EVALUATION AND SELECTION OF BARI DEVELOPED POTATO VARIETIES FOR KHULNA REGION ON THE BASIS OF THEIR GROWTH AND YIELD CHARACTERISTICS

A THESIS

BY

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(STUDENT ID: MS-200814)

MASTER OF SCIENCE

IN

HORTICULTURE

AGROTECHNOLOGY DISCIPLINE

LIFE SCIENCE SCHOOL

KHULNA UNIVERSITY

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KHULNA, BANGLADESH

MAY, 2023

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ABSTRACT

A field experiments was conducted at the Germplasm Centre of Agrotechnology Discipline, Khulna University, Khulna during November 2020 to March 2021 to evaluate and select BARI developed potato varieties on the basis of their growth and yield characteristics. The experiment was conducted on ten potato varieties viz. BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-56, BARI Alu-62, and BARI Alu-63 in a Completely Randomized Block Design with three replications. Data were recorded on different growth parameters and yield parameters. The growth and yield components varied significantly among the varieties except number of plant plot^{-1}, number of leaves plant^{-1} and potato eye depth. Results revealed that less time was required for sprouting (12.67 day) in BARI Alu-63. The highest number of sprouting (75) was found in BARI Alu-37. The highest plant height (98.17 cm) was found in BARI Alu-36 which was statistically similar to BARI Alu-40 (97.72 cm) and BARI Alu-37 (96.33 cm). The highest leaf length and leaf breadth was recorded in BARI Alu-37 i.e. 25 cm and 11.91 cm respectively. Maximum number of tubers per plot (777.0), tuber yield (18.86 ton h^{-1}), tuber shape index (1.49), dry matter content (26.00) and Specific gravity (1.32) was found in BARI Alu-47, BARI Alu-40, BARI Alu-37, BARI Alu-48 and BARI Alu-47 respectively. Disease incidence was the highest in the plot of BARI Alu-48 (91.28%) which was statistically similar to BARI Alu-41 (91.14%) and BARI Alu-37 (88.23%). Number of infected tubers and weight of infected tubers were highest in BARI Alu-63 which was 43.74% of total tubers and 23.2% of total yield respectively. It could be concluded that BARI Alu-40 produced the highest yield and number of tubers with least disease incidence. Therefore BARI Alu-40 may be selected for commercial cultivation in Khulna region.

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The Author

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The potato (*Solanum tuberosum L.*) - the king of vegetable - is a starchy, tuberous herbaceous annual of the genus Solanum under Solanaceae or Nightshade family and to the large and diversified genus Solanum. It is considered as the most important root and tuber crop worldwide (Mekashaw et al., 2020). Potato occupies a wide eco-geographical range and is unique among the major world food crops in producing stolon (underground stems), which under suitable environmental conditions swell to form tubers (Namugga, 2017). First cultivation of potato was started in the vicinity of Lake Titicaca near the present border of Peru and Bolivia (Hafiz, 2015).

Being the world's fourth largest food crop after maize, wheat and rice, it contributes substantially in the world's caloric intake contributing around 2% of the world's dietary energy supply (Thapa and Thapa, 2019). It is grown in more than 125 countries and more than a billion of people consumed potato daily. Hundreds of millions of people in developing countries depend on potatoes for their survival (Lutaladio et al., 2009).

Potato was introduced in this subcontinent in the sixteenth century. That time it was grown in small plots as a vegetable. Potatoes have been grown in Bangladesh since at least the 19th century. By the 1920s, the first commercial production of the crop was established in the country (Mukul et al., 2013).

Potato has very good nutritional importance and it can produce more energy and protein per unit area per unit time than most other major food crops; it is fat-free and contains substantial amounts of minerals. The crop is also rich in several micronutrients and vitamins, especially vitamin C; a single medium sized potato of 150 g provides nearly half of the daily adult

CHAPTER II

REVIEW OF LITERATURE

2.1 Introduction

Potato (Solanum tuberosum) is one of the world's major staple crops and a leading agricultural crop in Bangladesh. Its importance is increasing as a vital food-security crop as well as a suitable alternative to costly imported cereals. There are many popular potato varieties in cultivation. Growth and yield attributes of potato vary from variety to variety. Researchers have done many varietal evaluations of potato in respect of growth and yield performance. Evaluation of potato germplasm is needed for selection of suitable variety for continuous production. So, there is a need to evaluate germplasm to find out the suitable group for higher yield (Rakibuzzaman et al., 2021).

A number of studies related to performance on the different potato varieties have so far been conducted. A brief review of the literature available in Bangladesh and elsewhere related to varietal performance is discussed below:

2.2 Growth attributes of potato varieties

2.2.1 Sprouting time

Sprouting is a complex process that depends mainly on genetic background and some other environmental factors (Mani and Hannachi, 2015). They found significant variation in case of time required for sprouting of different potato varieties. They describe the effect of cytokinin, gibberellins and ABA on sprouting time and stated that cytokinin and gibberellins promote sprout growth whereas ABA and ethylene tends to suppress sprouting.

Other review from Belay et al. (2022) found the ability of essential oils on sprouting time depending on potato varieties and they claimed that the rate of sprouting varied between potato varieties may be result of their genetic variation. Whereas Islam et al. (2017) found no significant variation in days required for 80% emergence while working with six potato varieties. The time required for emergence ranged between 17.3 to 19.7 days.

2.2.2 Number of sprouts

Hampson (1991) stated apical dominance plays an important role in determining the number of sprouts produced per tuber and found a high degree of variation between varieties and seasons. Maris Piper, Pentland Javelin and Arran Pilot produced four or more sprouts per tuber, whereas highest two eyes per tuber was observed for King Edward and Record. These differences in the average numbers of sprouts produced by the tubers of varieties can be accounted for only in part by different mean tuber sizes and number of eyes per tuber.

Belay et al. (2022) conducted an experiment on effects of essential oils on potato tuber sprouting. They found that commencement of tuber sprouting depends on potato varieties and sources of essential oils used. Essential oils quantities and frequencies affect the number of sprouts.

Mishra et al. (2019) found considerable range of variation in tuber sprouting among 33 varieties of potato. In their study, the percentage ranged from 56.17 to 74.34.

While working with different potato cultivars (Frieslander, Marfona and Sante) Otroshy and Struik (2010) found a highly significant effect of tuber, growth regulator and cultivar on the sprouting behavior. Frieslander produced higher number of sprouts and also more weight of sprouts than other cultivars. In case of number of sprouts the effects of the tuber size and GA were all significant.

2.2.3 Number of plants

A study was undertaken by Islam et al. (2017) on field performance of six NSB-released table purpose modern potato varieties (BARI Alu-7, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-53 and BARI Alu-77) at Debiganj Station of Advanced Seed Research and Biotech Centre (ASRBC). They found variation in the number of stem hill^{-1} which varied from 8.5 (BARI Alu-77) to 4.1 (BARI Alu-53) among six potato varieties.

Another experiment was conducted by Fantaw et al. (2019) where they investigated the performance of different varieties of potatoes for yield and its components using two improved varieties and one local variety. They reported a significant influence of potato varieties on number of stems plant^{-1} which vary between 3.32 to 5.85.

Mishra et al. (2019) found same varietal difference in case of number of shoots among 33 potato varieties. According to their report the number of shoots varied from 4.75 to 8.49 per plant.

Eaton et al. (2017) found no significant variation in case of the number of stems hill^{-1} among the varieties experimented on six modern varieties of potatoes (Diamant, Cardinal, Granola, Felsina, Provento and Asterix) to evaluate their yield and plant growth parameters. However, the number of stems hill^{-1} ranged from 4.67 to 6.17 among the varieties.

Haverkort (2018) depicts relationship between tuber size and the number of eyes with the number of plants. According to him, four sprouting eyes give rise to the formation of four stems plant^{-1} on average. He also claimed that this number is lower when very small tubers of less than 20 g are used and higher when large tubers over 100 g are planted.

Along with genetic factors of the varieties Eaton et al. (2017) and Tessema et al. (2020) claimed that seed tuber size, environmental variations and agronomic practices viz. mother tuber size, plant spacing also had a significant influence on number of stems hill^{-1}.

2.2.4 Height of plants

Plant height is such a genetic character that enabled them to took energetic start and absorbed more food resources in form of mineral nutrients, moisture and solar radiations during early and entire growing season and resulted more height (Khan et al., 2019).

Michael et al. (2020) claimed that there has been a relationship between plant height, branching and canopy coverage of potato plant. Taller plants produce more branch leading to greater canopy cover. The influence of each other's pathway to yield rely on the strength or correlation among them and their individual direct effect on yield.

