SCREENING OF POTATO VARIETIES TO EARLY HEAT CONDITION IN NORTHERN PART OF BANGLADESH

A THESIS

BY

MST. MORTUZA KHANAM

Registration No. 1905115

Session: 2019

Thesis Semester: January-June, 2020

MASTER OF SCIENCE (M.S.)

IN

AGROFORESTRY AND ENVIRONMENT

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HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

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HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE 2020

DEDICATED TO MY BELOVED PARENTS

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June, 2020 *The Authoress*

DECLARATION

I hereby declare that the work presented in this thesis entitled ”**SCREENING OF POTATO VARIETIES TO EARLY HEAT CONDITION IN NORTHERN PART OF BANGLADESH”** has been carried out by myself and that it has not been submitted for any previous degree. All quotations have been distinguished by quotation marks and all sources of information specifically acknowladged by references to the authors.

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SCREENING OF POTATO VARIETIES TO EARLY HEAT CONDITION IN NORTHERN PART OF BANGLADESH

ABSTRACT

A field experiment was conducted at the farmers field located at Nekmarad, Ranishankoil, Thakurgoan from September 04, 2019 to February 29, 2020 to find out the growth and yield performance of different potato varieties to early heat condition. Fifteen potato varieties viz. Carolus, Granula, Farida, Taisiya, BARI Alu-41, Aloutte, Zina red, BARI Alu-72, Columba, Memphis, Fortus, Cimega, 747, Asterix and Diamant were considered in this experiment. The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Uniform cultural practices were adopted for all treatments. Significant differences in growth and yield parameters were observed among the varieties. Results revealed that the variety 'Taisiya' took the maximum days (14.67 days) for start emergence whereas, the minimum (10 days) was taken by 'Cimega'. In case of eighty percent emergence, 'Granula' was the early to 80% emergence variety whereas, 'Zina red' was the late one. The emergence percentage of the variety 'Granula' was maximum (99.44%) at 30 days after planting (DAP) and the minimum (50%) was measured from 'Cimega'. The longest plant height (110.2 cm) was measured at 60 DAP from '747' variety whereas the shortest one (74.53 cm) from 'Aloutte'. The maximum stem numbers hill^{-1} (7.73) was obtained from the variety 'Zina red' at 60 DAP and minimum (3.27) was obtained from 'Granula'. At 60 DAP, the maximum percentage of foliage coverage plant^{-1} (96.00%) was observed from the variety 'Carolus' whereas the minimum number (81.00%) was observed from 'Zina red'. Result also revealed that the maximum number of tuber (13.67) was recorded from the 'Cimega' variety whereas, the minimum (4.33) was obtained from the 'BARI Alu-72' variety. The maximum average tuber weight (455.33 g) was recorded from the 'Carolus' variety whereas, the minimum (193.00 g) was obtained from the 'Memphis' variety. The highest tuber yield (30.36 t ha^{-1}) was obtained from the variety 'BARI Alu-41' while the minimum (12.87 t ha^{-1}) was found from the 'Memphis'. In case of quality parameter, the maximum dry matter content of tuber flesh (22.10 %) was recorded from the variety 'Fortus' which statistically similar with 'Diamand' (21.52 %) whereasthe minimum tuber flesh dry matter content (13.56 %) was recorded from 'Aloutte'. Numerically the highest specific gravity (1.0827 g cm^{-3}) was obtained from the 'Diamand' whereas, the lowest (1.0420 g cm^{-3}) specific gravity was found from the 'Memphis' variety. Considering the results of the present experiment, it may be concluded that early heat condition had potential effect on growth and yield performance of potato.

Keywords: potato, early heat, heat stress, growth, Bangladesh

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CHAPTER I

INTRODUCTION

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INTRODUCTION

1.1 Background information of the study

Potato (*Solanum tuberosum* L.), commonly known as the ”king of Vegetables”, is the fourth most important food crop in the world after rice, wheat and corn (FAOSTAT, 2014). It is one of the most important food and vegetable crops in Bangladesh and is being cultivated all over the country. Today, the potayo has become the third most important food in Bangladesh (FAOSTAT, 2012) and production is increasing every year. Among the crops, the potato (*Solanum tuberosum* L.) has become an important crop for farmners and consumers in Bangladesh. Due to favorable soil and climate, the potato area doubled over the same period and the yield doubled (Rashid, 1987). Northern Bangladesh is considered to be one of the most important potato production areas, with an average yield estimated at 15-18 tons per hectare. Compared with other crops in Bangladesh, potatoes are highly profitable.

Environmental stresses like higher atmospheric temperatures, salinity and drought affect plant growth and productivity in several crop species including potato (Luthra, 2018). Negative impact of abiotic stresses (temperature and water) due to changing climate scenario is expected to increase in coming decades on potato production and its extension in non-traditional areas (Hijmanns, 2003). High temperature during active crop growth phase is major limiting factor for potato production in many developing countries (Dodds, 1990). Reduction in leaf area, tuber number and tuber weight has been reported as symptoms of elevated temperatures during potato growing season (Menzel, 1985). Heat stress creates imbalance in source-sink relation, delay in tuber initiation and bulking and malformation and necrosis of tubers (Levy and Veilleux, 2007). Optimum temperature for the growth of crop canopy is about 25°C. Minimum night temperature plays a crucial role in tuberization and largely determines whether plant will tuberize or not. Optimum temperatures for tuber formation are widely in the range of 10-17^{0}C (Bodlaender 1963; Moorby and Milthorpe, 1975). Normally, tuberization is reduced at higher night temperatures (> 20°C) with complete inhibition of this process above 25°C. A progressive reduction in tuberization is encountered with increasing temperature up to 30°C (Khanna, 1966). The weather condition favors potato production but because of the

tropical and humid climate the potato cultivation is severely affected by the pests such as insect, diseases and weeds etc.

A rise in temperature leads to increased transpiration in the plants, thus raising their demand for water. In many of the drier potato growing regions this will cause water stress, leading yields to decline. Temperature has a crucial influence on starch deposition in potato tubers. The ideal temperature range is between 15 and 18°C. Overnight temperatures above 22°C severely hamper tuber development (Dhar *et al.,* 2010).

Winter season in Bangladesh is very short. In the later stage temperature raises very fast so potato plants cannot survive in high temperature. Exposure of potato plants to heat stress alters the hormonal balance in the plants and results in partitioning of most of assimilated carbon in favor of above ground vegetative parts at the cost of the tubers (Dhar *et al.,* 2010). Early planted crop is vulnerable to attack of sucking pests like leafhopper (*Amrasca biguttula* Ishida) and mite (*Polyphagotorsonemus latus* Banks) resulting in significant yield reduction (Malik and Luthra, 2007; Luthra *et al*., 2013). It is imperative to develop potato clones which could germinate, grow and tuberize well under high night temperatures to mitigate the likely effect of climate change and to introduce potato cultivation in non-traditional areas/ seasons, with relatively higher temperature during crop growth period (Luthra *et al*., 2013).

1.2 Research problem

Several potato clones which are relatively able to maintain higher yields at high temperatures have been identified in field evaluation (Levy, 1984; Malik *et al*., 1992, Malik and Luthra 2007; Luthra *et al*., 2003; Luthra *et al*., 2013). Identification of drought tolerant genotypes for yield maintenance and breeding purposes is now a priority for improving heat tolerance of potato crop, saving irrigation water, and ensuring yield and food security in changing scenario of global climate and growing demand of water (Luthra *et al*., 2011; Luthra *et al*., 2013). Many parts of Bangladesh, especially in Barind areas (drought prone) are facing the problem of temperature fluctuation. So there is an urgent need to identify varieties suitable for growing under varied temperature.

1.3 Research objectives

Considering the above fact, the study is conducted to achieve the following objectives.

1. To assess the performance of different potato varieties to early heat condition and
2. To identify the potato varieties/germplasm suitable for cultivation under heat stress.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Potato is the most important tuber crop in the world as well as in Bangladesh. Numerous experiments have been conducted throughout the world on potato crop but information regarding growth and yield performance to early heat condition are still inadequate. Brief reviews of available literature pertinent to the present study have been reviewed in this chapter.

This chapter deals with the following headlines-

2.1 Description of the fifteen potato varieties

2.2Varietal effect in potato production

2.3 Temperature effect in potato production

2.1 Description of the fifteen potato varieties

The varieties used in this experiment are briefly described here (Source: https://extranet.agrico.nl/en/products-and-services/potato-varieties/):

Table 2.1: Characteristics of the fifteen selected potato varieties

Variety Name	Characteristics
CAROLUS	Maturity - early maincrop Initial development - good Flower colour - violet Average yield - moderate Skin color - multicolor Flesh color - yellow Tuber shape - oval Dry matter content - high Dormancy - long Common Scab - susceptible

	Late Blight-tuber - immune Late Blight-foliage - immune
GRANULA	Plant type - Intermediate Growth habit-Upright Color of flower - Red-violet Foliage development - Slow Number of tubers - High Dormancy - High, Very high Tuber shape - Round oval Flesh color - Yellow Common scab – high Yield – High
FARIDA	Sector - Traditional Coocking Type - B - Slightly mealy Maturity - Medium late Yield mature - Very high Tuber Size - Large Tuber shape - Oval/Long oval Number of tubers - 9-11 Flesh after cooking - Light yellow Skin color - Yellow Dormacy period - Medium Tuber Blight - Resistant Common Scab - Slightly Susceptible Powdery Scab – Susceptible
TAISIYA	Taisia is a promising Dutch variety, most recently officially recognized in Russia. General characteristics - medium early table variety of high yield Starch content - 12-16% Yield - high Consumer quality - excellent taste, average stewiness Skin color - yellow Pulp color - yellow

	Preferred growing regions - Central, Central Black Earth, Volga-Vyatka, North-West, Ural Disease resistance - highly resistant to rhizoctoniosis, rust, Y-virus and Yntn-virus, moderately resistant to scab, late blight Features of growing- germination of planting material recommended, the variety tolerates drought and elevated temperatures Originator - Solana (Germany)
BARI Alu - 41	Developed by - Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh Method of development/origin - Developed in Bangladesh from inheritance Carlita ×TPS 67 and evaluate in Bangladesh environment, At last this variety was developed. Year of release - 2012 Main characteristics - Plant medium height and average number of stem 4/5, stem green, anthocynine spread larger, leaf large, very few wave like, medium anthocynine presence on middle vain of leaf. Potato round to flat round shape, color deep red and skin smooth, flesh of potato light yellow, eye medium shallow, sprout initiation in 45-50 days in general temperature. Sprout medium ovoid, weak and medium hairy on base and tip medium. Quality of the product - Dry matter in potato 21.20 ±1%
ALOUETTE	Flower colour - light purple Skin color - red Flesh color - yellow Tuber shape - oval long Tuberisation - average Regularity size - regular Dry matter content - moderate Harvest damage - sensitive Superficiality of eyes - shallow Tubersize - medium Common Scab - little susceptible Powdery Scab - quite resistant

