.8) was obtained from the harvest at 80 DAP (Figure 11). Present study showed that tuber numbers increased with maturity time up to certain time, after that the number of tubers did not increase. Khan *et al.* (2011) found that total number of tubers increased with the delay in harvesting.

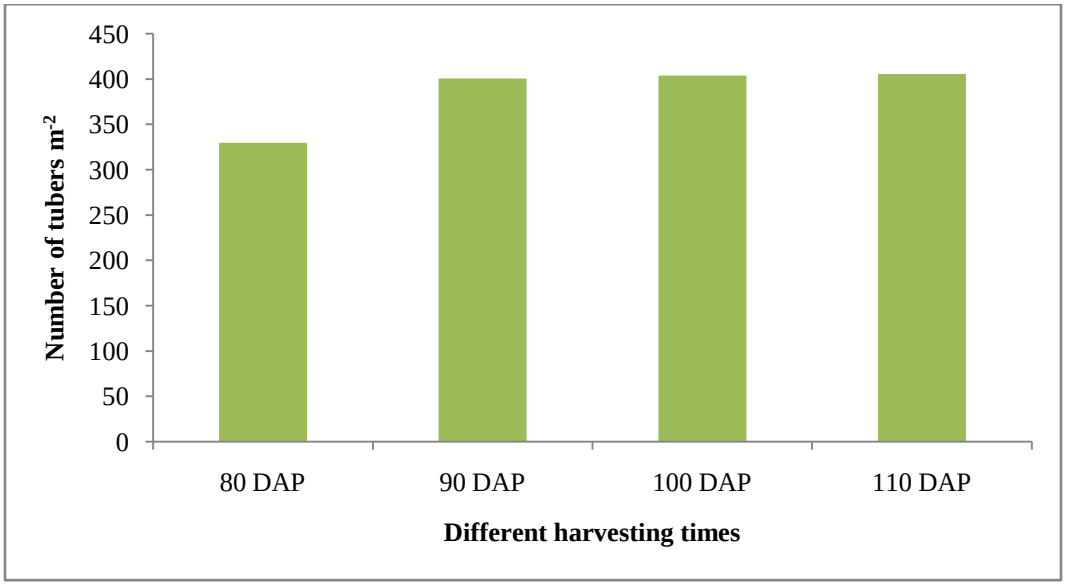


Figure 11. Effect of harvesting time on number of tubers m^{-2}

[SE value =7.442]

4.4.3 Combined effect of varieties and harvesting time

Combined effect of different potato varieties and harvesting time showed statistically significant variation in number of tubers m^{-2} (Appendix III). The maximum number of tubers m^{-2} (604.7) was recorded from 'Sada Pakri' harvested at 110 DAP which was statistically similar to same variety harvested at 100 DAP (695.7), 90 DAP (598), 'Fata Pakri' harvested at 90 DAP (575), 100 DAP (577.7) and 110 (578) while the minimum (160) was recorded from 'BARI TPS-1' harvested at 80 DAP (Figure 12). Present study showed that tuber numbers of all variety increased with maturity time up to certain time. Khan *et al.* (2011) also found that total number of tubers increased with the delay in harvesting.

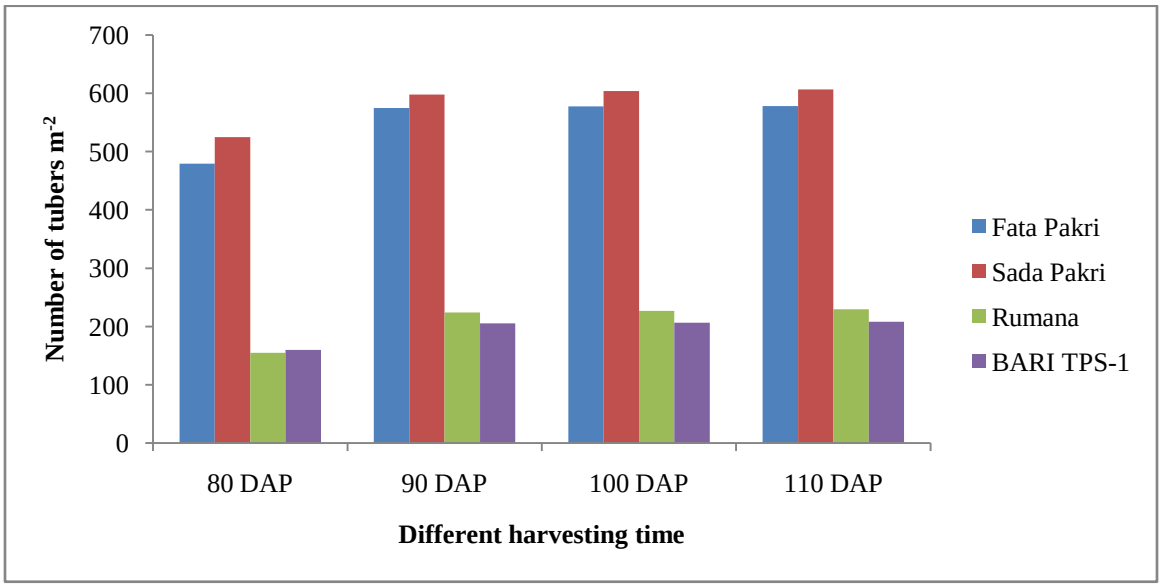


Figure 12. Combined effect of variety and different harvesting time on number of tubers m^{-2}

[SE value = 14.88]

4.5 Weight of tubers hill^{-1} (g)

4.5.1 Effect of variety

It was observed from the results that different potato varieties significantly varied with the tuber weight hill^{-1} (Appendix III). The maximum (306.9 g) was found in 'BARI TPS-1' while the minimum (189.7 g) was recorded from 'Rumana'. On the other hand 'Fata Pakri' (226.2 g) and 'Sada Pakri' (210.7 g) produced statistically similar results (Figure 13). Present study reviled that modern variety 'BARI TPS-1' produced maximum tuber weight hill^{-1} than the local varieties. All the local cultivars gave low yields may be due to their genetically low yield potential. 'BARI TPS-1' attained higher yield due to its hybrid vigor in its first clonal generation (Pandey *et al*., 2002).

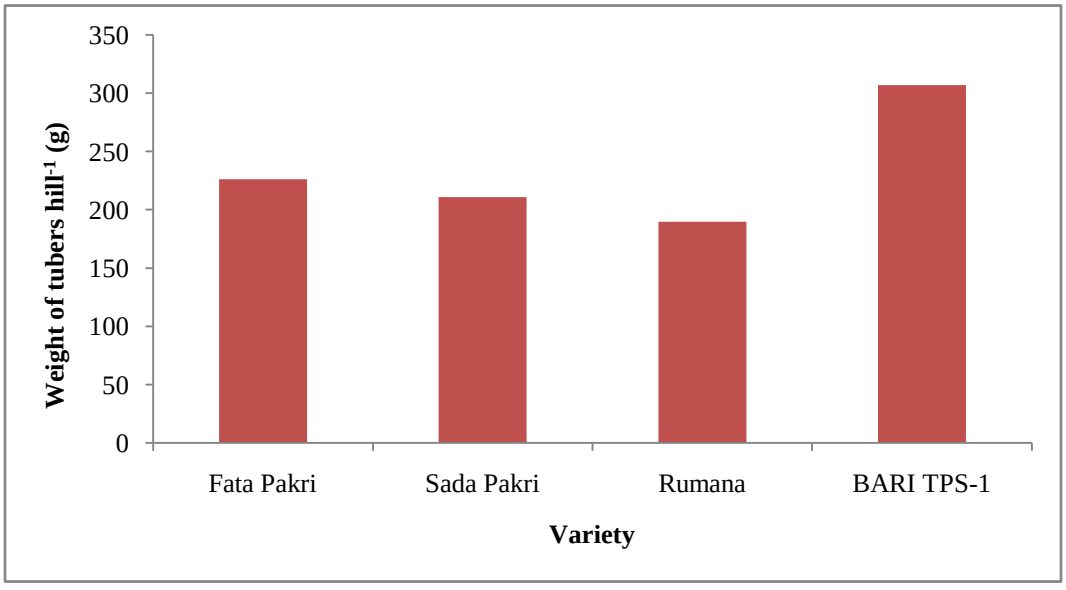


Figure 13. Varietal performance on weight of tubers hill^{-1} (g)

[SE value = 5.754]

4.5.2 Effect of harvesting time

Weight of tubers hill^{-1} varied significantly with different harvesting time (Appendix III). The maximum tuber weight hill^{-1} (265.4 g) recorded from the harvest at 110 DAP while the minimum (201.5 g) was in 80 DAP (Figure 14). Present study showed that tuber weight of all variety increased with maturity time. Increasing maturity time helps to gather more plant dry bio-mass which leads to increase weight of tubers. Khan *et al.* (2011) also found that tuber yield increased with the delay in harvesting.