Eaton et al. (2017) found significant variations among the potato varieties in respect of plant height. Asterix and Diamant produced the tallest plants (61.33 and 59 cm respectively) where Granola produced the shortest plants (51.17 cm). He explained the difference in plant height among the varieties as a varietal characteristic, which is greatly influenced by the physiological state of seed tubers and use of either cut or whole tubers as planting material.

Islam et al. (2017) found significant variation among the varieties in yield components and yield. They found longest plant in BARI Alu-53 (99.0 cm) and the shortest plants in BARI Alu-77 (49 cm). They stated that, the height of plant is basically a varietal character, which is influenced by growing environment and crop management practices. In their experiment, since all six varieties were grown under the same environmental conditions and production practices, they explained the variation among the varieties in plant height in the light of varietal characteristics of potato, taking varietal responses to growing environment under consideration.

Jafar et al. (2020) conducted an experiment to identify adaptable, high yielding and diseases and pest tolerant varieties from eight potato varieties (Bubu, Gudanie, Dagim, Jalenie, Horro Marachere, Belete and Gorobela) based on agronomic data and farmers preferences toward the varieties. They found significant difference on height of plant. The highest plant height (76.92cm) was recorded from Bubu while the lowest plant height (44.87cm) was recorded from Dagim. They stated that differences in plant height among the varieties may be caused by genetic variations, which may result variable performances in growth and development.

An experiment comprising of 11 exotic genotypes of potatoes were evaluated for yield and baking quality traits. They found, CIP28 genotype produced maximum plant height (70.00 cm) and minimum in CIP8 (31.60 cm). They presumed that the differences in plant height among various genotypes may be due to combined effects of plant genetics, nutrient status of soil and agro-environmental conditions, under which the plants were grown (Khan et al. 2019).

2.2.5 Number of leaves

Mishra et al. (2019) found considerable variation in number of leaves among 33 varieties while Tessema et al. (2020) found the number of leaves per plant as expected, as genotypes typically differ genetically in their growth habits. Fender et al. (2011) claimed that the number of leaves is affected by soil moisture and nitrogen supply, and the interaction of these factors, and also by the prevailing saturation deficit of the air.

From an experiment of Haque et al. (2015), significant variation was found in number of leaves $plant^{-1}$ among potato germplasm. They found maximum number of leaves in Jam alu (167.3) and minimum number of leaves found in Courage (26.67).

In another experiment by Khan et al. (2013), variation was found in case of number of leaves per hill in potato germplasm and found it varied from 75 to 126 within different germplasm.

2.2.6 Length of leaves

Leaf length and leaf breadth are related to leaf area of a plant (He et al., 2020). Leaf area of a plant has relationship with the photosynthesis potential of a crop by increase in absorption of solar radiation (Struik, 2007). White (2007) claimed that a higher photosynthesis potential increases the synthesis and accumulation of reserve carbohydrates in the potato tuber which has a direct effect on the final yield of potato tuber.

From an experiment by Mishra et al. (2019), they observed that the length of leaf varied among varieties which ranged from 18.17 cm to 23.75 cm.

2.2.7 Breadth of leaves

Mishra et al. (2019) conducted an experiment and found variation in case of width of leaf which varied from 10.57 to 22.29 cm.

2.3 Yield attributes of potato varieties

2.3.1 Number of tubers plot^{-1}

Number of tuber plant^{-1} is a genetic attribute mainly. High-yield cultivars of potato plant develop larger tuber clusters (Bernik et al., 2015). Khan et al. (2019) claimed that the difference in number of tubers per plant depends on genetic makeup of plant, canopy development and environmental conditions.

Subarta and Upadhya, (1997); Gebreselassie et al. (2016) suggests that the number of tubers plot^{-1} will depend mainly on the number of stems per plot, total number of stolons and stolons which tuberize. In this case, both genetic and environmental factors play a vital role in stolon development and tuberization process. The difference in tuber number might be due to varietal character and growing environmental factors.

Islam et al. (2017) conducted a study on six potato varieties and recorded the number of tubers per hill at harvest. They reported that number of tubers per hill showed a significant variation and ranged from 12.1 (BARI Alu-53) to 18.5 (BARI Alu-41). They also stated that number of tubers per hill is a varietal characteristic in potato, and is considerably influenced by growing environment and production practices.

Eaton et al. (2017) also found significant differences in the number of tubers per hill among six varieties of potatoes. Asterix, produced the greatest number of stems hill^{-1} (13 tubers hill^{-1}) where Felsina produced the lowest (8.67 tubers hill^{-1}).

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

Yield differences among genotypes attributed both by the inherent yield potential of genotypes and growing environment as well as the interaction of genotype x environment (Asmamawu, 2007; Gebreselassie et al. 2016 and Tekalign, 2011).

Alam et al. (2003) depict that, large number of leaves and stems results highest yield which caused by deposition of greater amount of photosynthates and ultimately maximize the yield.

Amanullah et al. (2010) conducted an experiment to evaluate the effect of different irrigation regimes on the yield and yield contributing characters of four high yielding potato varieties (Binella, Cardinal, Chamak and Heera). Based on their study, they concluded that under the different irrigation regimes potato variety show yield differences where they found that Chamak is superior than other variety in respect of tuber yield.

Eaton et al. (2017) experimented on some potato varieties and found significant variations in yield of tuber ha^{-1} among the varieties investigated in their experiment. yield varied from 29.60 t ha^{-1} to 25.13 t ha^{-1} among all varieties. According to them differences in the yield among varieties might be caused by the genetics, the quality of the potato seed, or to better adaptability of the variety to the climatic conditions of the experimental site.

Islam et al. (2017) observed statistically significant variation among six varieties of potatoes in terms of yield (tubers plot^{-1}) recorded at harvest which ranged between 115 to 142 kg plot^{-1} (36 m^2). The variety BARI Alu-40 gave the highest yield of tubers per plot. The estimated yield of tubers of six varieties from the per plot yield data, ranged between 31.9 to 39.4 Mt ha^{-1}.

Michael et al. (2020) conducted a study on five potato varieties and observed significant differences among them in terms of the number and weight of marketable tuber yield. They claimed that the high yield among varieties may be correlated with the wide canopies and the leaf area of the variety

Jafar et al. (2020) found significant differences among their experimented potato varieties for marketable, unmarketable, and total tuber yield attributes.

Eaton et al. (2017) found differences, in the percentage of different grades regarding to yield among the experimented potato varieties. He added that variation in the percentage of grades might be due to the adaptability of the variety to the climatic conditions of the experimental site, the genetics of the variety or the quality of the potato seed.

2.3.3 Tuber shape index

Precise determination of potato tubers shape and variability existing among individual potato varieties is necessary (e.g. for modeling of handling and transport processes).

Tuber shape is control by large number of characters, which determine the ration between length and width (Khan et al., 2019). Sharma and Sarjeet (2009) claimed that tuber shape is a varietal character which is affected by vigor of plants and their adaptability

Bubeníčková and Simeonovová (2011), carried out an experiment to determine contour and shape characteristics of ten potato varieties. They found significant differences on tuber shape index. They claimed that this difference may be due to genetic variability among the varieties as length and width of the potato tubers depends on their genetic constitution.

Akhter et al. (1994) and Alam et al. (2003) found same varietal difference in case of potato shape from their respective experiments.

2.3.4 Tuber color

Skin color of potatoes along with some other external quality traits, are crucial aspects for consumers, because they are immediately obvious during the purchase (Werij, 2011). Skin color of potatoes is affected by or controlled by numbers of genetic factors (Khan et al., 2019).

Khan et al. (2019) laid out an experiment to evaluate yield and baking quality traits of 11 exotic genotypes based on yields and phenotypic quality traits. In their study, they observed different tuber skin color (yellow to light yellow color, red and brown color) which varied variety wise.

Rahman et al. (2021) also found different skin color for different variety in their experiment. They observed red skin color in BARI Alu-36, BARI Alu-41, BARI Alu-72, BARI Alu-78 and BARI Alu-79, other varieties were yellow in color. Where Islam et al. (2017) found red and white-skinned potato varieties among the selected varieties.

Similarly, varietal differentiation on the basis of tuber skin color of potatoes and its association with other quality parameters has also been reported Akhter et al. (1994) and Alam et al. (2003).

2.3.5 Skin type of tubers

Rahman et al. (2017) conducted an experiment to evaluate different physical and other quality attributes for processing industry among 40 potato varieties. They found varietal differences in case of skin type of tubers.