	Late Blight-tuber - quite resistant
ZINA RED	✓ Maturity - medium early ✓ Very high yield ✓ Long oval tubers ✓ Deep red skin colour and yellow colour of flesh ✓ Remarkable smooth and bright skin ✓ Dry matter content: 19.3% ✓ Cooking type AB, practically no discoloration after cooking ✓ Resistant to potato cyst nematodes, Ro1,4 ✓ Fairly strong against common scab General remarks Zina Red is a potato variety, suitable for the table market in Europe and Northern Africa. Because of the very nice dark red, large oval to long oval tubers, the Zina Red is a very attractive variety for the local fresh market. The flesh colour is yellow. Cooking type AB and suitable for home fries. The yield is high with an average dry matter content of 19.3%. Introduction of the Zina Red has started in Mediterranean countries with preference for red skin varieties.
BARI Alu – 72	Developed by Bangladesh - Agriculture Research Institute (BARI), Gazipur, Bangladesh Year of release - 2016 Main characteristics - Medium plant height with Intermediate type of stem. Stem greenish purple with some very strong extension of anthocyanine coloration at the stem. Leaf dark green, medium sized leaf. No anthocyanine coloration of mid rib and blade of the young leaflets. Short oval shaped medium-large size tuber with shallow eye depth. Red skin colour with yellow flesh color. crop duration 85-90 days Yield - 25-30 t/ha Quality of the product - This variety is resistant to heat and salt and suitable for table purpose.
COLOMBA	Grade name - Colomba General characteristics - very early Dutch cultivar with stable yield

	Gestation period - 50-65 days Starch content - 11-15% Mass of commercial tubers - 80-130 gr The number of tubers in the bush - up to 12 Yield - 220-420 c / ha Consumer quality - normal taste, minimal friability Recumbency - 95% Skin color - yellow Pulp color - yellow Preferred growing regions - Central, Central Black Earth, North Caucasus, North-West, Volga-Vyatka Disease resistance - resistant to nematodes and potato cancer Features of growing - avoid planting in cold soil Originator - Colombo potatoes (Colomba) were hybridized in the Netherlands. The originator is HZPC Holland. Included in the state register of the Russian Federation in the middle belt of the country, the Caucasus region and the Central Black Soil Region.
MEMPHIS	✓ Big size tubers ✓ Good yield ✓ Suitable for second (autumn/winter)crop ✓ Good tolerance to dry circumstances ✓ Good resistance package Cooking type - AB - Slightly firm Maturity - early Yield - High matureTuber size - Large Tuber shape - Oval / Long oval Number of tubers - 12-14 Flesh after cooking - Light yellow Skin colour - Red Dormancy period - medium Emergence - normal Metribuzin sensitivity – Moderately sensitive

	Foliage development - strong Internal bruising - little sensitive Little Potato disorder - sensitive Dry matter content/Starch - 19,2% / 13,3% UWW / Specific gravity - 349 / 1,074 Spraing - Highly resistant Foliage Blight - Susceptible Tuber Blight - Suscebtible Common scab - Slightly susceptible Powdery scab - Slightly susceptible PVY - Very Susceptible Yntn tuber tolerance – Tolerant
CIMEGA	Cimega has a very nice presentation with its nicely-shaped tubers. Cimega is our new variety for the fresh market in Southern Europe, The Middle East and North Africa. It is an improved Spunta with better marketable yield, resistances and presentation. Category - Fresh Market Usage - Consumption Maturity - Medium early Yield - Very high Foliage - Full covering with big leafs Tuber size - Big Tuber shape - Oval Number of tubers - 14-16 Skin colour - Yellow Flesh colour - Light yellow Eyedepth - Very shallow Cooking type - AB-B Dry matter content - Moderate Dormancy period - Medium long Nematodes - Ro 1, 4 Wart disease - Resistant Foliage blight - Medium resistance

	Tuber blight - Good resistance Common scab - High resistance Internal defects - Low Virus - Medium susceptible
SEVEN FOUR SEVEN	Maturity - Medium early Plant type - Intermediate Growth habit - Semi-upright Color of flower - Light red-violet Foliage development - Rapid, Medium Number of tubers - Medium Dormancy - Medium, High Tuber shape - Long oval, Oval Flesh color - Cream, White Eye depth - Very shallow Skin color - Light yellow Skin characteristic - Smooth Leaf blight - Medium Tuber blight - High Rhizoctonia - Medium Common scab - High Internal rust spot - Medium, High Second growth - High Silver scurf - High Damages - Very high Bruising - Very high Market outlet - Ware, Pre-packing Yield - High Share oversize - High Share undersize - Very low Cooking type - Fairly firm cooking After cooking discoloration - Very low Discoloration raw - Very low Dry matter content – Low

ASTERIX	Maturity - Intermediate to late Growth habit – Erect, Semi erect to erect Foliage cover – Moderate, Good to dense Flower colour - Red violet Flower frequency - Occasional to frequent, Frequent to very frequent, Berries Rare, Rare to occasional Tuber skin colour - Red Primary tuber flesh colour - Light yellow Tuber shape - Oval to long Tuber eye depth - Shallow to medium, Shallow Tuber skin texture - Smooth to intermediate Yield potential - Very low, high to very high Early harvest yield potential - High to very high Tubers per plant – Many, Many to very many Tuber size – Large, Large to very large Tuber shape uniformity - Medium to uniform Secondary growth – Medium Resistance to external damage - Resistant to very resistant Resistance to internal bruising – High Dormancy period – Medium Taste - Good Crisp suitability – Poor French fry suitability – Good Frying colour – Pale Dry matter content - High to very high Resistance to late blight on tubers (Artificial inoculum in the field) - High to very high Resistance to late blight on tubers (Laboratory test) - Very high Resistance to late blight on foliage (Laboratory test) – Medium Resistance to late blight on foliage (Artificial inoculum in the field) – Medium Resistance to common scab (Streptomyces scabies) - Medium to high
DIAMOND	Utilization - Chip processing and table stock

	Yield Potential - Exceptionally High Vine - Large, vigorous vine; blooms profusely; white flowers Tubers - Smooth, round tubers with bright white skin, white flesh, and shallow eyes Maturity - Medium-late; tubers size very quickly Specific Gravity - High (1.090 average across the US) Storability - Stores well; low sugar accumulation in storage Resistances - Resistance to common scab, moderately resistant to pink rot. Some preferential avoidance by Colorado potato beetle in choice cage studies.
FORTUS	Fortus is a Dutch varity, selected for it's strong growth. It produces a good yield of large tubers. It stores well and is good for chipping as well as general use. Resistance Blight - Low Scab - Low Eelworm - Low Tuber - Oval Skin - Yellow Flesh - Pale Yellow Shape - Oval

2.2 Varietal effect

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.

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 t/ha.

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.

Kassim *et al.,* (2014) run an experiment and reported a result that reducing physiological functions of above ground part of potato plant (leaf area and total chlorophyll content), the number and the weight of tuber decreased, so the productivity of the plant decreased.

Abebe (2013) conducted an experiment at three distinct locations in the Amhara region of Ethiopia for evaluation of the specific gravity of potato varieties. The pooled specific gravity values ranged from 1.058 to 1.102. The specific gravity of tubers of the improved variety Belete was the highest while that of Menagesha was the lowest. Furthermore, the specific gravity values for varieties grown at Debretabor were higher than those for the corresponding varieties grown at Adet and Merawi. He mentioned that specific gravity is the measure of choice for estimating dry matter and ultimately for determining the processing quality of potato varieties.

Ali *et al.,* (2009) conducted an experiment with two varieties of sweet potato *viz*., i) BARI Sweet Potato-5 and ii) BARI Sweet Potato-7 .The highest sweet potato yield was obtained from BARI SP-7 with (IPNS) basis fertilizer doses (33.9 t ha-1). The lowest sweet potato yield was obtained from BARI SP-7 with control treatment.

Kumar *et al.,* (2005) evaluated the result under water weight, specific gravity, dry matter and starch content of potatoes grown at Modipuram, Uttar Pradesh. He found that there was a positive correlation between under water weight and specific gravity (r=0.99), under water weight and dry matter (r=0.92).

Ranjbar and Mirzakhan (2012) conducted an experiment with treatments included 11 cultivars of commercial and conventional potato that Ramous, Sante ,Shepody, Marfona, Santana, Maradona, Milova, Boren ,Cosima, Granola, Agria. In this study growth indies such as: days to maturity, plant height, number of stem per plant, number of tuber per plant and mean weight of tubers were assessed. Results showed that all cultivars have Significant different at the 1% probability levels in all of growth traits. Results indicated that Cosima variety with mean weight of tubers (26.2 g) and Ramus variety with mean weight of tubers (14 g) were significantly superior to the other cultivars. The purpose of this study, evaluate the phenology of potato cultivars in green house condition.

Jatav *et al.,* (2013) conducted a study at Central Potato Research Station, Jalandhar during 2009-11 to evaluate potato cultivars*viz.* Kufri Jyoti, Kufri Jawahar, Kufri Bahar,

Kufri Sutlej, Kufri Pukhraj, Kufri Pushkar, Kufri Surya and Kufri Gaurav. Results revealed that Kufri Gaurav recorded maximum yield, agronomic efficiency and net return at all the levels of nitrogen followed by Kufri Pushkar and Kufri Pukhraj. Kufri Surya yielded minimum with least agronomic efficiency. This variety can be useful for poor farmers as this produces higher yield compared to other released varieties.

Hossain (2011) run three experiments with BARI released twelve potato varieties to determine the yield potentiality, natural storage behavior and degeneration rate for three consecutive years. He found that the highest emergence was observed in Granola at 34 DAP. At 50 DAP plant height (cm) of Diamant was (43.50 %), BARI TPS 1 (47.70 %), Felsina (52.00 %), Asterix (52.97 %), Granola (38.30 %), Cardinal (46.33 %).

Karim *et al.*, (2011) run an experiment with ten exotic potato varieties (var. All Blue, All Red, Cardinal, Diamant, Daisy, Granola, Green Mountain, Japanese Red, Pontiac and Summerset) to determine their yield potentiality. The highest total tuber weight per plant (344.60g) recorded in var. Diamant and total tuber weight plant-1 was the lowest (65.05 g) recorded in var. All red, all blue varieties showed the most potential yield in this experiment.

Güler (2009) conducted an experiment and observed that first, second, third class tuber yields and total tuber yield, tuber number per plant, mean tuber weight and leaf chlorophyll were significantly influenced by potato cultivar. There were significant correlations between chlorophyll and yield and yield related characters. Total yield significantly correlated with leaf chlorophyll. Correlations between yield and total yield as well as total yield and tuber number plant-1 were highly significant.