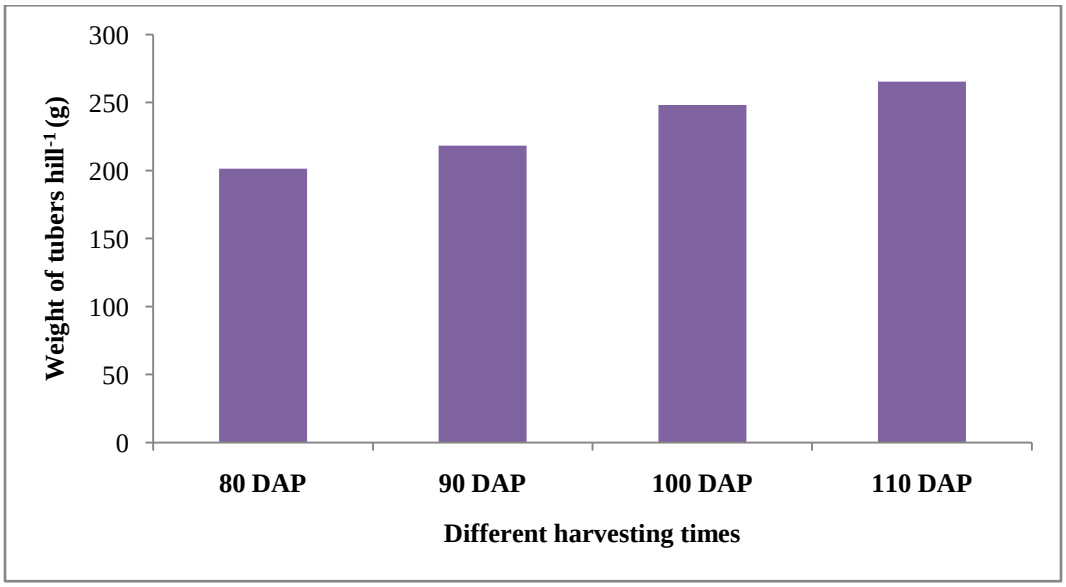


Figure 14. Effect of harvesting time on tubers weight hill^{-1} (g)

[SE value = 5.754]

4.5.3 Combined effect of varieties and harvesting time

Treatment combination of potato varieties and harvesting times influenced the weight of tubers hill^{-1} significantly (Appendix III). The weight of tubers hill^{-1} was observed the maximum in 'BARI TPS-1' harvested at 110 DAP (341.1 g) which was statistically similar to same variety harvested at 100 DAP (323.4 g) while the minimum (165.9 g) was found on 'Rumana' harvested at 80 DAP which was statistically similar (196.5 g) to same variety harvested at 90 DAP (Figure 15). Present study showed that tuber weight hill^{-1} of 'BARI TPS-1' was highest compared to those of other local cultivars irrespective of harvesting time may be due to its varietal characteristics. From this study it was showed that tuber weight of all variety increased with maturity time. Increasing maturity time helps to gather more plant dry bio-mass which leads to increase weight of tubers. Khan *et al.* (2011) also found that tuber yield increased with the delay in harvesting.

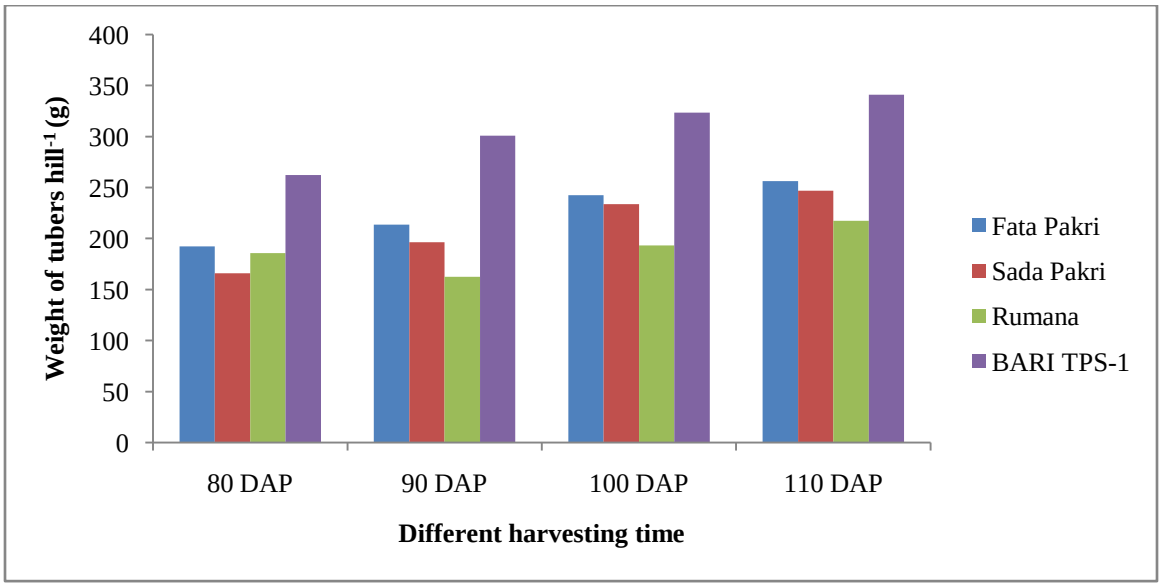


Figure 15. Combined effect of variety and different harvesting time on weight of tubers hill^{-1} (g)

[SE value =11.51]

4.7 Yield of tuber (t ha^{-1})

4.7.1 Effect of variety

It was observed that different potato varieties significantly varied with the tuber yield (Appendix III). The maximum (24.47 t ha^{-1}) tuber yield was recorded in 'BARI TPS-1' while minimum was in 'Rumana' (14.61 t ha^{-1}) (Figure 16). 'Fata Pakri' and 'Sada Pakri' gave statistically similar yield of tuber. Present study showed that all the local cultivars gave low yields may be due to their genetically low yield potential. 'BARI TPS-1' attained higher yield due to its hybrid vigor in its first clonal generation (Pandey *et al*., 2002).

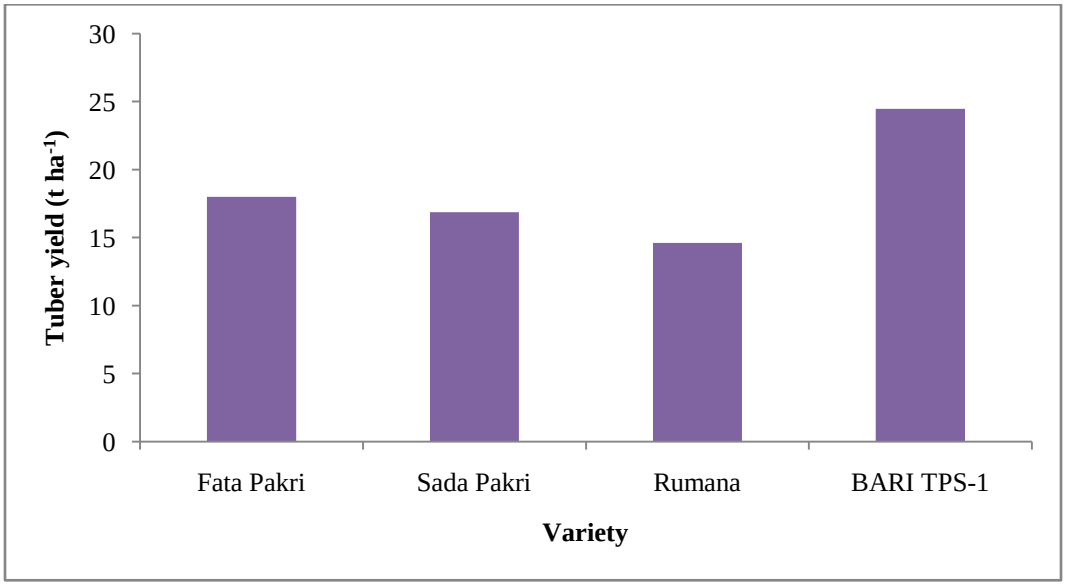


Figure 16. Varietal performance on tuber yield (t ha^{-1})

[SE value = 0.744]

4.7.2 Effect of harvesting time

Significant variation in respect of tuber yield was observed on the different harvesting time (Appendix III). The mean tuber yield of all cultivars significantly increased with maturity (Figure 17). The maximum (21.02 t ha^{-1}) tuber yield was recorded in harvesting at 110 DAP which was statistically similar (19.86 t ha^{-1}) to harvesting at 100 DAP whereas the minimum (15.35 t ha^{-1}) recoded from 80 DAP. Harvesting at 100 and 110 DAP showed statistically similar yield. The maximum increase in yield was noticed between 90 and 100 DAP. All cultivars attained maturity on 100 DAP. Khan *et al.* (2011) found that total number of tubers, tuber yield and plant dry bio-mass increased with the delay in harvesting.