Arifa et al. (2018) worked with 42 potato genotypes for yield and phenotypic quality traits under subtropical climate to select the best genotype for the processing industry. From their experiment, they found that, in case of skin type of tubers, all the genotypes produced smooth skin tubers.

2.3.6 Dry matter content of tubers

In potato quality parameters, the specific gravity is very important because it shows the dry matter or solid contents of potatoes (khan et al., 2019). This quality traits significantly influenced by both variety and growing environment (Abebe et al., 2012; Tessema et al., 2020; Arslanović-Lukač et al., 2021). Whereas, Abbas et al. (2011) also elucidated that tuber dry matter content is a strong genetically governed characteristic and differs significantly among cultivars.

According to Abebe et al. (2012), a potentially high yielding variety will yield to its highest capacity if suitable environment is provided. They reported the significant effect of genotype and interactions among location, genotype and environment on dry matter content of 25 potato varieties.

2.3.7 Specific gravity of tubers

With regard to potato specific gravity, effects of both variety and locations were found highly significant by Tai and Coleman (1999), Tessema et al. (2020) and Rahman et al. (2017).

Tessema et al. (2020) stated that good quality potatoes should have a specific gravity value of more than 1.080 and values less than 1.070 are generally unacceptable for processing.

Abbas et al. (2011), conducted an experiment on different potato varieties where he observed that specific gravity varied with respect to genotypes. In their experiment specific gravity ranged from 1.0343 - 1.1443. They claimed that differences in specific gravity among the varieties could be due to differences in range of diameter and mass.

2.3.8 Number of eyes tuber^{-1}

Khan et al. (2019) found significant difference in case of number of eyes per tuber while experimenting with 11 exotic genotypes. The number ranges between 4 to 7 eyes per tuber.

Rahman et al. (2017) reported same varietal differences in case of number of eyes per tubers where the mean number of eyes per tuber ranged from 3 to 7.6.

2.3.9 Tuber shape

Rahman et al. (2021) conducted a study on field performance of ten potato varieties (BARI Alu-36, BARI Alu-37, BARI Alu-40, BARI Alu-41, BARI Alu-72, BARI Alu-73, BARI Alu-78, BARI Alu-79 and BARI Alu-81) under different saline stress conditions of the coastal areas of Bangladesh. They showed great diversity in shape of the potato tubers of varieties in their study. They reported that, BARI Alu-40, BARI Alu-41, BARI Alu-72 and BARI Alu-78 were round while BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-73, BARI Alu-79 and BARI Alu-81 produced oval shape tuber.

Khan et al. (2019) found difference in the shape of potato tuber of different potato variety. They claimed that, tuber shape of potatoes is control by genotypes of the variety. In their observation shape of potato differs round to oblong, oval etc.

Shrestha et al. (2020) found varietal effect on the shape of tuber, while conducting an experiment on different potato varieties.

2.3.10 Depth of eyes of tubers

Depth of tubers is an important attribute in respect of consumer preferences and for processing industry. Tubers with medium to large size, and shallow eyes are the most preferred by processors because of low losses during peeling (Shrestha et al., 2020).

Rahman et al. (2017) and Shrestha et al. (2020) analyzed twenty and five genotypes of potatoes respectively to evaluate physical characteristics and varietal performances. in case of depth of eyes of tubers both found significant differences.

2.3.11 Disease incidence (%) of plants

Several studied had been conducted at different time to identify disease tolerant potato varieties. In this purpose Eaton et al. (2017) conducted an experiment on different potato varieties and they found difference in disease susceptibility among the varieties. From the investigation they recommended the farmers in Bangladesh to grow Asterix for its high yield and resistance to diseases and insects.

In another experiment of Bittara et al. (2016), they tried to assess susceptibility differences among genotypes (30 potato cultivars and 83 advanced clones) to evaluate them for powdery scab and root gall formation. In the results presented in their study they depicted the relative levels of susceptibility among potato genotypes and demonstrate the existence of resistance in some potato genotypes

With same intension of identify and select adaptable, high yielding and diseases and pest tolerant potato varieties same Jafar et al. (2020) conducted an experiment where they considered disease reaction as one of the top most important selection criteria. Result was that they found some varieties (Dagim, Gorobela and Horro) which were highly susceptible to late blight disease and some varieties (Belete, Bubu and Marachere) resistant reaction against the disease.

2.3.12 Weight of infected tubers (%)

Diseases cause a great loss of potato tuber yield. While conducting an experiment, Jafar et al. (2020) recorded maximum marketable yield from Belete variety (39.32t ha^{-1}) and lowest from Dagim variety (9.36t ha^{-1}). They blamed for lowest yield in Dagim variety to its susceptibility to late blight diseases.

From the above review of literature, it could be said that the works on the evaluation of BARI developed potato varieties in Khulna region is meager. For this instance, the present study was undertaken to compare and select some BARI developed potato varieties based on their growth and yield attributes.

CHAPTER III

MATERIALS AND METHODS

This chapter includes all the required information about the materials and methods that were used in conducting the experiment during the period from December 2020 to April 2021 with the following headings and subheading.

3.1 Study area

The study was carried out at the Germplasm Center of Agrotechnology Discipline, Khulna University, Khulna, Bangladesh. The area is located in the Agroecological Zone (AEZ) 13. The site is located at 22°50' North latitudes and 89°33' East longitudes at an altitude of 8 meters above the sea level (UNDP, 1988).

3.2 Soil

The area belongs to the Ganges flood plain (AEZ-13), soil is clay loam in texture having low organic matter (1.12%) moderately slow permeability and deficient in nitrogen, potassium and sulphur in comparison with the standard nutrient status. The soil is somewhat saline in nature having pH between 6.5 to 8.5.

3.3 Experimental design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

3.4 Plant material used

In this study a total of 10 varieties of potato developed by Bangladesh Agricultural Research Institute (BARI) were evaluated. The experimental material was provided by the On-Farm Research Division, BARI, Khulna.

3.5. Treatments

The following ten BARI developed potato varieties were taken as treatment in the field to assess their respective performance

1. T_1: BARI Alu-36
2. T_2: BARI Alu-37
3. T_3: BARI Alu-40
4. T_4: BARI Alu-41
5. T_5: BARI Alu-47
6. T_6: BARI Alu-48
7. T_7: BARI Alu-49
8. T_8: BARI Alu-56
9. T_9: BARI Alu-62
10. T_{10}: BARI Alu-63

Replication: 3

Total plot = 10×3 = 30

3.6 Land preparation

A piece of medium highland was selected at the germplasm centre of Agrotechnology Discipline, Khulna University, Khulna. The soil of the plots was prepared 15 days before sowing by ploughing with power tiller followed by laddering. Plant parts, inert materials, visible insect pests were eliminated from the soil and cow dung was incorporated to the soil. The field was then divided into blocks and unit plots.

3.7 Layout of field experiment

Thirty plots of 10 varieties with 3 replications were used to carry out the experiment. Each plot was 3.5 meter in length and 2 meter in width. All the treatments were allocated completely at random to the blocks. Medium sized potato tubers weighing 40-50 gm was used and spaced at 60 cm apart between rows and 20 cm between plants. The block to block distance was 1.5 meter and plot to plot distance was 0.5 meter.

3.8 Fertilizers and its application

Fertilizer rate as recommended by BARI were applied in a rate of Urea-350 kg ha^{-1}, TSP-220 kg ha^{-1}, MoP- 250 kg ha^{-1}, gypsum-120 kg ha^{-1}, $ZnSO_4$-10 kg $ha^{-1}$and Cow dung- 10 ton ha^{-1}. Cow dung and $ZnSO_4$ was applied during the final land preparation. Half of urea, total TSP, MoP and gypsum were applied during planting. The rest was added 30 days after planting (Anonymous, 2017).

Table 1. Name of fertilizers, amount and timing of application

Fertilizers/ Manures	Application rate	Time of application
Cow dung	10 ton ha^{-1}	During land preparation, 15 days before sowing
Urea	350 kg ha^{-1}	Half of urea during final land preparation and rest of the urea during 30 days after planting
TSP	220 kg ha^{-1}	During the final land preparation
MoP	250 kg ha^{-1}	During the final land preparation
Gypsum	120 kg ha^{-1}	During the final land preparation
$ZnSO_4$	10 kg ha^{-1}	During the final land preparation

3.9 Intercultural operations

The following intercultural operations were done for better growth and development of the plants during the periods of experiment.

3.9.1 Weeding and mulching

Weeding and mulching were done as and when necessary to keep the plants free from weeds, for better soil aeration and to break the crust. It also preserved the soil moisture.

3.9.2 Irrigation

Light irrigation was given just after sowing for better germination. Irrigation was done at 25 and 40 days after emergence and once during tuber development stage (Anonymous, 2017).