Rabbani and Rahman (1995) studied the performance of 16 Dutch potato varieties in their third generation. They reported that the height of the plants significantly varied among the varieties. The highest foliage coverage at maximum vegetative growth stage was found in the variety Cardinal (93.3%) followed by Diamant. The highest yield of tubers per hectare was obtained from Cardinal (35.19 t ha-1) followed by Romano (30.09 t ha-1) and the lowest from Stroma (11.11 t ha^{-1}).

Adhikari (2009) A field experiment was carried out to assess the effect of NPK on vegetative growth and yield of potato cultivars; Kufri Sindhuri and Desiree. Plant height,

number of stems, fresh weight of stem and leaves were recorded at 15 days interval during crop growth period and tuber yield at maturity stage. Kufri Sindhuri was taller than Desiree at all the stages of plant growth. The yield increase of potato tuber was associated with increase in the plant height, fresh weight of leaves and stems as a result of applied N.P.K.

Mahmud *et al.*, (2009) determined the yield of seed size tubers in five standard potato cultivars (Cardinal, Multa, Ailsa, Heera, and Dheera) in relation to dates of dehaulming (65, 70, and 80 days after planting) in a Seed Potato Production Farm, Debijong, Panchagarh. The maximum seed tuber yield was recorded from Cardinal at 80 DAP followed by Heera and Cardinal at 70 DAP, Dheera and Ailsa at 75 DAP.

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.

Anonymous (2009a) conducted an experiment with three potato varieties to observe their performance on yield under different soil moisture levels. The highest plant height (50.75 cm) was found in Cardinal which was similar to Diamant (48.88 cm). The lowest plant height was observed in Granola (38.50 cm). The highest foliage coverage (93.25%) was observed in Diamant followed by Cardinal (92.75%) and the lowest in Granola (90.33%). The highest no. of 26 stems hill-1 (6.25) was observed in Cardinal which was similar to Diamant (5.42) and the lowest in Granola (4.75). The highest no. of tubers hill-1 (13.83) was observed in Granola which was similar to Cardinal (13.33) and the lowest in Diamant (11.92).

Anonymous (2009b) conducted an experiment with twenty five varieties were evaluated at six locations. They found that, plant height (cm) in case of Diamant (47.87), Sagitta (56.20), Quincy (95.40); no. of stem hill-1 in Diamant (3.66), Sagitta (2.53), Quincy (2.26); Foliage coverage at 60 DAP (%) in Diamant (73.33), Sagitta (93.67), Quincy (92.00); No of tuber hill-1 in Diamant (6.72), Sagitta (3.94), Quincy (9.95); Weight of tuber hill-1 (kg) in Diamant (0.30), Sagitta (0.34), Quincy (0.35); dry matter (%) in case of Diamant (19.54), Sagitta (20.10), Quincy (18.70).

Anonymous (2009c) conducted an experiment with twelve varieties were evaluated at six locations in their third generation. They found that, plant height (cm) in case of Diamant (50.93), Granola (69.10), Sagitta (41.33), Quincy (65.87); no. of stem hill-1 in Diamant (5.66), Granola (3.20), Sagitta (3.46), Quincy (4.86); Foliage coverage at 60 DAP (%) in Diamant (92.00), Granola (91.00), Sagitta (89.33), Quincy (96.00); no. of tuber hill-1 in Diamant (7.24), Granola (6.82), Sagitta (5.23), Quincy (5.76); Weight of tuber hill-1 (kg) in Diamant (0.38), Granola (0.26), Sagitta (0.33), Quincy (0.35); dry matter (%) in case of Diamant (20.80), Granola (20.45), Sagitta (19.80), Quincy (18.40).

Anonymous (2009d) conducted an experiment with twenty eight varieties were evaluated at five locations. They found that, plant height at 60 DAP (cm) in case of Diamant (54.13), Sagitta (47.27), Quincy (80.93); no. of stem hill-1 in Diamant (4.66), Sagitta (5.40), Quincy (5.80); Foliage coverage at 60 DAP (%) in Diamant (93.67), Sagitta (90.67), Quincy (97.00); no. of tubers hill-1 in Diamant (8.11), Sagitta (5.41), Quincy (6.95); Weight of tubers hill-1 (kg) in Diamant (0.28), Sagitta (0.37), Quincy (0.45); dry matter (%) in case of Diamant (19.91), Sagitta (20.60), Quincy (18.34).

Anonymous (2009e) conducted an experiment with four exotic potato varieties along with check Diamant, Cardinal and Granola were evaluated at six locations in Regional Yield Trial. They found that plant height (cm) in case of Diamant (51.20), Cardinal (48.27), Meridian (48.33) and Laura (41.00); no. of stem hill-1 in Diamant (5.93), Felsina (82.22), Asterix (89.44), Granola (85.56), Cardinal (81.67). no. of stems hill-1 of Diamant was (4.06), BARI TPS 1 (3.21), Felsina (3.14), Asterix (4.03), Granola (3.30), Cardinal (3.89). Tuber yield hill-1 (g) of Diamant was (244.2), BARI TPS 1 (227.9), Felsina (300.1), Asterix (276.9), Granola (277.0), Cardinal (316.9). Under the grade 28-40mm, the highest number (48.63%) of seed tubers was produced by Granola which was statistically identical with Asterix (46.43%). Under the same grade (28-40 mm), the highest weight (43.46%) of seed tubers was produced by Patrone followed by Asterix (37.16%), Granola (36.64%) and Multa (35.39%) among which there was no significant variation. Cardinal (6.20), Meridian (5.67) and Laura (4.73); Foliage coverage (%) in Diamant (88.33), Cardinal (90.33), Meridian (95.67) and Laura (86.67); No. of tuber hill-1 in Diamant (9.48), Cardinal (9.81), Meridian (9.63) and Laura (7.50); Weight of tuber hill-1 (kg) in case of Diamant (0.313), Cardinal (0.377), Meridian (0.490) and Laura (0.430); dry matter (%) in case of Diamant (22.69), Cardinal (21.03), Meridian (19.49)

and Laura (20.22).

Anonymous (2009f) conducted an experiment with seven potato varieties were evaluated at MLT site. They found that plant height (cm) in case of Diamant (43.00), Lady Rosetta (37.00), and Courage (44.47); no. of stem plant-1 in Diamant (3.57), Lady Rosetta (2.80), and Courage (3.67); No of tuber plant-1 in Diamant (8.07), Lady Rosetta (5.67), and Courage (6.70).

Anonymous (2009g) conducted adaptive trails with new potato varieties at eleven districts. The mean yield of varieties over locations arranged in order of descending as BARI TPS-1 (23.87 t ha-1), Granola (23.68 t ha-1), Diamant (23.63 t ha-1), Asterix (20.83 t ha-1) and Raja (18.28 t ha-1).

Haque (2007) run a field experiment with 12 exotic potato germplasm to determine their suitability as a variety in Bangladesh. He found that all the varieties gave more than 90% emergence at 20-35 DAP. He also observed that Plant height (cm) of Quincy was (87.8), Sagitta (65.8), Diamant (62.6); no. of stems hill-1 was counted in Diamant (7.2), Quincy (4.5), Sagitta (4.4); Plant diameter (cm) of Sagitta was (4.0), Quincy (3.7), Diamant (2.6) at 60 DAP; Foliage coverage (%) of Sagitta was (100.0), Diamant (98.3), Quincy (96.6); No. of tubers plant-1 of Diamant was (13.06), Sagitta (8.34), Quincy (6.71); Wt. of tubers plant-1 (kg) of Quincy was (0.64), Sagitta (0.63), Diamant (0.49); dry matter (%) of Sagitta was (20.8), Diamant (20.1), Quincy (18.5).

Behjati *et al.,* (2013) observed a field experiment to evaluate the yield and yield components on promising potato clones. Clone No. 397031-1, had the highest yield and Lady Rosetta variety had the lowest yield compared with other varieties. The lowest and highest average number of main stems plant-1, related to Lady Rosetta and clone No. 397067-2. Lady Rosetta variety had the highest number of tube plant-1 and clone No. 397067-2 had 25 the lowest number of tubers per plant. The lowest and highest average tuber weight per plant related to clone No. 397067-2 and Lady Rosetta variety respectively.

Anonymous (2005) evaluated twenty one varieties along with two standard checks Diamant and Granola at seven locations. The yields of the varieties varied from location to location as well as within location. Of all the stations, except Pahartoli, none crossed

the check variety Diamant but comparatively higher yields were produced by the varieties Espirit, Courage, Innovator, Quincy, Matador, Markies, Laura and Lady Rosetta.

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.

Mondol (2004) conducted an experiment to evaluate the performance of seven exotic (Dutch) varieties of potato. He found that plant height (cm) of Diamant was (18.07), Granola (13.47); no. of main stem hill-1 of Diamant (4.36), Granola (4.90); no. of tubers hill-1 of Diamant (12.00), Granola (10.93); Weight of tubers plant-1 (kg) of Diamant (0.57), Granola (0.39); dry matter (%) of Diamant (17), Granola (16.30).

Alam *et al.,* (2003) conducted a field experiment with fourteen exotic varieties of potato under Bangladesh condition. The highest emergence (91%) was observed from Cardinal which was statistically identical with most of the varieties except the variety Granola (63%). The highest number of stem hill-1 was recorded in Ailsa (4.59) followed by Cardinal (4.50). Significantly maximum number of leaves hill-1 was produced from the plants of the variety Ailsa (53.80), which was followed by Cardinal (49.75). The yields ranged of exotic varieties were 19.44 to 46.67 t ha-1. Variety Ailsa produced the maximum yield (46.67 t ha-1) which was followed by Cardinal (42.21 t ha-1).

Hossain (2000) conducted an experiment to study the effects of different levels of nitrogen on the yield of seed tubers in four potato varieties. He found that the tallest plants were produced by the seedling tubers of BARI TPS-1 (74.51 cm) and the shortest plants came from the variety Diamant (58.63 cm); foliage coverage (%) of Diamant at 75 DAP was (79.00), BARI TPS-1 (89.00); no. of stems hill-1 of Diamant was (3.50), BARI TPS-1 (2.71); no. of tubers hill-1 of Diamant was (7.85), BARI TPS-1 (9.55); Weight of tubers hill-1 of Diamant 30 was (416.67), BARI TPS-1 (491.33); dry matter of tuber (%) of Diamant was (19.71), BARI TPS-1 (18.18).

Das (2006) carried out an experiment to study the physio-morphological characteristics and yield potentialities of potato varieties. He found that Foliage coverage (%) of Diamant was (93.3), Asterix (71.7), Granola (66.7), Quincy (90.0), Courage (63.3), Felsina (83.3), Lady Rosetta (83.3), Laura (78.3); no. of tubers hill-1 of Diamant (11.7), Asterix (8.00), Granola (11.3), Quincy (9.33), Courage (7.33), Felsina (8.00) Lady Rosetta (10.3), Laura (8.33); tuber weight hill-1 (g) of Diamant (380), Asterix (285), Granola (275), Quincy (300), Courage (320), Felsina (333), Lady Rosetta (348), Laura (258); dry matter (%) of Diamant (25), Asterix (17.5), Granola (23), Quincy (31), Courage (34.5), Felsina (22.5), Lady Rosetta (22.0), Laura (27.0); Regarding size grade distribution of tubers the varieties Courage, Espirit, Granola, Lady rosetta, Laura were found superior.