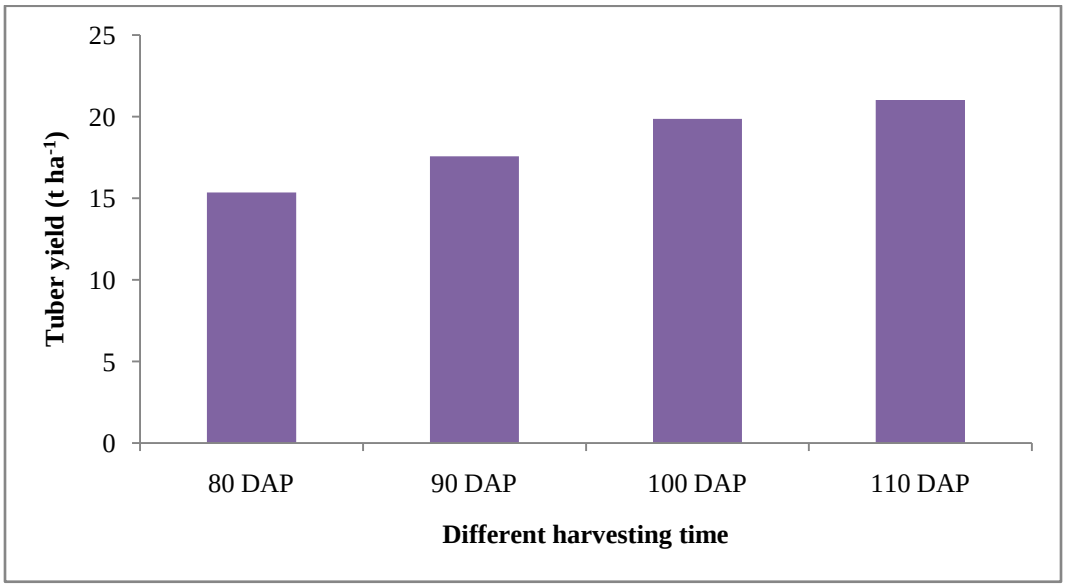


Figure 17. Effect of harvesting time on tuber yield (t ha^{-1})

[SE value = 0.744]

4.7.3 Combined effect of varieties and harvesting time

Treatment combination of variety and harvesting times had also significant effect on tuber yield (Appendix III). Among the sixteen treatment combinations, the cultivar, 'BARI TPS-1' harvested at 110 DAP attained the highest tuber yield (26.95 t ha^{-1}) and same variety harvested at100 DAP produced statistically similar yield (25.87 t ha^{-1}), whereas the lowest yield (12.19 t ha^{-1}) was recorded in 'Rumana' harvested at 80 DAP, same variety harvested at 90 DAP and 'Sada Pakri' at 80 DAP also produced statistically similar yield (Figure 18). All cultivars produced the minimum yield at early harvest (80 DAP). The yield of 'BARI TPS-1' was highest compared to those of other local cultivars irrespective of harvesting time may be due to its varietal characteristics. Among the local cultivars, 'Fata Pakri' showed the best performance (20.5 t ha^{-1}) when harvested at 110 DAP.

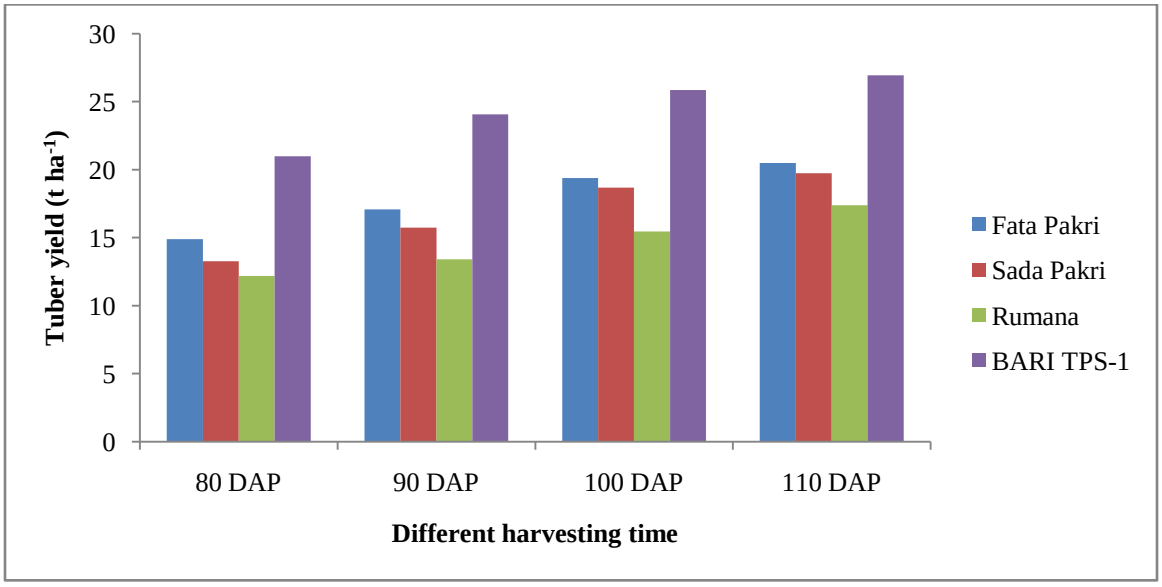


Figure 18. Combined effect of variety and different harvesting time on tuber yield (t ha^{-1})
[SE value = 0.744]

4.7 Average tuber weight (g)

4.7.1 Effect of variety

It was observed from the results of the present experiment that different potato varieties significantly varied with average tuber weight (Appendix III). The maximum average tuber weight (50.74 g) was found in 'BARI TPS-1' while the minimum (31.84 g) was recorded from 'Sada Pakri' (Figure 19). Present study reviled that modern variety 'BARI TPS-1' produced maximum average tuber weight than the local varieties. All the local cultivars gave lower average tuber weight may be due to their genetically low yield potential.

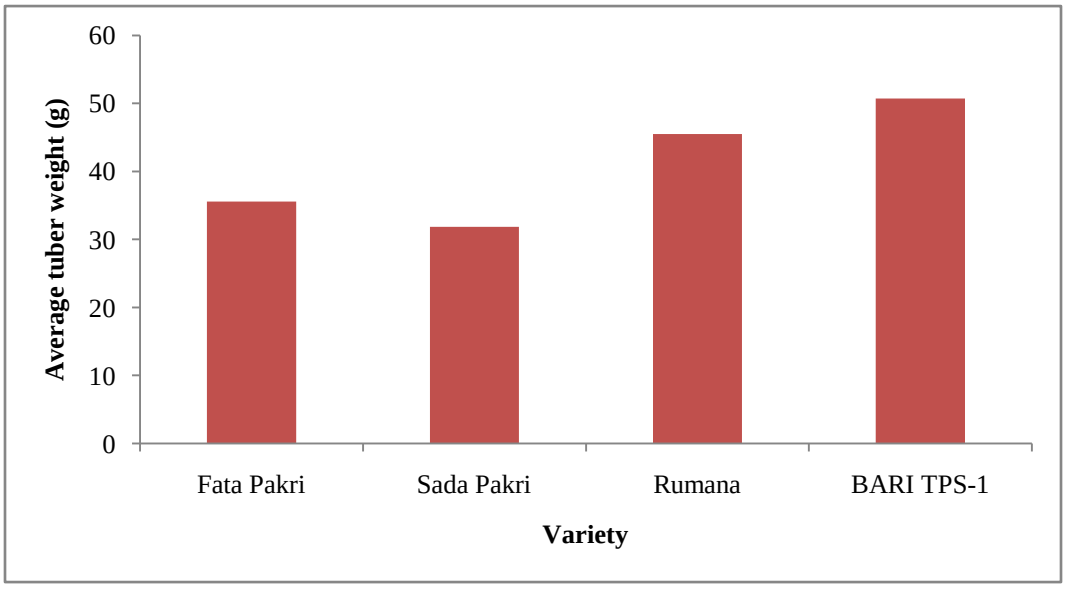


Figure 19. Varietal performance on average tuber weight (g)

[SE value = 0.364]

4.7.2 Effect of harvesting time

Average tuber weight varied significantly with different harvesting time (Appendix III). The maximum average tuber weight (44.46 g) recorded from harvested at 110 DAP while the minimum (36.92 g) was in harvested at 80 DAP (Figure 20). Present study showed that average tuber weight of all variety increased with maturity time. Increasing maturity time helps to gather more plant dry bio-mass which leads to increase weight of tubers. Khan *et al.* (2011) also found that tuber yield increased with the delay in harvesting.