3.9.3 Earthing up

For earthing up, potato shoots were mounded around with soil. Earthing up was done at 30 and 60 days after planting.

3.9.4 Insect pest control

Dithane M-45 was sprayed at the rate of 2g/L at 10 days interval during the foggy weather.

3.9.5 Humpulling

Humpulling is the removal of above ground plant parts and this was done 10 days before tuber collection.

3.9.6 Curing

Curing was done by keeping the tubers below ground for ten days after humpulling. It was done for tightening the tuber skin.

3.9.7 Harvesting

Harvesting was done carefully at 95 days after planting with the help of a spade. It was done carefully so that no injury could happen.

3.9.8 Sorting and grading

Diseased, injured and green tubers were sort out carefully, to keep the other healthy tubers free from infestation. The healthy tubers then divided into three grades according to their weight. Grade-1 contained tubers that were equal or more than $\geq$75g, grade-2 contained tubers of 40-75g and grade-3 contained tubers less than $\leq$40g.

3.10 Data Collection

From the experiment, data were collected on the basis of plant growth parameters, yield and yield contributing characters. Following observations were recorded during the experimental period.

3.10.1 Time required for completion of sprouting

The time between first and last date of sprouting was recorded for each of the variety.

3.10.2 Number of sprouting per plot

Total number of sprouts per plot was recorded at 10 days interval from day to emergence up to completion. And after completion of emergence the total sprout per plot was counted as final.

3.10.3 Number of plants per plot

Number of plants per plot was recorded at 15 days interval manually up to maturity.

3.10.4 Plant height

Plant height was taken from randomly selected six plants from each plot and measured from the soil surface to the top-most growing point of plants at physiological maturity time and the mean value was noted in centimeter (cm).

3.10.5 Number of leaves plant^{-1}

To count the number of leaves plant^{-1}, six plants of each plot were selected randomly from each replication and their leaves were counted and then averaged up to 60 days after emergence at 15 days interval.

3.10.6 Length of leaf

Length of leaf was measured from the base of the petiole to the tip of the leaf with a scale and was recorded in centimeter at 15, 30, 45 and 60 days after emergence.

3.10.7 Breadth of Leaf

Breadth of the leaf was measured at the widest part of the leaf by a meter scale and was expressed in centimeter at 15, 30, 45 and 60 day after emergence.

3.10.8 Number of tubers plot^{-1}

Tuber number plot^{-1} was recorded as the actual number of tubers collected from net plot area at the time of harvesting.

3.10.9 Weight of tubers plot^{-1}

Weight of tubers (kg plot^{-1}) was recorded by measuring all the tubers of each plot with the help of an electric balance. Considering the weight of tubers, yield samples of each varieties was graded into three groups. The tubers were categorized as large (>75g); medium (39-75g) and small (<39g) and the proportion of these groups of tubers were calculated in percentage (Gebreselassie et al., 2016).

3.10.10 Length of tuber

For the measurement of tuber size of each replication, six tubers from each of the three-tuber grade were selected randomly and their tuber size were measured with the help of slide calipers in centimeter from top to bottom of the tuber. Then the averaged value was recorded.

3.10.11 Breadth of tuber

To measure the breadth of tuber for each replication, six tubers from each of the three-tuber grade were selected randomly and their breadth was measured with slide calipers in centimeter (cm) at the middle portion of the tuber. Then the averaged value was recorded.

3.10.12 Shape index of tuber

Shape index of potato tuber was measured by using the following formula:

Tuber shape index = Length of tuber/ Breadth of tuber

3.10.13 Color of tubers

For tuber skin color, six tubers of each variety of each replication were observed carefully and their skin color was noted.

3.10.14 Skin type of tuber

Based on tuber skin characteristics (smooth or uneven) six tubers from each plot were observed carefully and their skin type was noted.

3.10.15 Number of eyes tuber^{-1}

Six tubers from each plot were observed visually and counted. Then their average eye number was recorded.

3.10.16 Depth of eyes of tuber

For eye depth of tuber, six tubers from each variety of each replication were measured carefully and their eye depth was noted.

3.10.17 Dry matter content of tuber (%)

Dry matter content of tuber was recorded by taking the fresh weight of tubers from six tubers of each plot at the time of harvesting. Then the tubers were sliced into small pieces and oven dried for 80°C for 72 hours. The dry weight was then measured using an electric balance and recorded in gram (g).

Dry matter (%) = (dry weight/fresh weight) × 100

3.10.18 Specific gravity of tubers

Specific gravity was measured with the weight-in-air/weight in water method (Sinha et al., 1992). Formula used for measuring specific gravity of tubers is:

Specific gravity = (weight in air)/ (weight in air – weight in water)

3.10.19 Disease incidence (%) of plant

Disease incidence of potato plant was measured by using the following formula:

Disease incidence = (number of infected plants × 100) / (number of total plant)

3.10.20 Number of infected tubers plot^{-1} (%)

The following formula was used to calculate the percentage of infected tubers.

Total number of infected tubers = (number of infected tuber plot^{-1}/ total number of tubersplot^{-1}) × 100

3.10.21 Weight of infected tuber (%)

Total weight of infested tubers (%) per plot of each variety from each replication were measured and noted by using the following formula

Weight of infested tuber (%) = (Weight of infested tuber per plot/weight of total tuber per plot) × 100

3.11 Data analysis

The data of growth, yield and yield contributing characters were statistically analyzed for ANOVA to find out the significance of the experimental results. Collected data on various parameters under study were statistically analyzed using Statistix-10 software. Significance of differences among treatment means were evaluated by Duncan's New Multiple Range test (DMRT) (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter includes the presentation and discussion of the performances of ten BARI developed potato varieties in accordance with their growth and yield characteristics. The results are presented in tables and the discussion has been made under the following subheadings.

4.1 Growth attributes of potato varieties

4.1.1 Sprouting time

The variation of time required for completion of sprouting was statistically significant (Appendix I). BARI Alu-37 required longest time (17 days) for the completion of sprouting followed by BARI Alu-48 (16.33 days) and BARI Alu-56 (16.33 days). BARI Alu-41 required the shortest time (8.00 days) preceded by BARI Alu-40 (11.33 days) and BARI Alu-47 (12.33 days).

The result of the present study was in agreement with those of Mani and Hannachi (2015) and Belay et al. (2022). They found that the time of sprouting of potato tubers varied between potato varieties and responsible genetic background of the varieties and some environmental factors. In another study, Islam et al. (2017) found no significant differences in time required for 80% emergence but for first emergence while working with six potato varieties.

4.1.2 Number of sprouts plot $^{-1}$

From the experiment, it was observed that the variation in number of sprouts per plot of different potato variety was statistically significant (Appendix I). The highest number of sprouting (75.00) was recorded from of BARI Alu-37 and the lowest number of sprouts was found in BARI Alu-40 (61.67) (Table 2). This result was supported by the findings of Hampson

(1991), Belay et al. (2022), Mishra et al. (2019) and Otroshy and Struik (2010), where they found varietal differences in case of number of sprouts per tuber.

Hampson (1991) ascribed apical dominance for variation in number of sprouts produced per tuber among varieties. While Mishra et al. (2019) accused varietal response only. Otroshy and Struik (2010) make responsible the effects of tuber size and GA for the difference in number of sprouts in different varieties.

4.1.3 Number of plants plot^{-1}

The number of plants per plot did not differ significantly among the varieties (Appendix I). However numerically, the plant number ranged from 234 to 126 per plot within the varieties (Table 2).

The highest number of plant plot^{-1} was observed in BARI Alu-37 (234.80) followed by BARI Alu-41 (230.78) and BARI Alu-49 (187.39). The lowest number was found in BARI Alu-40 (126.64) preceded by BARI Alu-10 (131.88) BARI Alu-9 (134.40).

Similarly, Eaton et al. (2017) did not get significant variation in case of number of plants per plot among six varieties of potato.

Present study was not supported by Islam et al. (2017). They found variation in case of number of stem hill^{-1} among six varieties of potato. They explained difference in number of main stems per hill among the varieties as a varietal characteristic, which is greatly influenced by the physiological state of seed tubers and use of either cut or whole tubers as planting material.

Not all eyes lead to sprouts, not all sprouts lead to stems, a stem yields more than one stolon and a stolon more than one tuber, resulting in several tubers produced per planted sprout. The actual data depend on variety, seed physiology, health status and environmental weather and soil conditions (Haverkort, 2018).