2.3 Temperature effect

Ahmed *et al.,* (2017) was conducted an experiment on the performance of different potato varieties to different planting dates and they found highest number of tuber/plant (13) was recorded from December 5 sowing in var. BARI Alu-41. The highest leaf area was found in December 5 sowing of BARI Alu-40 while the lowest leaf area in November 20 sowing in var. BARI Alu-35. The highest tuber weight/plant (97.25 g) was observed in var. BARI Alu-5 at December 5 sowing and the lowest tuber weight/plant (25.58 g) in var. BARI Alu-35 at November 20 sowing. The maximum potato yield (42.12 t/ha) was obtained at December 5 sowing of BARI Alu-35 followed by same date of var. BARIAlu- 41. From the experiment it was revealed that the first decade of December is the optimum date for planting of potato due to the physiological maturity and tuber yield.

Rymuza *et al.,* (2015) was conducted an experiment based on data on monthly air temperature and precipitation and early potato yields in 2000-2013 obtained from seven COBORU (Research Centre for Cultivar Testing) stations and they found the relationships between potato yields and average monthly air temperatures and monthly precipitation of the growing season were studied with step-wise multiple regression followed by polynomial regression. Precipitation affected early potato yields more than temperature, particularly in June and July.

Fela *et al.,* (2017) was conducted an experiment on five potato varieties during the autumn and seven potato varieties during the winter season were evaluated for their vegetative growth performance under rain fed condition with the objective of evaluating the performance and adaptability of improved and local varieties and found that plant height and number of shoots were significantly influenced during autumn season of growth while during the winter cropping season, plant height and number of leaves per plant was significantly influenced by cultivars. Belete variety had the highest plant height and shoot numbers whereas; Local variety-1 (Father) had the lowest plant height and shoot number among the other varieties. Statistically significant differences were recorded among the varieties in leaf number during the winter season. The maximum number of leaves was recorded in Degemegn variety followed by Belete variety whereas; the least number of leaves was recorded in Gudene in the winter season. Tolcha variety had the least number of leaves per plant in the autumn cropping season.

Luthra *et al.,* (2013) was conducted an experiment onthe evaluation of potato genotypes under high temperature stress conditions on genetic parameters and character association were estimated for ten characters in 105 potato genotypes grown under high temperature stress conditions for identification of superior parents with high tuber yield and tolerance to mite damage and hopperburn and they found the results revealed high genetic variability, heritability and genetic advance for tuber yield and its components. Tuber yield possessed significant positive correlation with marketable tuber yield and average tuber weight. Tuber number were positively correlated with stem number and negatively correlated with average tuber weight. The results showed that parental lines could be selected based on tuber yield and its component characters; however, a compromise needs to be made between tuber number and average tuber weight for achieving high yield. Based on pooled performance over seasons, CP2297, CP2298, CP2346, CP2351, CP2364, CP2365 and Kufri Surya were identified as promising genotypes.

Lizan *et al.,* (2017) was conducted an experiment on the impact of moderately high temperatures on yield and physiological traits, during tuber bulking (TB) of two native Chilean varieties and three commercial varieties and they found the result on effect of temperature on yield and physiological performance of genotypes were dependent on the timing of heat treatments. T1 increased tuber yield by 11.59%, but T2 did not modify tuber yield. Yield sensitivity was highly dependent on genotype. Harvest index was the

most sensitive trait to increase temperature at T1, decreasing in the range of temperatures evaluated without reduction for tuber yield. Increased tuber yield at T1 was associated with higher intercepted radiation between flowering and 50% of leaf brownship, explained in part by elongation of this period and stomatal conductance of leaves.

Kooman *et al.,* (1996) conducted an experiement to find out the genotype environment interactions in potato. They found that the potential and actual dry matter production of potato crops in tropical and subtropical environments were found to be lower than in a temperate climate. The light-use efficiency correlated negatively with light intensity. Variation in length of the growing season appeared to be the most important factor explaining the differences in both total and tuber yield. The harvest index was of minor importance. The variation in length of the growing season between sites was related to daylength and temperature such that shorter days at emergence and higher temperatures throughout the season resulted in a shorter growth cycle. The extent of these effects differed between cultivars and could partly be explained in terms of ground cover duration, length of the growing season and average seasonal weather data.

Tang *et al.*, (2018) conducted an experiment on physiological and growth responses of potato cultivars to heat stress and found thatthe effects of heat stress on the leaf chlorophyll content, plant growth, and tuber yield of 55 commercial potato cultivars in clonal tests under heat-stress conditions [HS; 35 °C (day), 28 °C (night)] and control (non-stress) conditions [CK; 22 °C (day), 18 °C (night)]. The potato cultivars varied in their response to heat stress. Overall, heat stress reduced leaf size, increased the SPAD index values for leaf chlorophyll by up to 65%, and increased plant height by 64%, but severely reduced (by 93%) the mass of the largest tuber. The HS:CK SPAD ratios positively correlated with the HS:CK plant height ratio, mass of the largest tuber under heat stress, and the HS:CK ratio for mass of the largest tuber. Potato cultivars displayed a correlated response to heat stress for their leaf chlorophyll content, plant height, and tuber mass.

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

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

3.1 Experimental period

The experiment was conducted during the period from 04September, 2019 to 29 February, 2020 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The experimental area was situated at 25°58'48.3"N latitude and 88°15'52.2"E longitude at an altitude of 8.6 meter above the sea level.

3.2.2 Agro-Ecological Zone

The experimental site belongs to the agro-ecological zone ofOld Himalayan Piedmont Plain. This distinctive region is developed in an old Tista alluvial fan extending from the foot of the Himalayas. It has a complex relief pattern. Deep, rapidly permeable sandy loams and sandy clay loams are predominant in this region. They are strongly acidic in topsoil and moderately acidic in subsoils; low in weatherable K minerals. Seven general soil types occur in the region, of which non-calcareous brown floodplain soils, black terai soils, and non-calcareous dark grey floodplain soils predominate. Organic matter contents are generally higher than in most floodplain soils of Bangladesh. The natural fertility of the soil is moderate but well sustained. Soil fertility problems include rapid leaching of N, K, S, Ca, Mg and B. The experimental site was shown in the map of AEZ of Bangladesh (Figure 3.1).

3.2.3 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone during the months from 04 September, 2019 to 29 February, 2020 (Rabi season). Plenty of sunshine and moderately high temperature was prevailed during planting time (September) but after October it prevailed low temperature which was suitable for potato growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix I.

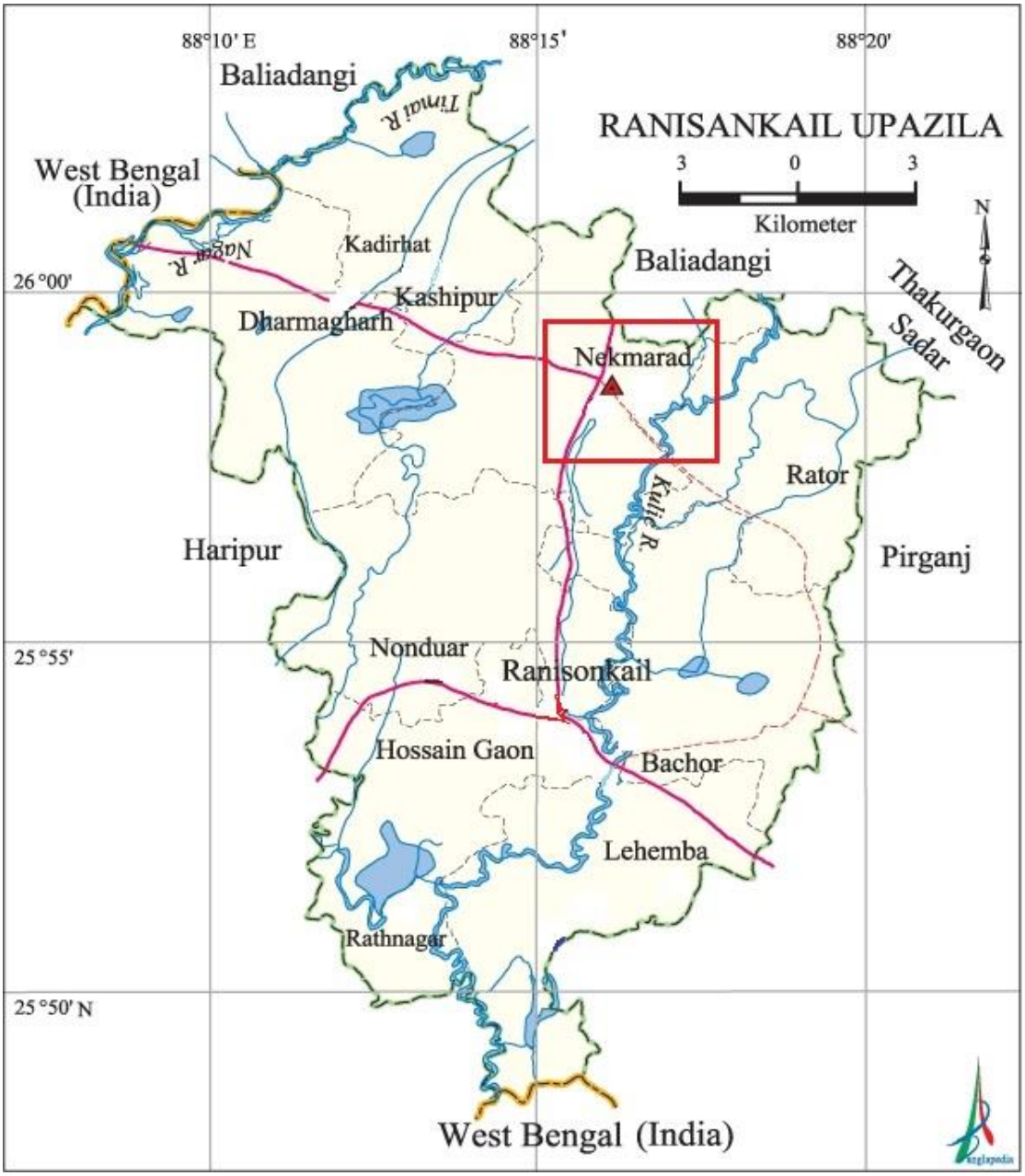


Figure 3.1: Map showing the experimental area (Source: google map)

3.3 Details of the Experiment

3.3.1 Experimental treatments

The experiment consisted of single factor such as variety. The treatments were V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

3.3.2 Experimental design

The experiment was laid out in a Randomized Complete Block Design with3 replications.