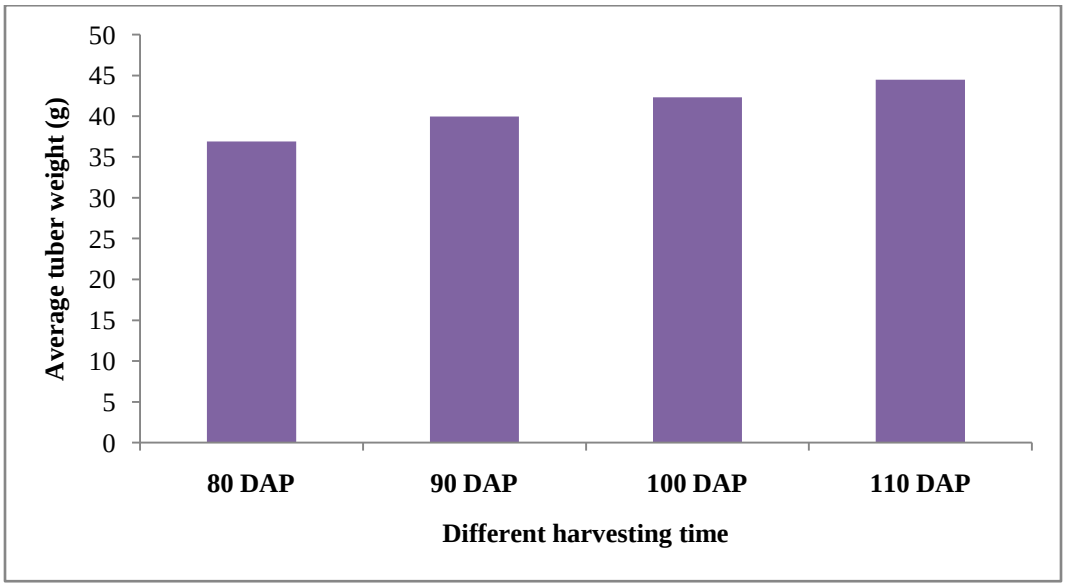


Figure 20. Effect of harvesting time on average tuber weight (g)

[SE value = 0.364]

4.7.3 Combined effect of varieties and harvesting time

Treatment combination of potato varieties and different harvesting time influenced the average tuber weight significantly (Appendix III). The maximum average tuber weight (54.64 g) was observed in 'BARI TPS-1' harvested at 110 DAP which was statistically similar to same variety harvested at 100 DAP (52.87 g) while the minimum (28.43 g) was found on 'Sada Pakri' harvested at 80 DAP (Figure 21). Present study showed that average tuber weight of 'BARI TPS-1' was highest compared to those of other local cultivars irrespective of harvesting time may be due to its varietal characteristics. From this study it was also observed that average tuber weight of all variety increased with maturity time. Increasing maturity time helps to gather more plant bio-mass which leads to increase weight of tubers. Khan *et al.* (2011) also found that tuber weight increased with the delay in harvesting.

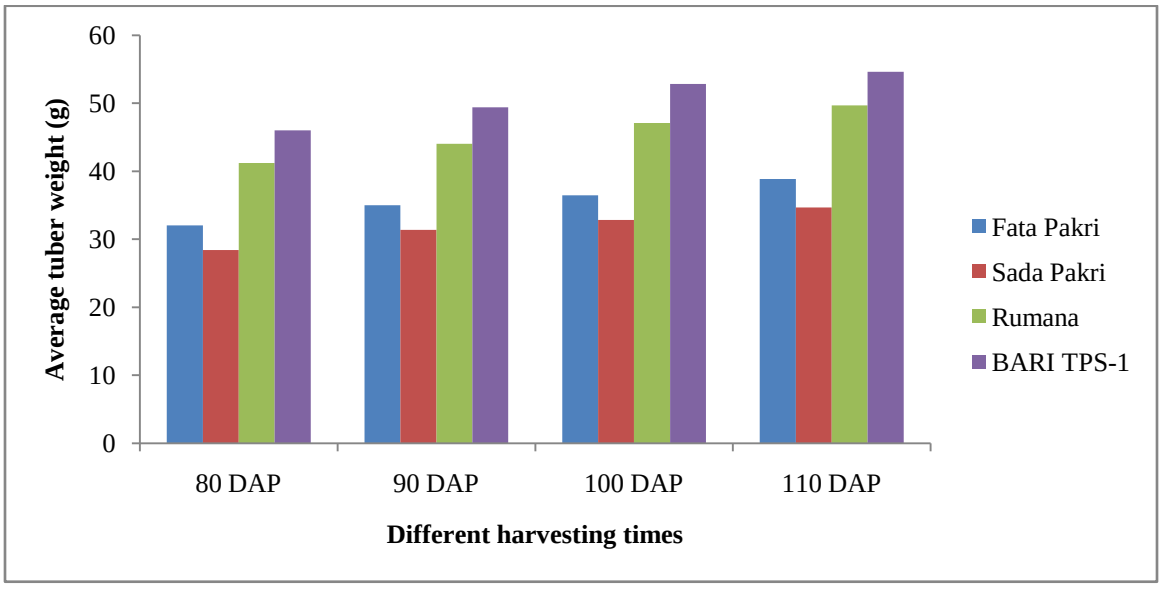


Figure 21. Combined effect of variety and different harvesting time on average tuber weight (g)

[SE value =0.727]

4.8 Dry matter content of tuber

4.8.1 Effect of variety

Tuber Dry Matter (DM) content was significantly affected by different variety (Appendix IV). Among four varieties, ‘Sada Pakri’ showed the maximum (20.28%) DM content while BARI-TPS-1was recorded minimum (17.90%) DM content (Table 1). It was observed that all local varieties exhibited maximum dry matter content of tuber compared to those of modern variety ‘BARI TPS-1’. The rate of accumulation of dry matter depended on cultivar, which was confirmed in the study by Gąsiorowska and Zarzecka (2002). According to Rytel (2004) and Lisińska (2006), delayed harvest results in increased dry matter contents of potato but the rate of their accumulation depends on cultivar and growing conditions.

4.8.2 Effect of harvesting time

Tuber dry matter content was significantly affected by different harvesting time (Appendix IV). The maximum dry matter content of tuber (21.72%) was recorded from harvested at 110 DAP whereas the minimum (16.94%) was recorded from harvested at 80 DAP (Table 2). The results of this study demonstrated that the time to harvest affected dry matter content of tubers. These results are consistent with those of Muli and Agili (2010), whose study demonstrated that the percent dry matter increased as more time was allowed for tuber development, before harvesting. According to Rytel (2004) and Lisińska (2006), delayed harvest results in increased starch and dry matter contents of potato.

4.8.3 Combined effect of varieties and harvesting time

Combined effect of potato varieties and different harvesting time significantly influenced on dry matter content of potato tubers (Appendix IV). Among the fourteen treatment combinations, 'Sada Pakri'' tubers exhibited the maximum (22.78%) DM content at 110 DAP, while 'BARI TPS-1' showed the minimum (15.37%) DM content at 80 DAP (Table 3). Tubers that have a longer time to accumulate carbohydrates will generally have higher DM content than those with shorter growth periods. This result is in agreement with (Misra *et al*., 1993; Marwaha, 1998; Ali *et al*., 2003; Elfnesh *et al*., 2011; Mehta *et al*., 2011) who reported that DM content increased with the maturity of tuber and crops grown usually have more time to mature those produce tubers with high DM content. A positive correlation between specific gravity and dry matter of tubers was observed earlier (Walter *et al*., 1997).

4.9 Specific gravity of tuber

4.9.1 Effect of variety

Significant variation in respect of specific gravity was observed for the different varieties (Appendix IV). Differences in specific gravity of tuber among the four varieties were consistent irrespective of harvesting time (Table 1). 'Sada Pakri' tubers showed the highest specific gravity (1.084) than those from the other three varieties, whereas, the lowest value (1.053) was recorded in 'BARI TPS-1'. It was revealed that all local varieties exhibited maximum specific gravity compared to those of 'BARI TPS-1'.

4.9.2 Effect of harvesting time

Specific gravity was significantly affected by different harvesting time (Appendix IV). The specific gravity of tubers significantly increased with increasing harvesting time. The highest specific gravity of tuber (1.085) was recorded from 100 DAP which was statistically similar (1.082) to 110 DAP whereas the lowest (1.050) was recorded from 80 DAP (Table 2). Jeong *et al.* (1996) reported gradual increase in specific gravity until 100 days after planting, and showed a decrease thereafter, present study also showed that specific gravity gradually increased with increasing harvesting time up to 100 DAP, and showed a decrease thereafter. Marwaha (1998) also observed an increase in the specific gravity of tubers with the increase in harvesting time.