Table 2. Varietal effect of potato on sprouting, number plant of and height of plant

Variety	Time of sprouting (days)	No. of sprout $plot^{-1}$	Number of plants $plot^{-1}$	Height of plant (cm)
BARI Alu-36	12.67 c	67.00 abcd	186.73	98.17 a
BARI Alu-37	17.00 a	75.00 a	234.80	96.33 a
BARI Alu-40	11.33 cd	61.67 d	126.64	97.72 a
BARI Alu-41	8.00 d	68.00 abcd	230.78	80.83 ab
BARI Alu-47	12.33 c	70.00 abc	176.33	60.39 b
BARI Alu-48	16.33 ab	69.00 abcd	144.05	65.78 b
BARI Alu-49	13.67 abc	71.67 ab	187.39	80.11 ab
BARI Alu-56	16.33 ab	68.33 bcd	142.34	62.83 b
BARI Alu-62	13.00 bc	62.33 cd	134.40	58.84 b
BARI Alu-63	12.67 c	66.67 bcd	131.88	74.69 ab
Level of Significance	**	*	NS	**

**= significant at 1% level, *= significant at 5% level, NS= non-significant

Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.1.4 Height of plants

There was significant variation in plant height among the varieties (Appendix I).

Plant height varied from 98.17 cm to 58.84 cm (Table 2). The tallest plant was found in BARI Alu-36 (98.17cm) which was statistically similar to BARI Alu-40 (97.73 cm) and BARI Alu-37 (96.33cm). The shortest plant was found in BARI Alu-62 (58.84 cm) preceded by BARI Alu-47 (60.39cm) and BARI Alu-56 (62.83cm).

The results of the present study were similar to those reported by other investigators Eaton et al. (2017), Jafar et al. (2020), Hossain et al. (1980), and Hossain (1981). This study was also in agreement with the findings of Jafar et al. (2020), who reported that plant height differ between 54.1 cm and 77.4 cm among the varieties.

Plant height depends on the genetic constitution and proper growth of the plant that is influenced by growing environment and crop management practices (Rahman et al., 2021). In the present experiment, since all ten varieties were grown under the same environmental conditions and production practices, the variation among the varieties in plant height can be interpreted in the light of varietal characteristics of potato, taking varietal responses to growing environment under consideration. It seems that BARI Alu-36 (98.17cm) BARI Alu-40 (97.73 cm) and BARI Alu-37 (96.33cm) have such genetic character that enabled them to took energetic start and absorbed more food resources in form of mineral nutrients, moisture and solar radiations during early and entire growing season and resulted more height.

4.1.5 Number of leaves plant^{-1}

Potato varieties did not show significant differences in respect of leaf number (Appendix I). Leaf number varied from 10.22 to 21.11 among the varieties (Table 3).

Out of ten varieties maximum number of leaves was found in BARI Alu-37 (21.11) followed by BARI Alu-40 (17.89), BARI Alu-36 (17.72) and the minimum number of leaves was observed in BARI Alu-63 (10.22) preceded by BARI Alu-48 (14.50) and BARI Alu-62 (14.55). The result of the present study on overall number of leaves was not in agreement with the findings of Fender et al. (2011), Mishra et al. (2019) and Tessema et al. (2020). Mishra et al. (2019) found considerable variation in number of leaves among 33 varieties while Tessema et al. (2020) found the number of leaves per plant expected as genotypes normally differ genetically in their growth habit.

This may be due to genotypic similarity among the varieties. Along with genetic similarity, it also could be due to uniformity in soil moisture and nitrogen supply, and the interaction of these factors as Fender et al. (2011) claimed that the number of leaves is affected by these factors.

4.1.6 Length of leaves

The length of leaves among the varieties was differed from each other significantly (Appendix I).

The longest leaf was found in BARI Alu-37 (25.50 cm) followed by BARI Alu-36 (23.06 cm), BARI Alu-40 (21.64 cm), and the shortest leaf was found in BARI Alu-49 (17.36 cm) followed by BARI Alu-63 (17.58 cm) and BARI Alu-47 (17.61 cm) (Table 3).

Variety had a high significant effect on the length of leaves. These difference in the length of leaves among the varieties may also be a genetic peculiarity as well as influenced by environmental factors and the quality of the plant material. This result is in agreement with Mishra et al. (2019). They found similar result in case of the length of leaf which varied from 18.17 cm to 23.75 cm.

4.1.7 Breadth of leaves

There was significant variation in breadths of leaves among the varieties (Appendix I). The maximum was (11.91 cm) and minimum (6.83 cm) was observed from the experiment.

Widest leaf was found in BARI Alu-37 (11.91 cm) followed by BARI Alu-40 (10.67 cm), BARI Alu-41 (9.19 cm), and the narrowest leaf was found in BARI Alu-49 (6.83 cm) preceded by BARI Alu-48 (7.17 cm) and BARI Alu-63 (7.58 cm) (Table 3).

Mishra et al. (2019) also observed similar result in case of width of leaf among different potato varieties which ranged between 10.57 to 22.29 cm.

Table 3. Varietal effect on different leaf parameters of potato plant

Variety	No. of Leaves plant^{-1}	Length of leaves (cm)	Breadth of leaves (cm)
BARI Alu-36	17.72	23.06 ab	8.44 cde
BARI Alu-37	21.11	25.50 a	11.91 a
BARI Alu-40	17.89	21.64 bc	10.67 ab
BARI Alu-41	15.28	21.11 bcd	9.19 bc
BARI Alu-47	14.67	17.61 de	8.19 cde
BARI Alu-48	14.50	18.17 cde	7.17 de
BARI Alu-49	15.28	17.36 e	6.83 e
BARI Alu-56	14.56	18.72 cde	9.18 bc
BARI Alu-62	14.55	19.95 bcde	9.05 bcd
BARI Alu-63	10.22	17.58 e	7.58 cde
Level of Significance	NS	**	**

**= significant at 1% level, NS= non-significant

Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2 Yield attributes of potato varieties

4.2.1 Number of tubers plot^{-1}

Number of tubers plot^{-1} showed significant differences among the varieties (Appendix II). Number of tubers differed from 777 to 290.67 per plot (Table 4).

In case of number of tuber plot^{-1} BARI Alu-47 (777.00) showed the highest number of tubers followed by BARI Alu-37 (556.33) and BARI Alu-49 (443.33) and the lowest number of tubers was found in BARI Alu-62 (290.67) preceded by BARI Alu-48 (321.00) and BARI Alu-63 (336.67) (Table 4).

Tuber number in grade-1 showed highly significant variation (Table 4). In case of grade-1, BARI Alu-63 (11.15% of total tubers) showed the highest number followed by BARI Alu-40 (7.95%), and BARI Alu-62 (7.25%), and the lowest number was found in BARI Alu-47 (0.15%) followed by BARI Alu-41 (1.48%) and BARI Alu-49 (1.63%).

Tuber number in grade-2 showed highly significant variation (Table 4). In case of grade-2, BARI Alu-40 (40.77%) showed the highest number followed by BARI Alu-36 (32.96%) and BARI Alu-62 (31.22%) and the lowest number was found in BARI Alu-47 (11.86%) followed by BARI Alu-56 (18.57%) and BARI Alu-48 (19.22%).

Tuber number in grade-3 showed highly significant variation (Table 4). In case of grade-3, BARI Alu-47 (87.99%) gave the highest number of tubers which was statistically similar with BARI Alu-56 (79.75%) and BARI Alu-40 (51.28%) preceded the least number of Gd3 tubers preceded by BARI Alu-62 (61.53%) and BARI Alu-36 (61.67%).

The result was similar with the findings of Khan et al. (2019); Subarta and Upadhya. (1997); Gebreselassie et al. (2016) and Islam et al. (2017).

Khan et al. (2019) claimed that the difference in number of tubers per plant depends on genetic makeup of plant, canopy development and environmental conditions.

Subarta and Upadhya, (1997); Gebreselassie et al. (2016) suggested that the number of tubers per plot will depend mainly on the number of stems per plot, total number of stolons and stolons which tuberize. In this case, both genetic and environmental factors play a vital role in stolon development and tuberization process. The difference in tuber number might be due to varietal character and growing environmental factors. Islam et al. (2017) claimed that number of tubers per hill is mainly a varietal characteristic also influenced by growing environment and production practices.