3.3.3 Plot size

The plot size was 3m × 3m. Distance between row to row was 50 cm and plant to plant distance was 25 cm. Distance between plot to plot was 40 cm.

3.4 Planting material

The planting materials comprised the certified seed tubers of fifteen potato varieties. The varieties were Carolus, Granula, Farida, Taisiya, BARI Alu-41, Aloutte, Zina red, BARI Alu-72, Columba, Memphis, Fortus, Cimega, Seven Four Seven, Asterix and Diamand.

3.5 Crop management

3.5.1 Collection of seed

All variety of seed potato (certified seed) was collected from, Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and from BARI sub-station. Individual weight of seed potato was 60-70 g.

3.5.2 Preparation of seed

Collected seed tubers were kept in room temperature to facilitate sprouting. Finally

sprouted potato tubers were used as a planting material.

3.5.3 Soil preparation

Research field was selected at the farmers field located at Nekmarad, Ranishankoil, Thakurgoan. The soil was sandy loam. The soil was ploughed 4-5 times by cross section and labeled the soil by laddering. Weeds and stubbles were completely removed from soil.

3.5.4 Fertilizer application

The experimental soil was fertilized with following dose of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid.

Fertilizers	**Dose (kg ha^{-1})**
Urea	250
TSP	150
MoP	250
Gypsum	120
Zinc Sulphate	10
Boric Acid	10

Source: Mondal *et al.,* (2011)

The entire amounts of triple superphosphate, muriate of potash, gypsum, zinc sulphate, boric acid and one third of urea were applied as basal dose at 7 days before potato planting. Rest of the urea was applied in two equal installments i.e., first was done at 30 days after planting (DAP) followed by first pouring the soil for complete the earthing up in the field and second was at 50 DAP followed by pouring the soil.

3.5.5 Planting of seed tuber

The well sprouted healthy and uniform sized potato tubers were planted according to treatment. Seed potatoes were planted in such a way that potato does not go much under soil or does not remain in shallow. On an average, potatoes were planted at 4-5 cm depth in soil on October 01, 2019.

3.5.6 Intercultural operations

3.5.6.1 Weeding

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

3.5.6.2 Watering

Two times irrigation was done in the field to keep upon moisture status of soil retained as requirement of plants. Excess water was not given, because it always harmful for potato plant.

3.5.6.3 Earthing up

Earthing up was done by pouring the soil in the base of the plant at two times, during crop growing period. First pouring was done at 45 days after planting and second was at 60 DAP.

3.5.6.4 Plant protection measures

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

3.5.6.5 Haulm cutting

Haulm cutting was done at December 23, 2019 at 85 DAP, when 40-50% plants showed senescence and the tops started drying. After haulm cutting the tubers were kept under the soil for 7 days for skin hardening. The cut haulm was collected, bagged and tagged separately for further data collection.

3.5.6.6 Harvesting of potatoes

Harvesting of potato was done at January1, 2020 at 7 days after haulm cutting. The potatoes of each plot were separately harvested, bagged and tagged and brought to the laboratory. The yield of potato plot^{-1} was determined in kg. Harvesting was done manually by hand.

3.5.7 Recording of data

Experimental data were recorded from 30 DAP and continued until harvest. Dry weights of different plant parts were collected after harvesting. The following data were collected during the experimentation.

A. Crop growth characters

i. Days to start emergence

i. Days to 80% emergence

ii. Percent of emergence at 30 DAP

iii. Plant height

iv. Number of stems hill^{-1}

v. Percent of foliage coverage plant^{-1}

B. Yield and yield contributing characters

vi. Number of Tuber

vii. Average weight of tuber

viii. Marketable yield

ix. Yield (t ha^{-1})

C. Quality characters

xi. Dry matter (%)

xii. Specific gravity (g cm^{-3})

3.5.8 Experimental measurements

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

A. Crop growth characters

i. Days to first emergence: After planting the potato tuber keenly observed the first emergence in each plot twice in a day (morning and afternoon).

ii. Days to 80% emergence: The plot was keenly observed the 80% emergence.

iii. Percent of emergence at 30 DAP: The plot was keenly observed the percentage of emergence at 30 DAP.

iv. Plant height (cm): Plant height refers to the length of the plant from ground level to the tip of the tallest stem. It was measured one time at 60 DAP. The height of each plant of each plot was measured in cm with the help of a meter scale and mean was calculated.

v. Foliage coverage plant^{-1}: Foliage coverage plant^{-1} was measured at 60 DAP. Leaves number plant-1 were recorded by counting all leaves from each plant of each plot and mean was calculated.

v. Number of stems hill^{-1}: Number of stems hill^{-1} was counted 60 DAP. Stem numbers hill^{-1} was recorded by counting all stem from each plot.

B. **Yield and yield components**

i. Yield of tuber plot^{-1}: Tubers of each plot were collected separately from which yield of tuber per plot was recorded in kg.

ii. Average weight of tuber (g): Average weight of tuber was measured by using the following formula-

Average weight of tuber = Yield of tuber per plot/Number of tuber per plot

C. Quality characters

i. Tuber flesh dry matter content (%): The samples of tuber were collected from each treatment. After peel off the tubers the samples were dried in oven at 72°C for 72 hours. From which the weights of tuber flesh dry matter content % were recorded.

ii. Specific Gravity (gcm^{-3})

It was measured by using the following formula (Gould, 1995)-

Specific gravity = Weight in air/Weight in water at 4^0C

3.5.9 Statistical Analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using STATISTIX 10 software and Microsoft Excel 2007. The significant differences among the treatment means were compared by Tukey HSD test at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

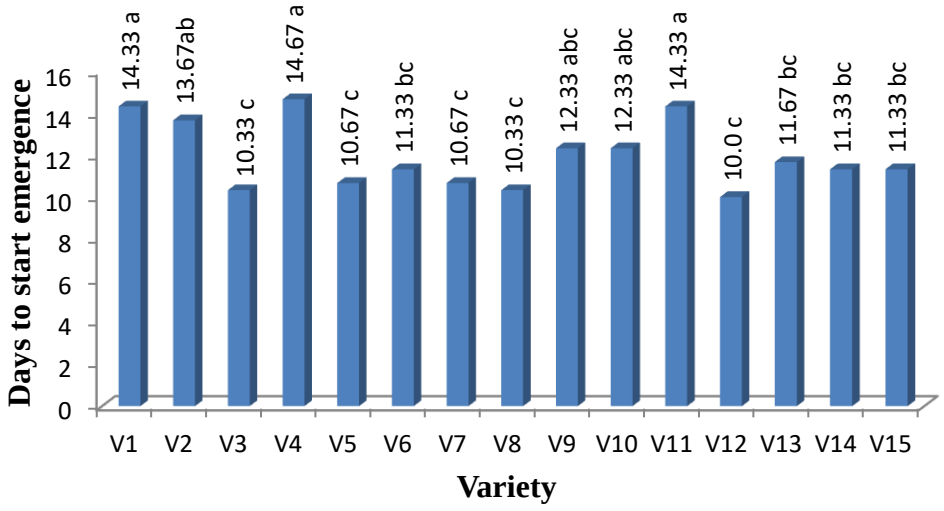
RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of early heat condition on different potato varieties. The results obtained from the study have been presented, discussed and compared in this chapter through figures and appendices. The analysis of variance of data in respect of all the parameters have been shown in Appendix II-XIV. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings.

4.1 Crop growth characters

4.1.1 Days to start emergence (visual observation)

Days to start emergence was significantly influenced by the different potato varieties (Figure.4.1 and Appendix II). Results revealed that the variety 'Taisiya' took the maximum days (14.67 days) for start emergence whereas, the minimum (10 days) was taken by 'Cimega'.This result showed that 'Taisiya' was the early to start emergence variety whereas, 'Cimega' was the late one. This might be due to varietal characters. Chandra (2015) also found similar results in his experiment in different potato varieties.

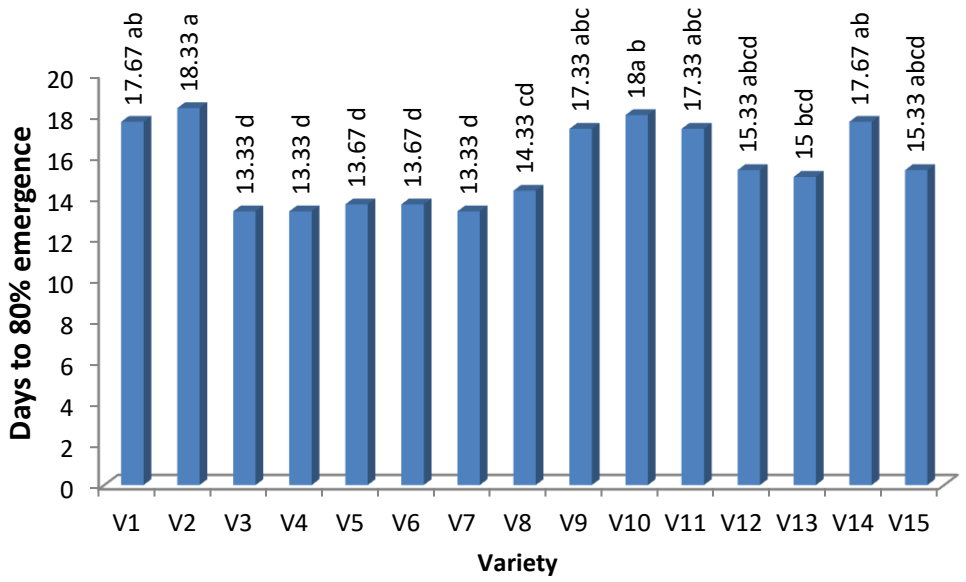


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.1: Effect of varieties on days to start emergence of potato

4.1.2 Days to 80% emergence (visual observation)

Days to 80% emergence was significantly influenced by the different potato varieties (Figure.4.2 and Appendix III). Results revealed that the variety 'Granula' took the maximum days (18.33 days) for 80% emergence whereas, the minimum days (13.33 days) was taken by 'Zina red'. This result showed that 'Granula' was the early to 80% emergence whereas, 'Zina red' was the late one. This might be due to varietal characters.