4.9.3 Combined effect of varieties and harvesting time

Combined effect of potato varieties and different harvesting time significantly influenced on specific gravity of potato tubers (Appendix IV). Among the sixteen treatment combinations, 'Sada Pakri' tubers exhibited the highest (1.079) specific gravity at 110 DAP, while 'BARI TPS-1' showed the lowest specific gravity (1.032) at 80 DAP (Table 3). Tubers that have a longer time to accumulate carbohydrates will generally have higher specific gravity than those with shorter growth periods. This result is in agreement with (Misra *et al*., 1993; Marwaha, 1998; Ali *et al*., 2003; Elfnesh *et al*., 2011; Mehta *et al*., 2011), who reported that specific gravity and DM content increased with the maturity of tuber and crops grown usually have more time to mature those produce tubers with high specific gravity and DM content. A positive correlation between specific gravity and dry matter of tubers was observed earlier (Walter *et al*., 1997).

4.10 Total soluble solid (°brix)

4.10.1 Effect of variety

Significant variation in respect of total soluble solid (°brix) was observed for the different varieties (Appendix IV). 'Fata Pakri' tubers showed the highest (7.38) total soluble solid which was statistically similar (7.35) to 'Sada Pakri' whereas the lowest (6.18) was recorded in 'BARI TPS-1' (Table 1). It was revealed that all local varieties exhibited maximum TSS compared to those of 'BARI TPS-1'. Total soluble solid was measured in potato juice and local varieties showed significantly higher range of 7.5-8.1% TSS effects with the same DAP. The local varieties consisted thick juice than HYV varieties like TPS which can be an indication of using the local varieties for ready to drink juice along with other materials like malt and flavours (Islam and Jalaluddin, 2004; Sohail *et al*., 2013).

4.10.2 Effect of harvesting time

Total soluble solid did not affect significantly by different harvesting time (Appendix IV). The maximum total soluble solid (TSS) of tuber (7.22) was recorded from harvested at 90 DAP whereas the minimum (6.38) was recorded from harvested at 80 DAP (Table 2).

4.10.3 Combined effect of varieties and harvesting time

Combined effect of potato varieties and different harvesting time significantly influenced on total soluble solid of potato tubers (Appendix IV). Among the fourteen treatment combinations, 'Sada Pakri' tubers exhibited the maximum (8.07) TSS harvested at 100 DAP which was statistically similar to same variety and 'Fata Pakri' irrespective of harvesting time, ''Rumana'' harvested at 90 DAP and 100 DAP and 'BARI TPS-1' harvested at 90 DAP while 'BARI TPS-1' showed the minimum (5.37) TSS harvested at 100 DAP (Table 3).

Table 1. Performance of different varieties related to on specific gravity, dry matter content and TSS of tuber

Variety	Dry matter content (%)	Specific gravity	TSS (°brix)
Fata Pakri	19.58 b	1.068 b	7.38 a
Sada Pakri	19.66 b	1.084 a	7.35 a
Rumana	20.28 a	1.072 b	6.34 b
BARI TPS-1	17.90 c	1.053 c	6.18 b
SE value	0.041	0.005	0.037
CV%	4.7	1.75	6.3
Level of Significance	**	**	*

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
** - significant at p≤0.01 and * significant at p≤0.05.

Table 2. Effect of harvesting time on specific gravity, dry matter content and TSS of tuber

Harvesting time	Dry matter content (%)	Specific gravity	TSS (°brix)
80 DAP	16.94 d	1.050 c	6.38
90 DAP	18.48 c	1.061 b	7.22
100 DAP	20.28 b	1.085 a	6.93
110 DAP	21.72 a	1.082 a	6.73
SE value	0.041	0.005	0.037
CV%	4.7	1.75	6.3
Level of Significance	**	**	ns

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
ns - non-significant and ** - significant at p≤0.01.

Table 3: Combined effects of variety and harvesting time on specific gravity, dry matter content and TSS of tuber

Treatment combination		Dry matter content (%)	Specific gravity	TSS (%)
Variety	**Harvesting at**			
Fata Pakri	**80 DAP**	17.26 j	1.056 gh	7.20 a-c
	90 DAP	18.73 fg	1.060 f-h	6.97 a-d
	100 DAP	20.47 d	1.074 b-f	7.73 ab
	110 DAP	21.86 bc	1.081 b-d	7.63 ab
Sada Pakri	**80 DAP**	17.26 j	1.055 gh	6.97 a-d
	90 DAP	18.32 gh	1.070 c-g	7.13 a-c
	100 DAP	20.62 d	1.089 b	8.07 a
	110 DAP	22.78 a	1.124 a	7.23 a-c
Rumana	**80 DAP**	17.86 hi	1.056 gh	5.97 c-e
	90 DAP	19.07 f	1.069 d-g	7.27 a-c
	100 DAP	21.42 c	1.079 b-e	6.53 a-e
	110 DAP	22.36 ab	1.086 bc	5.60 de
BARI TPS-1	**80 DAP**	15.37 k	1.032 i	5.40 e
	90 DAP	17.75 ij	1.047 hi	7.53 ab
	100 DAP	18.62 fg	1.063 e-h	5.37 e
	110 DAP	19.86 e	1.071 c-g	6.43 b-e
SE value		0.331	0.011	0.151
CV%		4.7	1.75	6.3
Level of Significance		**	*	*

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
** - significant at $p \leq 0.01$ and * significant at $p \leq 0.05$.

4.10 Skin colour of tuber

4.11.1 Effect of variety

The statistical analysis revealed significant differences ($p<0.05$) for lightness (L*), green-red chromaticity (a*), blue-yellow chromaticity (b*), chroma and hue angle of potato skin and fresh in different varieties but not for harvest dates (Appendix V). Among four varieties, the skin of 'BARI TPS-1' had the highest L* value compared to those of others whereas the lowest was observed in 'Rumana' (Table 4). In case of b*, chroma and hue angle value 'BARI TPS-1' produced the maximum result (34.38, 35.28 and 1.35 respectively) whereas 'Rumana' produced the minimum b* and hue angle value and 'Fata Pakri' produced the minimum chroma value (16.47, 0.82 and 24.24 respectively).

4.11.2 Effect of harvesting time

Harvest date had no effect on lightness (L*), degree of yellowness (b*), redness (a*) and chroma value for skin but significant effect was recorded on hue angle value (Appendix V). The highest hue angle value was recorded on harvesting of tuber at 110 DAP which was statistically similar to 90 DAP and 100 DAP whereas the lowest was recorded from harvested at 80 DAP (Table 5).

4.11.3 Combined effect of varieties and harvesting time

The combination effect of variety and harvest date had significant effect on skin colour (L*, a* and b value) (Appendix V). Among sixteen combinations, the skin of 'BARI TPS-1' and 'Sada Pakri' exhibited the maximum L* values (63.63-59.10) irrespective of all harvest time. The skin of 'Rumana' was characterized by the highest a* value (23.57) at 80 DAP, while the lowest was exhibited in 'BARI TPS-1' (6.93) at 100 DAP (Table 4). 'BARI TPS-1' produced the maximum b*, chroma and hue angle value while the minimum recorded on 'Rumana' and 'Fata Pakri' irrespective of all harvest time.

Table 4. Performance of varieties related to skin colour of potato

Variety	Skin colour				
	L^*	a^*	b^*	Chroma	Hue Angle
Fata Pakri	49.47 c	16.46 b	17.76 b	24.24 d	0.82 c
Sada Pakri	59.86 b	10.69 c	30.88 a	32.69 b	1.23 b
Rumana	47.36 d	19.03 a	16.47 b	25.50 c	0.72 d
BARI TPS-1	62.76 a	7.917 d	34.38 a	35.28 a	1.35 a
SE value	0.539	0.001	0.351	0.221	0.002
CV%	5.3	2.5	4.7	2.39	0.34
Level of Significance	**	**	**	**	**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
** - significant at p≤0.01.

Table 5. Effect of harvesting time related to skin colour of potato

Harvesting at	Skin colour				
	L^*	a^*	b^*	Chroma	Hue Angle
80 DAP	54.742	14.43	24.15	29.58	0.99 b
90 DAP	54.467	13.44	25.18	29.36	1.04 a
100 DAP	55.042	13.33	24.41	29.04	1.04 a
110 DAP	55.200	12.90	25.74	29.73	1.05 a
SE value	0.539	0.001	0.351	0.221	0.002
CV%	5.3	2.5	4.7	2.39	0.34
Level of Significance	ns	ns	ns	ns	**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
ns - non-significant and ** - significant at p≤0.01.