Table 4. Variation in tuber number of different potato varieties

Variety	Number of Tuber Plot^{-1}			
	Total	Grade I (%)	G II (%)	G III (%)
BARI Alu-36	414.67 cd	5.37 bcd	32.96 ab	61.67 bcd
BARI Alu-37	556.33 b	1.65 de	25.67 abc	72.68 abc
BARI Alu-40	349.33 cd	7.95 ab	40.77 a	51.28 d
BARI Alu-41	331.67 cd	1.48 de	22.44 bc	76.09 abc
BARI Alu-47	777.00 a	0.15 e	11.86 c	87.99 a
BARI Alu-48	321.00 cd	2.94 cde	19.22 bc	77.84 ab
BARI Alu-49	443.33 bc	1.63 de	20.53 bc	77.84 ab
BARI Alu-56	332.33 cd	1.67 de	18.57 bc	79.75 a
BARI Alu-62	290.67 d	7.25 abc	31.22 ab	61.53 cd
BARI Alu-63	336.67 cd	11.15 a	26.26 abc	62.59 bcd
Level of Significance	**	*	**	**

**= significant at 1% level, *= significant at 5% level

Means followed by common letter(s) in a column do not differ significantly by DMRT.

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

The weight of tubers among the varieties was differed from each other and the result indicate that the variation in tuber yield of different potato variety was statistically significant (Appendix II). Tuber yield varied from 11.39 ton to 18.86 ton within the potato varieties (Table 5).

The maximum tuber yield was found in BARI Alu-40 (18.86 t ha^{-1}) followed by BARI Alu-37 (18.09 t ha^{-1}) and BARI Alu-36 (17.86 t ha^{-1}). The minimum yield was obtained from BARI Alu-48 (11.39 t ha^{-1}) preceded by BARI Alu-56 (11.77 t ha^{-1}) and BARI Alu-49 (13.95 t ha^{-1}). Significantly higher yields of BARI Alu-40 have also been reported from a number of field studies conducted by Islam et al. (2017).

The result of the present study was similar with those of Alam et al. (2020) who found the highest yield in BARI Alu-37 and BARI Alu-35 from an experiment on five high yielding Potato varieties (HYVs) (BARI Alu-25, BARI Alu-35, BARI Alu-36, BARI Alu-37, BARI Alu-41 and one local potato variety).

In case of Grade-1, tuber yield showed highly significant variations within the varieties (Table 5). BARI Alu-37 (29.11%) showed the best performances followed by BARI Alu-62 (19.72%), BARI Alu-40 (19.50%) lowest yield was found in BARI Alu-47 (0.97%) followed by BARI Alu-41 (3.05%), BARI Alu-49 (5.59%).

In case of Grade-2, tuber yield showed significant variations within the varieties (Table 5). Maximum Grade-2 tuber yield was found in BARI Alu-40 (55.58%) followed by BARI Alu-36 (50.58%), BARI Alu-63 (46.67%) and minimum was observed in BARI Alu-41 (27.91%) followed by BARI Alu-47 (28.84%) and BARI Alu-56 (29.42%).

Grade-3 tuber yield showed highly significant variations among the varieties (Table 5). BARI Alu-47 (70.19%) and BARI Alu-41 (69.04%) had the maximum and statistically similar tubers.

Followed by BARI Alu-56 (63.08%). The lowest was found in BARI Alu-40 (24.97%) followed by BARI Alu-36 (34.42%), BARI Alu-37 (37.14%).

This result is in agreement with the findings of Eaton et al. (2017). They depict that, the genetics of the variety might be one of the major reasons for difference in percentage of different grades, among varieties.

Alam et al. (2003) claimed that, yield is associated with number of leaves and stems which helps in deposition of photosynthates and ultimately affect the yield.

Asmamaw (2007); Gebreselassie et al. (2016) and Tekalign (2011) reported that yield differences among genotypes were attributed both by the inherent yield potential of genotypes and growing environment as well as the interaction of genotype and environment. Though the environmental condition was similar, the yield difference may be due to varietal differences.

They depict the fact that a potentially high yielding variety from the hereditary point of view will yield to its capacity provided the environment is suitable.

Table 5. Tuber yield of different potato varieties

Variety	Total yield (t ha^{-1})	Weight (%)			
		Total weight of tuber plot^{-1} (kg)	Weight of tuber in grade-I (%)	Weight of tuber in grade-II (%)	Weight of tuber in grade-III (%)
BARI Alu-36	17.86 ab	11.343 ab	15.00 bc	50.58 ab	34.42 cd
BARI Alu-37	18.09 a	11.49 a	29.11 a	33.75 bcd	37.14 cd
BARI Alu-40	18.86 a	11.97 a	19.50 b	55.58 a	24.97 d
BARI Alu-41	14.20 ab	9.02 ab	3.05 d	27.91 d	69.04 a
BARI Alu-47	16.82 ab	10.68 ab	0.97 d	28.84 cd	70.19 a
BARI Alu-48	11.39 b	7.23 b	6.32 cd	33.97 bcd	59.71 ab
BARI Alu-49	13.95 ab	8.86 ab	5.59 d	37.22 abcd	57.19 ab
BARI Alu-56	11.77 b	7.47 b	7.50 cd	29.42 cd	63.08 ab
BARI Alu-62	14.07 ab	8.93 ab	19.72 b	40.89 abcd	39.39 cd
BARI Alu-63	17.25 ab	10.96 ab	6.90 cd	46.67 abc	46.43 bc
Level of Significance	*	*	**	*	**

**= significant at 1% level, *= significant at 5% level

Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.3 Tuber color

In case of tuber color, red color was observed in BARI Alu-36, BARI Alu-41, BARI Alu-56, BARI Alu-63. BARI Alu-40- showed cream color. Whereas BARI Alu-37, BARI Alu-47, BARI Alu-48, BARI Alu-49, BARI Alu-62- showed yellow color respectively (Table 6). Similarly, Akhter et al. (1994), Alam et al. (2003) and Rahman et al. (2021) found out different colors in different varieties of potatoes. Khan et al. (2019) also found similar result and depict that skin color of potatoes is affected by or controlled by numbers of genetic factors.

4.2.4 Tuber skin type

Different varieties produce different types of skin (Table 6).

In case of BARI Alu-36, BARI Alu-48, BARI Alu-56, BARI Alu-63 was produced uneven skin type. Whereas BARI Alu-37, BARI Alu-40 and BARI Alu-41 BARI Alu-47 BARI Alu-48 BARI Alu-49 and BARI Alu-62 gave smooth type of skin.

Rahman et al. (2017) found same varietal differences in case of skin type of tubers. The difference in skin type among the varieties might be associated to genetic differences, which may lead to the variation in skin type of tubers. The result is not similar to Arifa et al. (2018) as they found all genotypes produced smooth skin type tubers.

4.2.5 Tuber shape

Variation was observed in case of tuber shape of potato varieties (Table 6). BARI Alu-36, BARI Alu-37, BARI Alu-40 and BARI Alu-62 was oval in shape. BARI Alu-41, BARI Alu-56, BARI Alu-63 was round shaped; BARI Alu-47 was flatted oval shaped, and BARI Alu-48 and BARI Alu-49 was flatted round shaped.

The result was supported by Shrestha et al. (2020), Rahman et al. (2021) and Khan et al. (2019) who found varietal effect on the shape of tuber.

Table 6. Variation in different external quality parameters of tuber of different potato varieties

Variety	Color of Tubers	Skin type of Tubers	Tuber shape
BARI Alu-36	Red	Uneven	Oval
BARI Alu-37	Yellow	Smooth	Oval
BARI Alu-40	Creamy	Smooth	Oval
BARI Alu-41	Red	Smooth	Round
BARI Alu-47	Yellow	Smooth	Flatted oval
BARI Alu-48	Yellow	Uneven	Flatted round
BARI Alu-49	Yellow	Smooth	Flatted round
BARI Alu-56	Red	Uneven	Round
BARI Alu-62	Yellow	Smooth	Oval
BARI Alu-63	Red	Uneven	Round

4.2.6 Tuber shape index

Differences in tuber shape index was found highly significant among the Potato varieties (Appendix III). Tuber shape index varied from 1.49 to 1.02 within the varieties (Table 7).

The highest tuber shape index was found in BARI Alu-37 (1.49) followed by BARI Alu-62 (1.28) and BARI Alu-36 (1.25). The lowest tuber shape index was found in BARI Alu-49 (1.02) preceded by BARI Alu-48 (1.03) and BARI Alu-56 (1.08).

Our results are in line with Akhter et al. (1994), Rahman et al. (2021) and Alam et al. (2003) who found out great diversity in shape of different varieties of potatoes.

Bubeníčková and Simeonovová, (2011) found significant differences on tuber shape index working with ten different potato varieties. They depicted that, genetic differences among the varieties as length width of the potato tubers depends on their genetic constitution.

4.2.7 Dry matter content of tuber

From the experiment, dry matter content of tubers among the varieties was differed significantly from each other and the result indicate that the variation in dry matter content of tubers of different potato variety is statistically significant (Appendix III and Table 7).