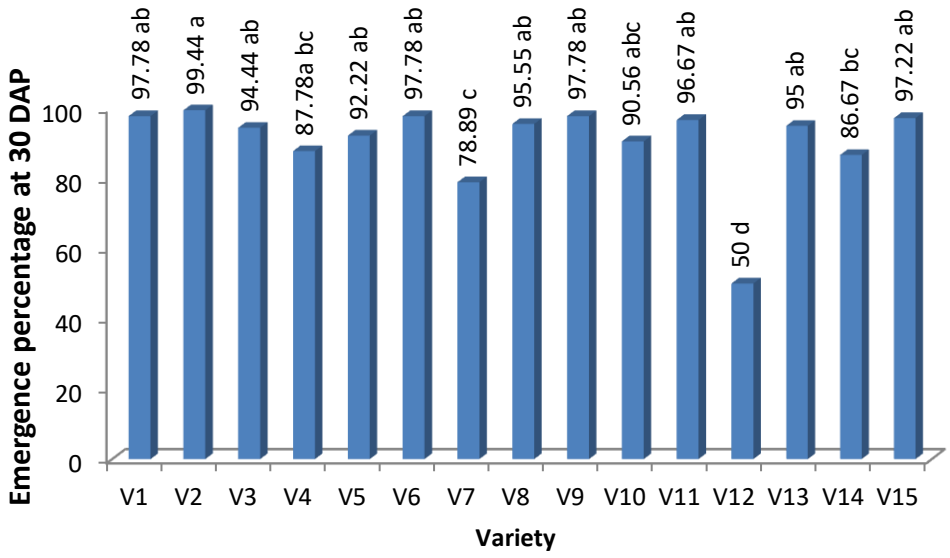


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.2: Effect of varieties on days to 80% emergence of potato

4.1.3 Percent of emergence at 30 DAP (visual observation)

The emergence percentageat 30 DAP was significantly influenced by the different potato varieties (Figure.4.3 and Appendix IV). Results revealed that the emergence percentage of the variety 'Granula' was maximum (99.44%) at 30 DAP whereas, the minimum (50%) was measured from'Cimega'.This result showed that 'Granula' was the best variety whereas, 'Cimega' was the poor one to early heat condition. A previous report (Alam *et. al.,* 2003) indicated that the rate of emergence among fourteen exotic varieties varied from 70 to 91 % which was closely related to these findings.

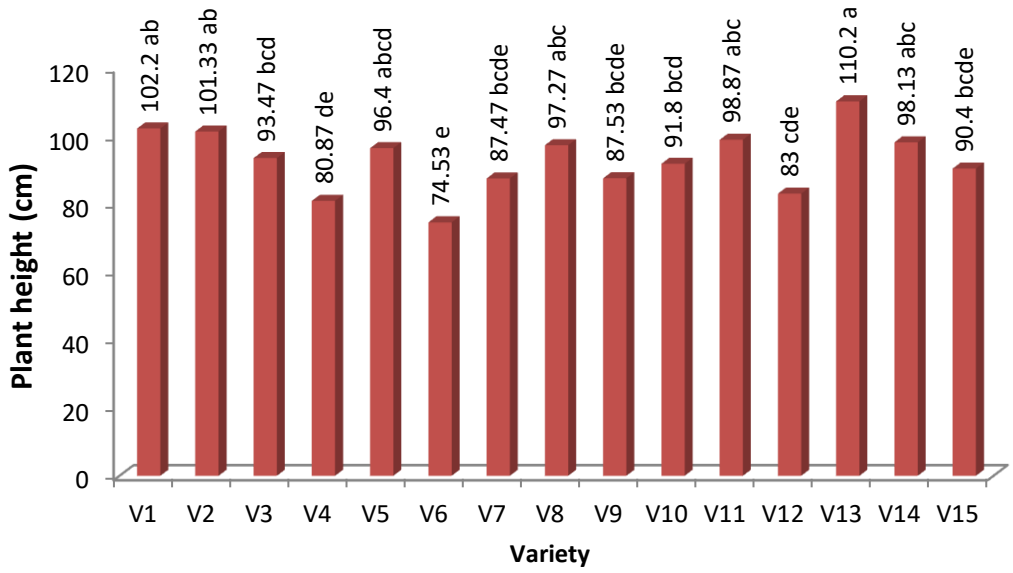


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.3: Effect of varieties on emergence percentage of potato at 30 DAP

4.1.4 Plant height (cm)

The plant height of potato varieties were measured at 60 DAP. It was evident fromFigure 4.4 and Appendix V that the height of plant was significantly influenced by thevariety. Result revealed that longest plant height (110.2 cm) was measuredat 60 DAP from'Seven Four Seven' variety whereasthe shortest one (74.53 cm) from 'Aloutte'. The numerical different of plant height of a crop depends on the plant vigor, cultural practices, growing environment and the varietal characters. In the present experiment since all the varieties were grown in the same environment and were given same cultural practices, the variation in the plant height among the varieties might be due to the varietal character.Height is a quantitative trait controlled by many genes, therefore, it is highly influenced by environmental factors like nutrient status of the soil, available soil moisture and intercepted radiation (Singh and Singh, 1973). This suggestion is consistent with that of Elfinesh`s (2008) finding, who reported varietal difference across locations in plant height and Chandra (2015) also found significance influence of varietal effect in plant height.

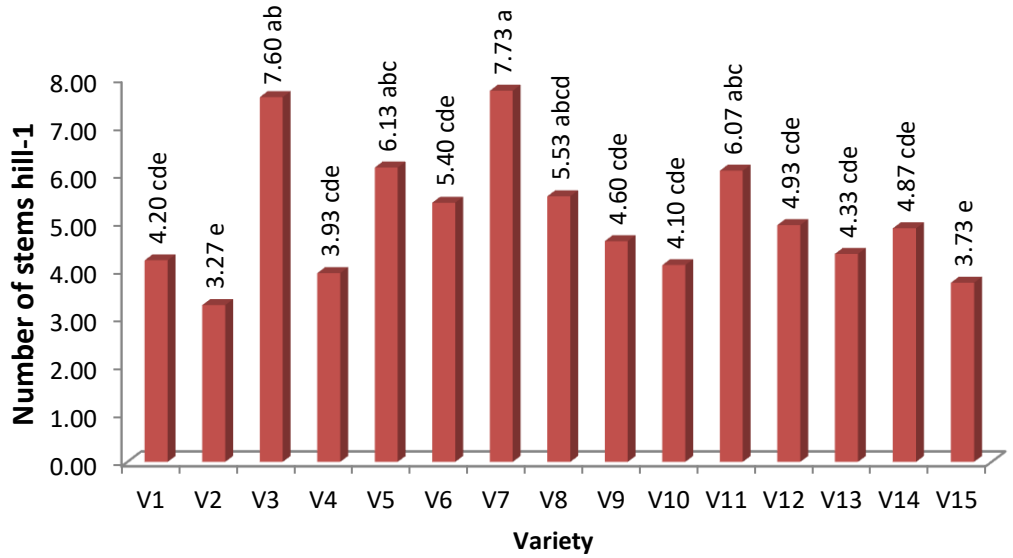


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.4: Effect of varieties on plant height (cm) of potato at 60 DAP

4.1.5 Number of stems hill^{-1}

The number of stems hill^{-1} was significantly varied among the varieties at 60 DAP (Figure 4.5 and Appendix VI).



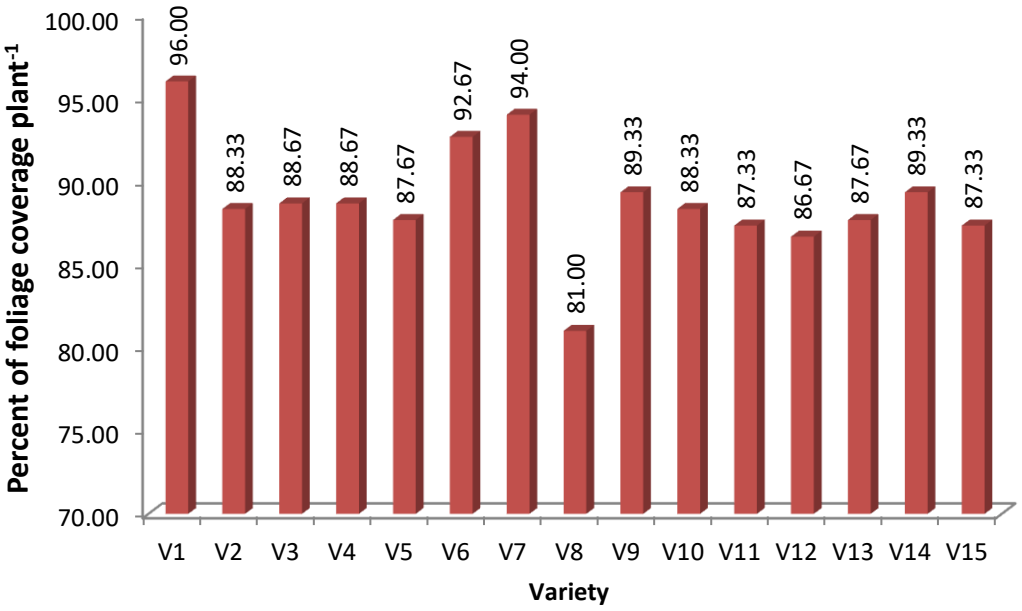
Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.5: Effect of varieties on number of stems hill^{-1} of potato at 60 DAP

Result revealed that the maximum stem numbers hill^{-1} (7.73) was obtained from the variety 'Zina red' at 60 DAP which statistically similar with the variety 'Farida' (7.60) whereas the minimum (3.27) was obtained from the 'Granula' which was statistically similar with 'Taisiya' (3.93). This might be due to varietal characters.This result is consistent with that of Morena et al. (1994) who showed that the number of stems per plant is influenced by variety.

4.1.5 Percent of foliage coverage plant^{-1}

Different varieties exhibited significant variation in respect of number of leaves plant^{-1} of potato at 60 DAP (Figure 4.6 and Appendix VII). The percent of foliage coverage plant^{-1}at 60 DAP was significantly influenced by the different potato varieties (Fig. 4.6). At 60 DAP, the maximum percentage of foliage coverage plant^{-1} (96.00%) was observed from the variety 'Carolus' whereas the minimum number (81.00%) was observed from 'Zina red'.