Table 6. Combined effects of variety and harvesting time on skin colour of potato

Treatment combination		Skin colour				
Variety	**Harvesting at**	**L***	**a***	**b***	**Chroma**	**Hue Angle**
Fata Pakri	**80 DAP**	50.60 c	15.07 b	17.13de	22.81 f	0.85 de
	90 DAP	50.40 c	16.43 b	18.67 d	24.87 ef	0.85 be
	100 DAP	46.83 cd	18.63 b	16.87de	25.13 e	0.74f
	110 DAP	50.07 c	15.70 b	18.37de	24.16 ef	0.87 d
Sada Pakri	**80 DAP**	60.77 ab	10.90 c	30.27 c	32.17 c	1.22 c
	90 DAP	58.10 b	11.23 c	29.10 c	31.19 c	1.20 c
	100 DAP	60.10 ab	10.57 cd	31.10 bc	32.85 bc	1.24 c
	110 DAP	60.47 ab	10.07 cd	33.03 a-c	34.53 ab	1.27 bc
Rumana	**80 DAP**	44.53 d	23.57 a	14.47 e	27.67 b	0.55 g
	90 DAP	47.57 cd	17.77 b	17.47de	24.92 ef	0.78 ef
	100 DAP	49.60 c	17.20 b	17.67de	25.46 de	0.80d-f
	110 DAP	47.73 cd	17.60 b	16.27de	23.97 ef	0.75 f
BARI TPS-1	**80 DAP**	63.07 a	8.17 cd	34.73ab	35.67 a	1.34 ab
	90 DAP	61.80 ab	8.33 cd	35.50 a	36.46 a	1.34 ab
	100 DAP	63.63 a	6.93 d	32.00 a-c	32.74 bc	1.36 a
	110 DAP	62.53 a	8.23 cd	35.30 a	36.25 a	1.34 ab
SE value		0.953	0.002	0.521	0.443	0.003
CV%		5.3	2.5	4.7	2.39	0.34
Level of Significance		*	**	**	*	**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

** - significant at p≤0.01 and * significant at p≤0.05.

4.11 Flesh colour of tuber

4.12.1 Effect of variety

The statistical analysis revealed significant differences ($p<0.05$) for lightness (L*), green-red chromaticity (a*), blue-yellow chromaticity (b*), chroma and hue angle of potato fresh in different varieties but not for harvest dates (Appendix V). Among four varieties, the flesh of 'Fata Pakri' and 'Sada Pakri' had L* values that were significantly higher than the values of others. 'Fata Pakri' was characterized by a higher a*, b* and chroma (2.03, 36.33 and 36.36 respectively) value which was statistically similar to 'Sada Pakri' whereas 'BARI TPS-1' showed lower a*, b* and chroma value. In case of hue angle the highest hue angle value (1.56) recorded from 'BARI TPS-1' whereas lowest (1.52) was recorded from 'Fata Pakri' and 'Sada Pakri' (Table 7). The variation of colour can be explained by differences in composition within varieties, particularly in antioxidant content and enzyme activity. 'Fata Pakri' and 'Rumana' varieties produced light coloured flesh (L*>50), which indicates that there was no excessive darkening. This can be attributed to low reducing sugars levels exhibited by the varieties. All the varieties tended towards the positive values of redness parameter (a*) of skin and flesh colour indicating that there was less or no excess browning of the products during frying. Lack of excess browning can be attributed to low and acceptable levels of sugars, major causes of browning during frying of potato products. Also all the potato varieties tended towards yellow as indicated by positive values of yellowness (b*) parameter. Abong and Kabira (2011) also found significant varietal differences in colour and textural properties of crisps and French fries with the product and variety. This might be attributed due to genetical, environmental or inter cultural factors. This colour parameter could be used as an objective colour index for preparing chips. Moreira *et al*. (1999) reported that low reducing sugar content (below 0.25% and preferably below 0.1% is desired for the production of potato chips.

4.12.2 Effect of harvesting time

The statistical analysis revealed that there was no significant effect on harvest date on lightness (L*), degree of yellowness (b*) and redness (a*) for flesh (Appendix V). In case of chroma and hue angle significant effect was found on harvesting date (Table 8). Harvesting at 90 DAP produce the highest chroma value which was statistically similar to harvested at 80 DAP while the lowest was recorded on harvested on 100 DAP. In case of hue angle, harvested at 80 DAP, 100 DAP and 110 DAP produced the highest value while harvested at 90 DAP produced the lowest result.

4.12.3 Combined effect of varieties and harvesting time

The combination effect on variety and harvest date had significant effect on flesh colour (Appendix V). The treatment combinations of variety and harvest date had significant effect on L*, a* and b value. Among sixteen combinations, the variety, ‘Sada Pakri’ showed the highest L* value (74.14) for flesh when harvested at 90 DAP, whereas, the lowest was recorded in ‘Rumana’ irrespective of harvest dates (Table 9). A higher L* value indicates a lighter colour, which is desirable in potato chips (Garayo and Moreira, 2002). ‘BARI TPS-1’, ‘Fata Pakri’ and ‘Sada Pakri’ were observed suitable for flesh colour. ‘Fata Pakri’ and ‘Sada Pakri’ demonstrated higher a* values irrespective of all harvested dates and ‘Rumana’ showed similar results at earlier harvesting time whereas, ‘BARI TPS-1’ was characterized by lower a* values (<0.8) irrespective of all harvesting times. The findings provided evidence of slightly less redness colour of ‘BARI TPS-1’ compared with other varieties. Among the treatment combinations, ‘Fata Pakri’ and ‘Sada Pakri’ exhibited dark yellow colour flesh and ‘Rumana’ and ‘BARI TPS-1’ displayed light yellow colour flesh irrespective of all harvesting dates. In case of chroma value ‘Fata Pakri’ harvested at 80 DAP recorded the highest chroma value (39.31) while ‘BARI TPS-1’ produced the lowest (25.77) value. On the other hand ‘BARI TPS-1’ harvested at 80 DAP produced the highest hue angle

value (1.57) while 'Fata Pakri' harvested at 100 DAP and 110 DAP produced the lowest value.

Table 7. Performance of varieties related to flesh colour of potato

Variety	Flesh colour				
	L^*	a^*	b^*	Chroma	Hue Angle
Fata Pakri	70.97 ab	2.03 a	36.33 a	36.36 a	1.52 c
Sada Pakri	72.72 a	1.69 a	34.77 a	34.80 b	1.52 c
Rumana	68.54 c	0.85 b	29.47 b	29.48 c	1.54 b
BARI TPS-1'	69.76 bc	0.35 b	27.27 b	27.69 d	1.56 a
SE value	0.539	0.001	0.351	0.221	0.002
CV%	5.3	2.5	4.7	2.39	0.34
Level of Significance	**	**	**	**	**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
** - significant at p≤0.01.

Table 8. Effect of harvesting time related to flesh colour of potato

Harvesting at	Flesh colour				
	L^*	a^*	b^*	Chroma	Hue Angle
80 DAP	71.32	1.167	31.93	32.35 a	1.54 a
90 DAP	70.04	1.567	32.53	32.56 a	1.53 b
100 DAP	70.27	1.058	31.41	31.43 b	1.54 a
110 DAP	70.37	1.150	31.97	31.99 ab	1.54 a
SE value	0.539	0.001	0.351	0.221	0.002
CV%	5.3	2.5	4.7	2.39	0.34
Level of Significance	ns	ns	ns	*	**

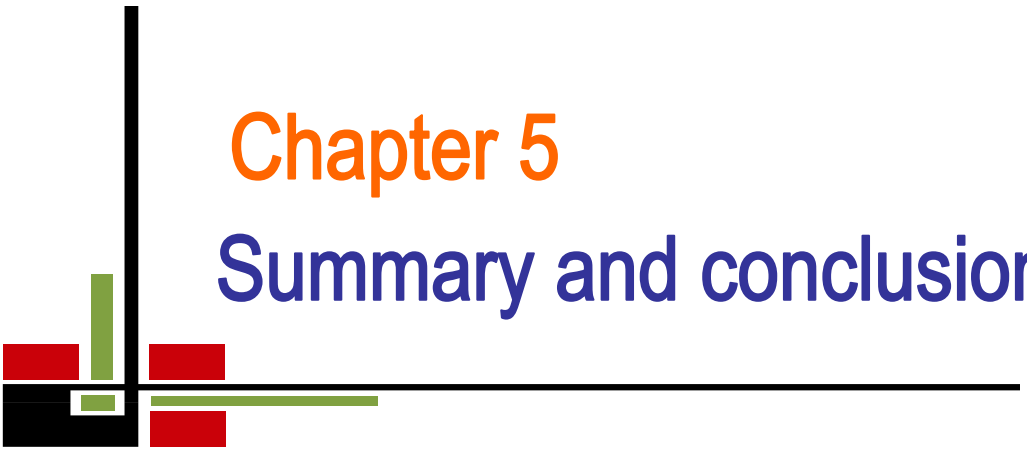
In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.
ns - non-significant, ** - significant at p≤0.01 and * - significant at p≤0.05.