The maximum dry matter content was observed in BARI Alu-48 (25.99) followed by BARI Alu-47 (24.46) and BARI Alu-49 (23.31). The minimum dry matter was recorded in BARI Alu-36 (17.24) preceded by BARI Alu-37 (18.01) and BARI Alu-63 (18.83).

The results agree with previous findings of Abebe et al. (2012), Tessema et al. (2020) and Arslanović-Lukač et al (2021). Tessema et al. (2020) and Mondal and Hosain (2006) claimed that potato tuber dry matter content significantly influenced by both genetic makeup and inherent differences of varieties and also by their growing environment.

Abebe et al. (2012) found pronounced inherent quality differences among varieties when grown under similar condition to identify genotypes with better dry matter contents. They marked it as a genetic character where a potentially high yielding variety will yield to its capacity when the environment is in favor.

4.2.8 Specific gravity of tubers

The specific gravity of tuber was found significant (Appendix III) among the Potato varieties. specific gravity of tuber varied from 1.32 to 1.12 within the varieties (Table 7).

Specific gravity was recorded the highest in BARI Alu-47 (1.32) followed by BARI Alu-62 (1.19), BARI Alu-48 (1.16) and BARI Alu-63 (1.16). The lowest specific gravity was found in BARI Alu-49 (1.12) preceded by BARI Alu-40 (1.14) and BARI Alu-41(1.14).

In consistent with this result, effects of both variety and locations were found highly significant on potato specific gravity by Tai and Coleman (1999), Tessema et al. (2020) and Rahman et al. (2017). Abbas et al. (2011) found specific gravity ranged from 1.03 to 1.14 and they claimed that differences in specific gravity among the varieties could be due to differences in range of diameter and mass. The difference might be due to genetic and environmental variations.

Table 7. Variation in different internal quality parameters of tuber of different potato varieties

Variety	Tuber Shape Index	Dry matter content of Tubers (%)	Specific Gravity of Tubers
BARI Alu-36	1.25 b	17.24 e	1.15 b
BARI Alu-37	1.49 a	18.01 e	1.15 b
BARI Alu-40	1.22 b	21.65 cd	1.14 b
BARI Alu-41	1.09 c	21.43 d	1.14 b
BARI Alu-47	1.24 b	24.46 ab	1.32 a
BARI Alu-48	1.03 c	25.99 a	1.16 b
BARI Alu-49	1.02 c	23.31 bc	1.12 b
BARI Alu-56	1.08 c	21.11 d	1.16 b
BARI Alu-62	1.28 b	23.30 bc	1.19 b
BARI Alu-63	1.08 c	18.83 e	1.16 b
Level of Significance	**	**	**

**= significant at 1% level

Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.2.9 Number of eyes tuber^{-1}

Significant differences were found in tuber eyes number of different varieties (Appendix III). Eyes number varied from 5.67 to 9.47 within the varieties (Table 8).

The maximum number of eyes was observed in BARI Alu-56 (9.47) followed by BARI Alu-37 (8.89) and BARI Alu-36 (7.83). The minimum number of eyes was found in BARI Alu-49 (5.67) preceded by BARI Alu-40 (5.89) and BARI Alu-48 (6.61).

Khan et al. (2019) and Rahman et al. (2017) found same varietal differences in case of number of eyes of tubers. The variation in eyes number of tubers may be attributed to inheritability of genotypes.

4.2.10 Depth of eyes of tubers

Non-significant variation was found in case of depth of eyes of tubers among the potato varieties (Appendix III). Numerically maximum eye depth was found in case of BARI Alu-63 (4.00 mm) followed by BARI Alu-48 (2.83 mm) and BARI Alu-56 (2.83 mm). The lowest eye depth of tuber was observed in case of BARI Alu-47 (1.50 mm) which was statistically similar to BARI Alu-62 (1.83 mm) and BARI Alu-36 (2.00 mm).

In opposition with this result Rahman et al. (2017) and Shrestha et al (2020) found varietal effect on depth of eyes of tubers.

4.2.11 Disease incidence (%) of plants

The disease incidence rate of the varieties was different from each other and the observed result indicate that the variation in the disease incidence rate of plants of different potato varieties was statistically significant (Appendix III). The infestation rate varied from 23.81% to 91.28% within the potato varieties (Table 8).

Minimum infestation was observed in case of BARI Alu-40 (23.81) which was statistically similar to BARI Alu-49 (24.49%) and BARI Alu-62 (32.87%). The maximum infected tubers were found in BARI Alu-48 (91.28%) preceded by BARI Alu-41 (91.14%) and BARI Alu-37 (88.23%).

This suggestion is in agreement with Eaton et al. (2017), Bittara et al. (2016) and Jafar et al. (2020)

Among the investigated varieties, Eaton et al. (2017) found differences in disease incidences and they recommended the farmers in Bangladesh to grow Asterix as it is resistance to diseases and insects and ultimately high yielding while Jafar et al. (2020) suggested Belete and Bubu variety.

Bittara et al. (2016) reported that, the existence of resistance to powdery scab and root gall formation and relative levels of susceptibility among potato genotypes against powdery scab and root gall formation in some potato genotypes is a varietal characteristic.

4.2.12 Number of infected tubers plot^{-1} (%)

The number of infected tubers among the varieties was not the same and the result indicated that the variation in the number of infected tubers was statistically significant (Appendix III).

Maximum infected tuber was found in BARI Alu-63 (43.74%). And the rest of the varieties showed statistically similar infestation rate those were BARI Alu-37 (9.48%), BARI Alu-41(6.61%), BARI Alu-36 (4.73%), BARI Alu-62 (3.95%), BARI Alu-48 (3.90%), BARI Alu-40 (3.26%), BARI Alu-49 (2.88%), BARI Alu-56 (2.70%) and BARI Alu-47 (1.68%).

4.2.13 Weight of infected tubers plot^{-1} (%)

Weight of infected tubers of the varieties was recorded during the experiment. Result revealed that the differences were significant (Appendix III).

The highest infected tuber weight was found in BARI Alu-63 (23.20%). And the rest of the varieties showed statistically similar infested tubers orderly BARI Alu-37 (7.85%), BARI Alu-62 (6.23%), BARI Alu-41(6.18%), BARI Alu-48 (4.56%), BARI Alu-49 (4.31%), BARI Alu-36(3.85%), BARI Alu-47 (2.58%), BARI Alu-56 (2.46%) and BARI Alu-40 (2.40%). This result is in agreement with the findings of Jafar et al. (2020) who claimed that varietal resistance and susceptibility to late blight diseases may be responsible for maximum yield from Belete (39.32t/ha) and lowest from Dagim (9.36t/ha) in their experiment.

Table 8. Other quality parameters for potato variety evaluation

Variety	No. of eyes tuber^{-1}	Depth of eyes (mm)	Disease incidence (%)	No. of infected tubers (%)	Weight of infected tubers (%)
BARI Alu-36	7.83 bc	2.00	58.89 abc	4.73 b	3.85 b
BARI Alu-37	8.89 ab	2.50	88.23 a	9.48 b	7.85 b
BARI Alu-40	5.89 de	2.17	23.81 c	3.26 b	2.40 b
BARI Alu-41	7.06 cd	2.33	91.14 a	6.62 b	6.18 b
BARI Alu-47	7.14 cd	1.50	53.01 abc	1.68 b	2.58 b
BARI Alu-48	6.61 cde	2.83	91.28 a	3.90 b	4.55 b
BARI Alu-49	5.67 e	2.33	24.49 c	2.88 b	4.31 b
BARI Alu-56	9.47 a	2.83	81.87 ab	2.70 b	2.46 b
BARI Alu-62	7.50 c	1.83	32.87 c	3.95 b	6.23 b
BARI Alu-63	7.50 c	4.00	46.14 bc	43.74 a	23.20 a
Level of Significance	**	NS	**	**	**

**= significant at 1% level, NS= non-significant

Means followed by common letter(s) in a column do not differ significantly by DMRT.

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATION

Summary

A field experiment was conducted to evaluate and select BARI developed potato varieties on the basis of their growth and yield performances. The experiment was carried out in a Completely Randomized Block Design (RCBD). The collected data were statistically analyzed using Statistix-10 package program and the means were evaluated by new Duncans Multiple Range Test.

During the experiment sprouting time differed significantly among the potato varieties. Highest time required for the completion of sprouting was 17 days found for BARI Alu-37. BARI Alu-41 required the lowest time (8 days).