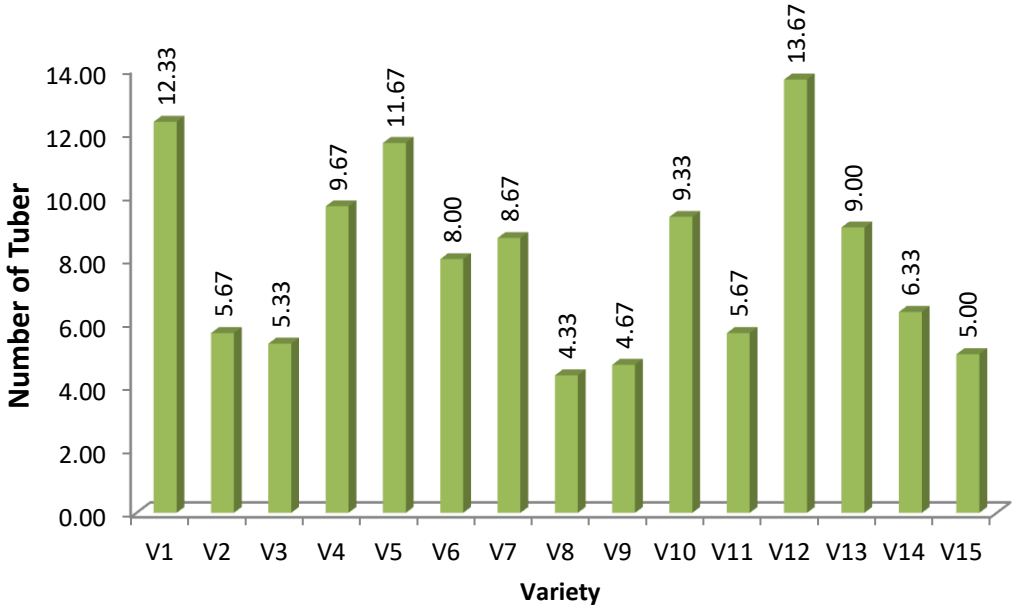
Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.6: Effect of varieties on percent of foliage coverage plant^{-1} of potato at 60 DAP

4.2 Yield and yield components

4.2.1 Number of Tuber

The number of tuber plant^{-1} varied significantly due to different varieties (Figure 4.7 and Appendix VIII). Result revealed that the maximum number of tuber (13.67) was recorded from the 'Cimega' variety whereas, the minimum (4.33) was obtained from the 'BARI Alu-72' variety.

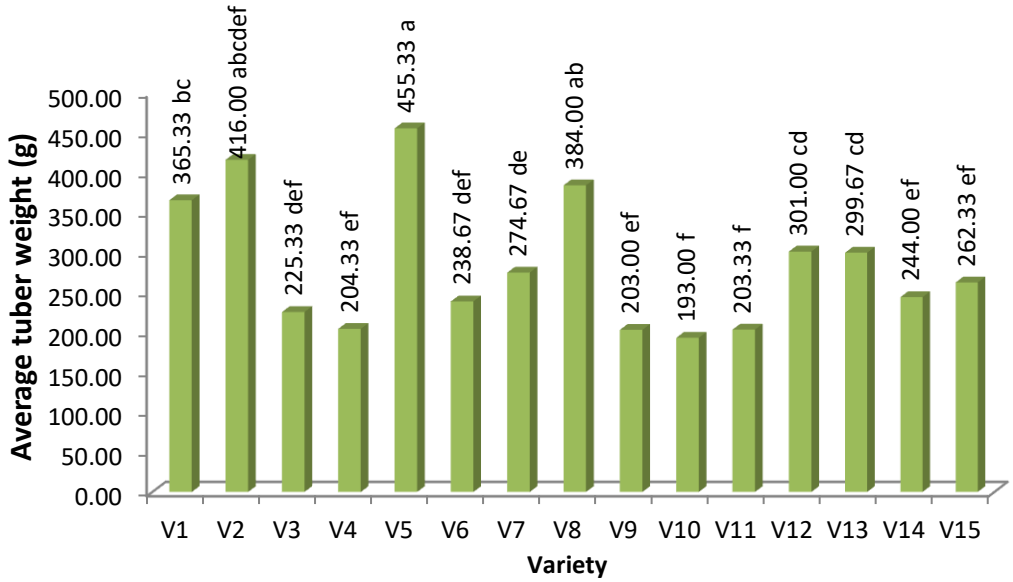


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.7. Effect of varieties on the number of tuber of potato

4.2.2 Average tuber weight (g)

The average tuber weight varied significantly due to different varieties (Figure 4.8 and Appendix IX). The maximum average tuber weight (455.33 g) was recorded from the 'Carolus' variety whereas, the minimum (193.00 g) was obtained from the 'Memphis' variety.

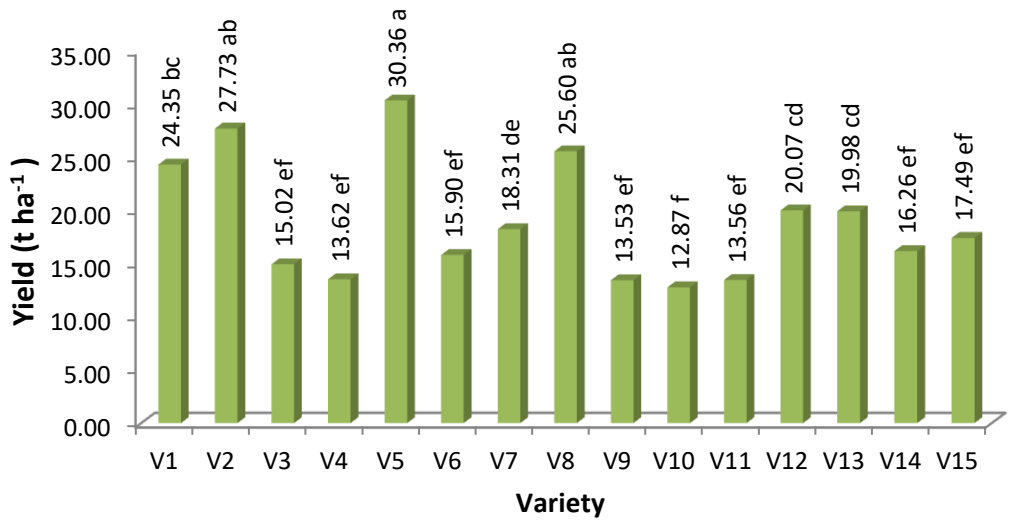


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.8. Effect of varieties on average tuber weight of potato

4.2.3 Yield (t ha^{-1})

Variety had significant effect on the yield of tuber t/ha (Figure 4.9 and Appendix X). The highest tuber yield (30.36 t ha^{-1}) was obtained from the variety 'BARI Alu-41' while the minimum (12.87 tha^{-1}) was found from the 'Memphis'.



Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

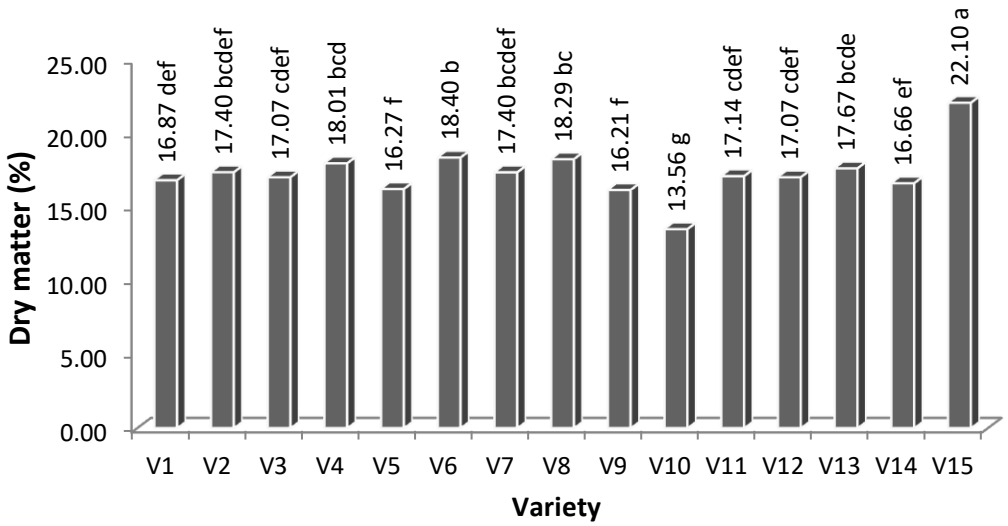
Figure 4.9 Effect of varieties on yield of potato tuber

The yields of different cultivars of potato were significantly different from each other reported by Kundu *et al.* (2012). Similar trend of yield performance was also reported by Hossain (2011), Dhar *et al.* (2009) and Das (2006). The probable reason for variation in yield due to the heredity of the variety, difference in agro-ecological condition and soils of the experimental site.

4.3 Quality characters

4.3.1 Dry matter (%)

Dry matter (%) content showed significant variations among the potato varieties (Figure 4.10 and Appendix XI). The maximum dry matter content of tuber flesh (22.10 %) was recorded from the variety 'Fortus' which statistically similar with 'Diamant' (21.52 %). The minimum tuber flesh dry matter content (13.56 %) was recorded from 'Aloutte'. The variation in dry matter content among the potato varieties were also observed by Suyre *et al.* (1975), Lana *et al.* (1970) and Capezio (1987). Variation in tuber dry matter content may be attributed to cultivars inherent in the production of total solids. Burton (1966) reported that genetic differences among varieties a role in their ability to produce high solids when grown on the same test plot. Dry matter content is subjected to the influence of both the environment and genotypes (Miller *et al.*, 1975; Tai and Coleman, 1999).

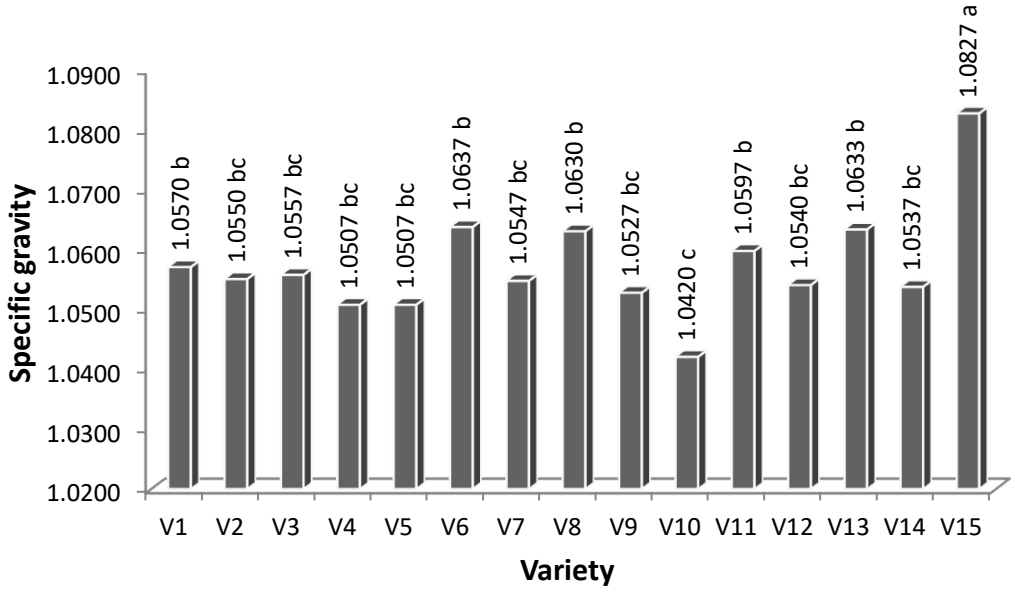


Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.10: Effect of varieties on dry matter (%) on potato tuber

4.3.2 Specific gravity

In present study varieties had significant effect on specific gravity (Figure 4.11 and Appendix XII). Numerically the highest specific gravity (1.0827 g cm^{-3}) was obtained from the 'Diamand' whereas, the lowest (1.0420 g cm^{-3}) specific gravity was found from the 'Memphis' variety. Asmamaw *et al.* (2010) and Elfnesh *et al.* (2011) reported a specific gravity ranging them 1.06 to 1.09 and 1.08 to 1.10, respectively in two separate experiments with nine potato varieties during evaluated their processing quality. Ekin (2011) also reported specific gravity values ranging from 1.07 to 1.08 from a study of eight potato varieties over two consecutive years.