Table 9. Combined effects of variety and harvesting time on flesh colour of potato

Treatment combination		Flesh colour				
Variety	**Harvesting at**	**L***	**a***	**b***	**Chroma**	**Hue Angle**
Fata Pakri	**80 DAP**	73.00ab	2.03ab	39.33 a	39.31 a	1.52 ef
	90 DAP	70.97a-c	1.63a-c	33.37 b-d	33.40 e	1.52 ef
	100 DAP	70.03a-c	2.30 a	36.83 ab	36.90 b	1.51 f
	110 DAP	69.90a-c	2.16 a	35.77 ab	35.83 bc	1.51 f
Sada Pakri	**80 DAP**	71.73a-c	1.63a-c	34.03b-d	34.06 de	1.52 ef
	90 DAP	72.03a-c	1.93 ab	35.33a-c	35.38 c	1.52 ef
	100 DAP	74.17 a	1.63a-c	34.67a-c	34.70 cd	1.52 ef
	110 DAP	72.93 ab	1.56a-c	35.03a-c	35.06 cd	1.53 de
Rumana	**80 DAP**	68.97 bc	1.00a-d	30.27c-f	30.28 g	1.54 cd
	90 DAP	68.63 bc	1.93 ab	31.90b-e	31.95 f	1.51 f
	100 DAP	68.37 c	0.16 d	27.60e-g	27.60 jk	1.56 ab
	110 DAP	68.20 c	0.33 cd	28.10e-g	28.10 ij	1.56 ab
BARI TPS-1	**80 DAP**	71.57a-c	0.12 d	24.10 g	25.77 l	1.57 a
	90 DAP	68.53 bc	0.76 b-d	29.50d-f	29.50 gh	1.55 bc
	100 DAP	68.50 bc	0.13 d	26.53 fg	26.52 kl	1.57 a
	110 DAP	70.43a-c	0.53 cd	28.97d-g	28.97 hi	1.55 bc
SE value		0.953	0.002	0.521	0.443	0.003
CV%		5.3	2.5	4.7	2.39	0.34
Level of Significance		**	*	*	*	*

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly.

** - significant at p≤0.01 and * - significant at p≤0.05.



Chapter 5

Summary and conclusion

CHAPTER V

SUMMARY AND CONCLUSION

In order to produce higher yield and quality potato for Bangladeshi farmers, a research was conducted to investigate the growth, yield and quality of potato varieties under different harvesting time at Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka during period from November 2013 to April 2014. Two factor experiment included 4 potato varieties viz. V_1 ('Fata Pakri'), V_2 ('Sada Pakri'), V_3 ('Rumana'), V_4 ('BARI TPS-1') and 4 harvesting time viz. H_1 (harvest at 80 DAP), H_2 (harvest at 90 DAP), H_3 (harvest at 100 DAP), H_4 (harvest at 110 DAP) was outlined in Randomized Complete Block Design (RCBD) with three replications.

The data on crop growth, yield and quality parameters like plant height, number of leaves plant^{-1}, number of stems hill^{-1} were recorded at different growth stages. Dry matter content (%) of tuber flesh, number of tubers hill^{-1}, tuber weight hill^{-1}, average weight of tuber and finally tuber yield (t ha^{-1}) were recorded after harvesting. Quality character parameters like specific gravity, total soluble solids (TSS, °brix), skin colour and flesh colour of tuber was recorded after harvesting. Collected data were statistically analyzed for the evaluation of treatments for the identification of the best variety of potato, the best harvesting time and the best combination. Summary of the results and conclusion have been described in this chapter.

Results showed that variety had significant effect on growth parameters. The rapid increase of plant height was observed from growth stages which was the tallest in the 'Fata Pakri' while the smallest in 'Rumana' at 80 DAP. Conversely, harvesting time was non-significant at 80 DAP. In combination of potato variety and

harvesting time, ‘Fata Pakri’ with 100 DAP generated the tallest plant whereas ‘Rumana’ with 80 DAP produced the shortest.

Considering the varietal characteristics, the maximum number of leaves plant^{-1} was generated by ‘BARI TPS-1’ and the minimum was produced by Roman at 80 DAP. Whereas observing the harvesting time non-significant effect was found. In combination ‘BARI TPS-1’ with 90 DAP generated the maximum number of leaves plant^{-1} while the minimum was recorded on ‘Rumana’ with 80 DAP.

Considering the varietal characteristics, the maximum number of stems hill^{-1} was generated by ‘Fata Pakri’ and the minimum number leaves were produced by ‘BARI TPS-1’ at 80 DAP. Whereas observing the harvesting time non-significant effect was found. In combination ‘Fata Pakri’ with 80 DAP produced the maximum number of stem hill^{-1} while the minimum was recorded on ‘BARI TPS-1’ irrespective of harvesting time.

Considering the varieties, ‘Sada Pakri’ produced the maximum number of tubers plot^{-1} m^{-2} and ‘BARI TPS-1’ produced the least. Whereas observing harvesting time, 110 DAP provided the maximum number of tubers plot^{-1} m^{-2} while the minimum produced by 80 DAP treatment. Conversely, ‘Sada Pakri’ harvested at 110 DAP generated the maximum number of tuber plot^{-1} m^{-2} while the minimum was recorded from ‘BARI TPS-1’ harvested at 80 DAP.

Among the varieties the maximum weight of tuber hill^{-1} was recorded in ‘BARI TPS-1’ and the minimum from ‘Rumana’. Whereas observing the harvesting time, 110 DAP generated the maximum weight of tuber hill^{-1} while the minimum was found in 80 DAP. In combination of potato variety and harvesting time, ‘BARI TPS-1’ harvested at 110 DAP produced the highest weight of tuber hill^{-1} and same variety harvested at100 DAP produced statistically similar weight of tuber hill^{-1},

whereas the lowest weight of tuber hill^{-1} was recorded in ‘Rumana’ harvested at 80 DAP.

Among the varieties, the maximum yield was recorded in ‘BARI TPS-1’ and the minimum from Roman. Whereas observing the harvesting time, 110 DAP generated the maximum yield which was statistically similar to 100 DAP treatment while the minimum was found in 80 DAP. In combination of potato variety and harvesting time, ‘BARI TPS-1’ harvested at 110 DAP attained the highest tuber yield and same variety harvested at100 DAP produced statistically similar yield; whereas the lowest yield was recorded in ‘Rumana’ harvested at 80 DAP.

Considering the varietal characteristics the maximum average weight of tuber was recorded in ‘BARI TPS-1’ and the minimum from ‘Sada Pakri’. Whereas observing the harvesting time, 110 DAP generated the maximum average weight of tuber while the minimum was in 80 DAP. In combination of potato variety and harvesting time, ‘BARI TPS-1’ harvested at 110 DAP attained the highest average weight of tuber and same variety harvested at 100 DAP produced statistically similar result; whereas the lowest average weight of tuber was recorded in ‘Rumana’ harvested at 80 DAP.

Among the varieties, ‘Sada Pakri’’ showed the maximum DM content while the minimum was from ‘BARI-TPS-1’. Whereas observing harvesting time the maximum dry matter content of tuber was recorded from 110 DAP whereas the minimum was recorded from 80 DAP. In combination ‘Sada Pakri’ tubers exhibited the maximum (22.78%) DM content harvested at 110 DAP, while ‘BARI TPS-1’ showed the minimum (15.37%) DM content at 80 DAP.

Considering the varietal characteristics, the maximum specific gravity of tuber was generated by ‘Sada Pakri’ whereas the minimum was produced by ‘BARI TPS-1’. Whereas observing the harvesting time, 100 DAP generated the maximum

specific gravity of tuber which was statistically similar to 110 DAP whereas 80 DAP produced the minimum specific gravity. In combination ‘Sada Pakri’ tubers exhibited the highest (1.079) specific gravity at 110 DAP, while ‘BARI TPS-1’ showed the lowest specific gravity (1.032) at 80 DAP at harvesting stage.

Considering the varietal characteristics ‘Fata Pakri’ tubers showed the highest total soluble solid while the lowest was recorded in ‘BARI TPS-I’. Whereas observing the harvesting time the maximum total soluble solid (TSS) of tuber was recorded from 90 DAP whereas the minimum was recorded from 80 DAP. In combination ‘Sada Pakri’ tubers exhibited the maximum TSS at 100 DAP, while ‘BARI TPS-1’ showed the minimum (5.37) TSS at 100 DAP.