The variation in number of sprouting of different potato varieties was statistically significant. Numerically the highest and lowest number of sprouting (75) were recorded in case of BARI Alu-37 and lowest number of sprouting was found in BARI Alu-40 (75.67).

Per plot plant number did not differ significantly among the varieties. The plant number ranged from 126 to 234 per plot within the varieties. The highest number of plant plot^{-1} was observed in BARI Alu-37 and the lowest number was found in BARI Alu-40.

There was significant variation in plant height among the varieties. The highest plant height was found for BARI alu-36 (98.17cm) which was statistically similar to BARI Alu-40 (97.73 cm) and BARI Alu-37 (96.33cm and the lowest plant height was observed in BARI alu-62 (58.84 cm) which was statistically similar to BARI Alu-47 (60.39cm), BARI Alu-56 (62.83cm) and BARI Alu-48 (65.78cm).

Potato varieties showed significant differences in case of per plant leaf number. Maximum number of leaves was found in BARI Alu-37 (21.11) and the minimum number of leaves was observed in BARI Alu-63 (10.22).

The result revealed that the variation in leaf length of different potato varieties was statistically significant. The longest leaf was found in BARI Alu-37 (25.50 cm) and the shortest leaf was found in BARI Alu-49 (17.36 cm) which was statistically similar to BARI Alu-63 (17.58 cm).

There was significant variation in breadths of leaves among the varieties. Widest leaf was found in BARI Alu-37 (11.91 cm) and the narrowest leaf was found in BARI Alu-49 (6.83 cm).

There was a highly significant differences in tuber number within the varieties. In case of tuber number per plot BARI Alu-47 (777.00) showed the highest tuber number and the lowest number of tubers was found from BARI Alu-62 (290.67). In case of Gd1 BARI Alu-63 (11.15% of total tubers) showed the highest number and the lowest number was found in BARI Alu-47 (0.15%). In case of Gd2 BARI Alu-40 (40.77%) showed the highest number and lowest number was found in BARI Alu-47 (11.86%). In case of Gd3 BARI Alu-47 (87.99%) showed the highest number of tubers and BARI Alu-40 (51.28%) showed the least number of Gd3 tubers.

In case of Gd-1 tuber yield showed highly significant variations among the varieties. BARI Alu-37 (29.11%) showed the best performances and minimum was found in BARI Alu-47 (0.97%) which was statistically similar with BARI Alu-49 (5.59%). In case of Gd2 tuber yield showed significant variations among the varieties. Maximum Gd3 was found in BARI Alu-40 (55.58%) and minimum was found in BARI Alu-41 (27.91%). Gd2 tuber yield showed highly significant variations among the varieties. BARI Alu-47 (70.19%) and BARI Alu-41 (69.04%) has the maximum and statistically similar Gd3 tubers and minimum tuber weight was found in BARI Alu-40 (24.97%).

Differences in tuber shape index was found highly significant among the Potato varieties. Highest value of tuber shape index was found in BARI Alu-37 (1.49) lowest tuber shape index was found in BARI Alu-49 (1.02).

Varietal differences were observed in case of tuber color. BARI Alu-36 showed red color, BARI Alu-37- yellow, BARI Alu-40- cream, BARI Alu-41- red, BARI Alu-47- yellow, BARI Alu-48- yellow, BARI Alu-49 yellow, BARI Alu-56-red, BARI Alu-62- yellow, BARI Alu-63- red color respectively.

In case of skin type of tubers, differences were observed among the varieties. BARI Alu-36, BARI Alu-48, BARI Alu-56, BARI Alu-63 has uneven skin type where BARI Alu-37, BARI Alu-40 and BARI Alu-41 BARI Alu-47 BARI Alu-48 BARI Alu-49 BARI Alu-62 has smooth skin type was found.

From the experiment, dry matter content of tubers among the varieties was different from each other. The maximum dry matter content was observed in BARI Alu-48 (25.99), and the minimum was observed in BARI Alu-36 (17.24).

During the experiment differences in specific gravity of tuber was found and the significant among the Potato varieties. Specific gravity was found highest in BARI Alu-47 (1.32). Rest varieties showed statistically similar values in a sequence of BARI Alu-62 (1.19), BARI Alu-48 (1.16), BARI Alu-63 (1.16), BARI Alu-56 (1.16), BARI Alu-36 (1.15), BARI Alu-37 (1.15), BARI Alu-41(1.14), BARI Alu-40 (1.14), BARI Alu-49 (1.12).

Highly significant differences were found in tuber eyes number of different varieties during the experiment. The maximum number of eyes was observed in BARI Alu-56 (9.47) and the minimum number of eyes was found in BARI Alu-49 (5.67).

variation in tuber shape was observed among the potato varieties. BARI Alu-36, BARI Alu-37, BARI Alu-40 and BARI Alu-62 was oval in shape. BARI Alu-41, BARI Alu-56, BARI

Alu-63 was round shaped; BARI Alu-47 was flatted oval shaped, and BARI Alu-48 BARI Alu-49 was flatted round shaped.

There is a non-significant variation was found in case of tuber eye depth among the potato varieties. Numerically maximum eye depth was found in case of BARI Alu-63 (4.00 mm) and lowest eye depth of tuber was observed in case of BARI Alu-47 (1.50 mm).

The variation in the disease incidence rate of different potato varieties was statistically highly significant. Minimum infestation was observed in case of BARI Alu-40 (23.81) which was statistically similar to BARI Alu-49 (24.49%) and BARI Alu-62 (32.87%). The maximum infected varieties were BARI Alu-48 (91.28%) which was statistically similar to BARI Alu-41 (91.14%) and BARI Alu-37 (88.23%).

The variation in the number of infected tubers of different potato varieties was statistically highly significant. Maximum infected tuber was found in BARI Alu-63 (43.74% of total tuber) and minimum was in BARI Alu-47 (1.68%).

The differences in weight of infected tubers were highly significant. Highest infected tuber weight was found in BARI Alu-63 (23.20% of total tuber) and lowest in BARI Alu-40 (2.40%).

Conclusion

After performance evaluation obtained from this study, it can be concluded that out of the 10 improved potato varieties developed by BARI, no single variety was found to be superior in case of all quality parameters. However, BARI Alu-40 gave highest yield ascertaining maximum marketable tuber yield (grade-1 and grade-2) in case of weight and number of tubers with least disease incidence rate and least infected tuber yield. In case of other attributes, it showed moderate result. BARI Alu-36 and BARI Alu-37 also showed a moderately congenial result like those of BARI Alu-40. In considering the yield and marketable size of tuber BARI Alu-40 may be selected for cultivating in Khulna region.

Recommendation

It could be recommended that further research could be conducted with other potato varieties by considering this comparative growth and yield attributes where the present study could provide a working document for further studies to select a proper potato variety for the region.

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CHAPTER VI

APPENDICES

Appendix I. Analysis of variance for the Varietal effect of potato on sprouting, plant number, plant height and leaf characteristics

Source of variance	Degrees of freedom	Mean Sum of Square (MS)						
		Time of sprouting (days)	No. of sprout $plot^{-1}$	Number of plants $plot^{-1}$	Height of plant (cm)	No. of Leaves $plant^{-1}$	Length of leaves (cm)	Breadth of leaves (cm)
Replication	2	5.43	43.43	9043.39	589.19	30.55	43.08	2.76
Factor A (Variety)	9	22.00	47.51	4850.78	736.77	24.49	22.33	7.35
Error	18	4.21	22.69	3693.09	194.44	12.87	4.18	1.29
P value		0.0014	0.0335	0.2965	0.0078	1.90	0.0013	0.0009
F value		5.22	5.35	1.31	3.79	0.1174	5.34	5.66

Appendix II. Analysis of variance of Number of Tuber Plot^{-1} and yield of tuber (ton h^{-1}) of ten potato varieties

Source of variance	Degrees of freedom	Mean Sum of Square (MS)							
		Number of Tuber Plot^{-1}				yield of tuber (ton h^{-1})			
		Total	G1 (%)	G2 (%)	G3 (%)	Total yield (t ha^{-1})	weight of tuber in grade-1 (%)	weight of tuber in grade-2 (%)	weight of tuber in grade-3 (%)
Replication	2	13158.7	49.68	1124.18	1610.80	11.53	276.84	1090.75	2196.96
Factor A (Variety)	9	67910.5	39.26	208.90	374.51	8.77	244.64	280.90	748.95
Error	18	6686.1	6.50	81.80	90.12	6.48	29.14	118.41	99.99
P value		0.0000	0.0006	0.0432	0.0049	0.0279	0.0001	0.0549	0.0002
F value		10.16	6.04	2.55	4.16	3.35	8.40	2.37	7.49