Among the varieties the skin of BARI TPS-1 had the highest L* value compared to those of others whereas the lowest was observed in ‘Rumana’. Whereas observing the harvesting time there was non-significant result were found. In combination the skin of ‘BARI TPS-I’ and ‘Sada Pakri’ exhibited the maximum L* values irrespective of all harvest time. The skin of ‘Rumana’ was characterized by the highest a* value at 80 DAP, while the lowest was ‘BARI TPS-1’ at 100 DAP. ‘BARI TPS-1’ produced the maximum b*, chroma and hue angle value while the lowest recorded on ‘Rumana’ and ‘Fata Pakri’ irrespective of all harvest time.

Among four varieties, the flesh of ‘Fata Pakri’ and ‘Sada Pakri’ had L* values that were significantly higher than the values of others. ‘Fata Pakri’ was characterized by a higher a*, b* and chroma value whereas ‘BARI TPS-1’ showed lower a*, b* and chroma value. In case of hue angle the highest hue angle value recorded from ‘BARI TPS-1’ whereas lowest was recorded from ‘Fata Pakri’ and ‘Sada Pakri’. Whereas observing the harvesting time there was non-significant result were found. In combination ‘Sada Pakri’ showed the highest L* value for flesh when harvested at 90 DAP, whereas, the lowest was recorded in ‘Rumana’ irrespective

of harvest dates. ‘Fata Pakri’ and ‘Sada Pakri’ demonstrated higher a* values irrespective of all harvested dates and ‘Rumana’ showed similar results at earlier harvesting time whereas, ‘BARI TPS-1’ was characterized by lower a* values (<0.8) irrespective of all harvesting times. Among the treatment combinations, ‘Fata Pakri’ and ‘Sada Pakri’ exhibited dark yellow color flesh and ‘Rumana’ and ‘BARI TPS-1’ displayed light yellow color flesh irrespective of all harvesting dates. In case of chroma value ‘Fata Pakri’ harvested at 80 DAP recorded the highest chroma value while ‘BARI TPS-1’ produced lowest value. On the other hand ‘BARI TPS-1’ harvested at 80 DAP produced the highest hue angle value while ‘Fata Pakri’ harvested at 100 DAP and 110 DAP produced the lowest value.

Considering the results of the present experiment, it may conclude that harvesting time had potential effect on tuber maturation and finally on specific gravity, dry matter content and tuber color. The findings revealed that though ‘SadaPakri’, ‘Fata Pakri’ and ‘Rumana’ produced lower yields than ‘BARI TPS-1’ but these local cultivars may be good for processing industry because of their more than 1.07 and 20% specific gravity and dry matter content respectively. These also displayed acceptable flesh color when harvested at 100-110 DAP.

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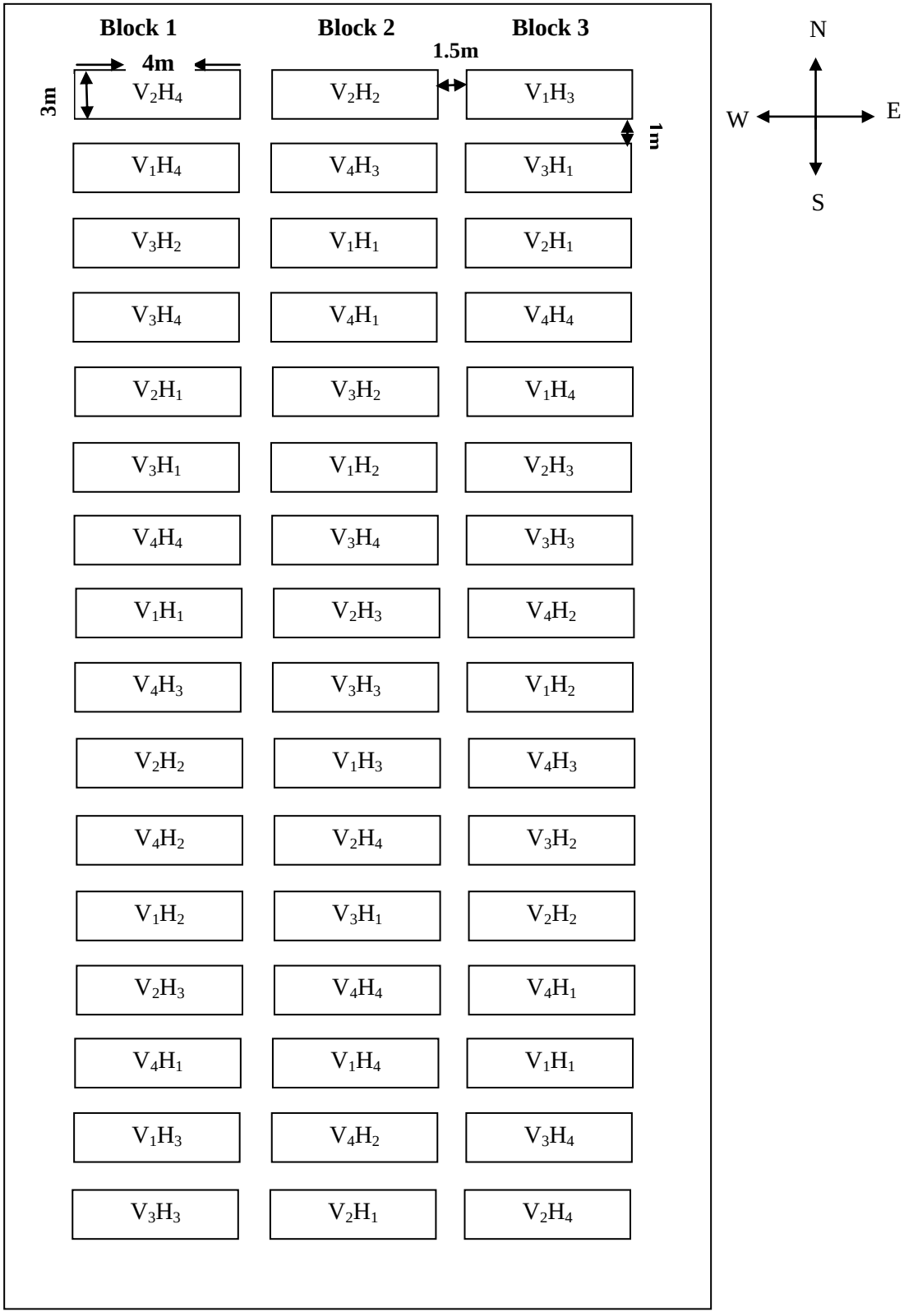
Appendices

APPENDICES

Appendix I. Layout of experiment



Appendix II. Analysis of variance of the data related to growth of potato plant

Source of Variation	Degrees of freedom (df)	Mean Square for		
		Plant height	Number of leaves plant^{-1}	Number of stem hill^{-1}
Factor A	3	893.455**	67.410**	8.389**
Factor B	3	7.047ns	0.354ns	0.056ns
Interaction (A x B)	9	10.994*	4.188*	0.185*
Error	30	23.246	2.924	0.413

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

Appendix III. Analysis of variance of the data related to growth of potato plant

Source of Variation	Degrees of freedom (df)	Mean Square for			
		Number of tubers plot^{-1} m^{-2}	Tuber weight hill^{-1}	Yield of tuber (t ha^{-1})	Average tuber weight (g)
Factor A	3	538108.111**	31500.390**	23.71**	913.13**
Factor B	3	16282.444*	9925.726**	74.24**	125.72**
Interaction (A x B)	9	335.185**	528.557**	1.06*	1.34**
Error	30	664.610	397.367	0.68	1.587

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

Appendix IV. Analysis of variance of the data related to quality of tuber

Source of Variation	Degrees of freedom (df)	Mean Square for		
		Dry matter content (%)	Specific gravity	TSS (°brix)
Factor A	3	7.783**	0.002**	0.005**
Factor B	3	0.13*	0.003	0.002ns
Interaction (A x B)	9	0.373**	0.001*	0.002*
Error	30	0.735	0.001	0.001

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

Appendix V. Analysis of variance of the data related to quality (colour) of tuber

Source of Variation	Degrees of freedom (df)	Mean Square for				
		L^*	a^*	b^*	Chroma	Hue Angle
Factor A	3	9.743**	0.002**	0.005**	206.973**	0.005**
Factor B	3	0.188ns	0.003ns	0.002ns	2.935ns	0.001**
Interaction (A x B)	9	0.263*	0.001*	0.001*	12.742**	0.001**
Error	30	0.375	0.001	0.001	0.588	0.001

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