Note: V_1 - Carolus, V_2 - Granula, V_3 - Farida, V_4 - Taisiya, V_5 – BARI Alu-41, V_6 - Aloutte, V_7 – Zina red, V_8 – BARI Alu-72, V_9 - Columba, V_{10} - Memphis, V_{11} - Fortus, V_{12} - Cimega, V_{13} – 747, V_{14} - Asterix and V_{15} - Diamant.

Figure 4.11: Effect of varieties on specific gravity of potato

CHAPTER V

SUMMARY, CONCLUSION AND RECOMMENDATIONS

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SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The experiment was conducted at the farmers field located at Nekmarad, Ranishankoil, Thakurgoan from September 04, 2019 to February 29, 2020 to find out the growth and yield performance of different potato varieties to early heat condition under the Old Himalayan Piedmont Plain (AEZ-1). Single factor experiment included 15 potato varieties *viz.* Carolus, Granula, Farida, Taisiya, BARI Alu-41, Aloutte, Zina red, BARI Alu-72, Columba, Memphis, Fortus, Cimega, Seven Four Seven, Asterix and Diamandwas outlined in Randomized Complete Block Design (RCBD) with three replications.

The data on crop growth parameters viz days to start emergence, days to 80% emergence, percent of emergence at 30 DAP, plant height, number of stems hill^{-1} and percent of foliage coverage plant^{-1} at different growth stages. Yield parameters like yield of tuber (t ha^{-1}) and, average weight of tuber (g) were recorded after harvest. Quality character parameters like specific gravity and dry matter percentage were recorded after harvest. Data were analyzed using Statistics 10 software and Microsoft Excel 2007. The mean differences among the treatments were compared by Tukey HSD Test at 5% level of significance.

Results showed that variety hadsignificant effect on growth parameters like days to start emergence, days to eighty percent emergence, percent emergence at 30 DAP, plant height and number of stem hill^{-1}but no significance effect observed in percent of foliage coverage plant^{-1}.In case of start emergance 'Taisiya' took the maximum days (14.67 days) to emerge out and 'Cimega' took minimum (10 days) to emergence. On the other hand 'Granula' took the maximum days (18.33 days) for 80% emergence whereas, the minimum days (13.33 days) was taken by 'Zina red'. Again the emergence percentage of the variety 'Granula' was maximum (99.44%) at 30 DAP whereas, the minimum (50%) was measured from 'Cimega'. Longest plant height (110.2 cm) was measured from 'Seven Four Seven'at 60 DAP whereas the shortest one (74.53 cm) from 'Aloutte'. The numerical different of plant height of a crop depends on the plant vigor, cultural

practices, growing environment and the varietal characters. The maximum stem numbers hill^{-1} (7.73) was obtained from the 'Zina red' at 60 DAP which statistically similar with the variety 'Farida' (7.60) whereas the minimum (3.27) was obtained from the 'Granula' which was statistically similar with 'Taisiya' (3.93). In case of foliage coverage at 60 DAP, the maximum percentage of foliage coverage plant^{-1} (96.00%) was observed from the 'Carolus' whereas the minimum number (81.00%) was observed from 'Zina red'.

Considering the yield contributing charater, result revealed that there was no significance effect of variety on the number of potato tubers but variety had significant effect on yield and average tuber weight. The maximum number of tuber (13.67) was recorded from the 'Cimega' and the minimum (4.33) was obtained from the 'BARI Alu-72'. In case of tuber wight, the highest average tuber weight (455.33 g) was recorded from the 'Carolus' whereas, the lowest (193.00 g) was obtained from the 'Memphis'. Consequently the highest yield (30.36 t ha^{-1}) was obtained from the 'BARI Alu-41' while the minimum (12.87 t ha-1) was found from the 'Memphis'.

In case of quality parameters, result showed significant varietal effect on dry matter percentage and specific gravity.The maximum dry matter content of tuber flesh (22.10 %) was recorded from the 'Fortus' which statistically similar with 'Diamand' (21.52 %) and minimum dry matter content (13.56 %) was recorded from 'Aloutte'. Consequently the highest specific gravity (1.0827 g cm-3) was obtained from the 'Diamand' whereas, the lowest (1.0420 g cm-3) specific gravity was found from 'Memphis'.

Considering the results of the present experiment, it may be concluded that early heat condition had potential effect on growth and yeild performance of potato.

5.2 Conclution

Increasing population and increasing food demand is creating continuous pressure on nature. Every year Bangladesh is seriously facing adverse environmental effects. Negative impact of abiotic stresses (temperature and water) due to changing climate scenario is expected to increase in coming decades on potato production and its extension in non-traditional areas. A complete mitigation of heat and water stress is impossible. Several potato clones which are relatively able to maintain higher yields at high temperatures have been identified in field evaluation. The growth and yield of

different potato varieties are affected by early heat condition i.e. early winter (month of September) and varietal characters. All fifteen varieties of potato variably responded to early heat condition. The higher potato yield was observed from 'BARI Alu-41'. 'BARI Alu-41' was the best variety with respect to yield. The present study emphasizes on the production of early potato in early heat condition.

5.3 Recommendation

Considering the trend of population growth and consequently the increased demand for food in the country and the dwindling cultivable land area and early production of potato, the potato is likely to play a very important role in the future. From the present research work findings the following recommendations may be considered.

1. Farmers of the nothwestern part of Bangladesh like Dinajpur, Thakurgoan etc. District can cultivate 'BARI Alu-41' and this variety in early heat condition like early winter to get maximum income.
2. This study was cinducted in a single location. So, for valid recommendation, repeated study in different location of Bangladesh are needed.

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APPENDICES

APPENDICES

Appendix I. Monthly meteorological information during the period from September, 2019 to February, 2020

Year	Month	Air temperature (C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	September	31.7	25.3	89	362.5
	October	31.0	22.3	87	156.8
	November	28.10	11.83	58.18	47
	December	25.00	9.46	69.53	0
2020	January	23.98	10.47	73.86	Trace
	February	26.45	14.83	75.38	Trace

Source: Metrological Centre, Dinajpur (Climate Division)

Appendix II. Randomized Complete Block ANOVA table for days to start emergence of potato

Source	DF	SS	MS	F	P
Replication	2	0.578	0.28889	12.72	0**
Variety	14	106.578	7.6127		
Error	28	16.756	0.59841		
Total	44	123.911			

** = Significant at 5% level of probability

Appendix III. Randomized Complete Block ANOVA table for days to 80% emergence of potato

Source	DF	SS	MS	F	P
Replication	2	4.444	2.2222	11.22	0**
Variety	14	158.311	11.3079		
Error	28	28.222	1.0079		
Total	44	190.978			

** = Significant at 5% level of probability

Appendix IV. Randomized Complete Block ANOVA table for percentage of emergence at 30 DAP of potato

Source	DF	SS	MS	F	P
Replication	2	58.7	29.351	27.06	0**
Variety	14	6550.47	467.891		
Error	28	484.13	17.29		
Total	44	7093.3			

** = Significant at 5% level of probability

Appendix V. Randomized Complete Block ANOVA table for plant height at 60 DAP of potato

Source	DF	SS	MS	F	P
Replication	2	37.81	18.905	9.33	0**
Variety	14	3606.92	257.637		
Error	28	772.99	27.607		
Total	44	4417.72			

** = Significant at 5% level of probability

Appendix VI. Randomized Complete Block ANOVA table for number of stems hill^{-1}of potato

Source	DF	SS	MS	F	P
Replication	2	1.4591	0.72956	9.49	0**
Variety	14	74.3524	5.31089		
Error	28	15.6676	0.55956		
Total	44	91.4791			

** = Significant at 5% level of probability

Appendix VII. Randomized Complete Block ANOVA table for percent of foliage coverage plant-1of potato

Source	DF	SS	MS	F	P
Replication	2	254.8	127.4	0.96	0.5132^{NS}

Variety	14	501.2	35.8		
Error	28	1043.2	37.257		
Total	44	1799.2			

NS = Not significant

Appendix VIII. Randomized Complete Block ANOVA table for number of tuber of potato

Source	DF	SS	MS	F	P
Replication	2	1.378	0.6889	2.36	0.0257^{NS}
Variety	14	373.911	26.7079		
Error	28	316.622	11.3079		
Total	44	691.911			

NS = Not significant

Appendix IX. Randomized Complete Block ANOVA table for average weight of tuber potato

Source	DF	SS	MS	F	P
Replication	2	930	464.9	29.8	0**
Variety	14	297814	21272.4		
Error	28	19986	713.8		
Total	44	318730			

** = Significant at 5% level of probability

Appendix X. Randomized Complete Block ANOVA table for yield of potato

Source	DF	SS	MS	F	P
Replication	2	4.17	2.0864	29.83	0**
Variety	14	1323.81	94.5581		
Error	28	88.76	3.1699		
Total	44	1416.74			

** = Significant at 5% level of probability

Appendix XI. Randomized Complete Block ANOVA table for dry matter percent of potato

Source	DF	SS	MS	F	P
Replication	2	0.184	0.09194	54.05	0**
Variety	14	1.29E+02	9.18E+00		
Error	28	4.76E+00	1.70E-01		
Total	44	1.34E+02			

** = Significant at 5% level of probability

Appendix XII. Randomized Complete Block ANOVA table for specific gravity of potato

Source	DF	SS	MS	F	P
Replication	2	3.99E-04	2.00E-04	10.29	0**
Variety	14	3.42E-03	2.45E-04		
Error	28	6.65E-04	2.38E-05		
Total	44	4.49E-03			

** = Significant at 5% level of probability

Appendix XIII. Tukey HSD Pairwise Comparisons Test of growth characters of different potato varieties

Variety	**Days to start emergence**	**Days to 80% emergence**	**Percent of emergence at 30 DAP**	**Plant height at 60 DAP**	**Number of stems/ hill**	**% of foliage coverage/ plant**
V1	14.33a	17.67ab	97.78ab	102.20ab	4.20cde	96.00a
V2	13.67ab	18.33a	99.44a	101.33ab	3.27e	88.33a
V3	10.33c	13.33d	94.44ab	93.47bcd	7.60ab	88.67a
V4	14.67a	13.33d	87.78abc	80.87de	3.93cde	88.67a
V5	10.67c	13.67d	92.22ab	96.40abcd	6.13abc	87.67a
V6	11.33bc	13.67d	97.78ab	74.53e	5.40bcde	92.67a
V7	10.67c	13.33d	78.89c	87.47bcde	7.73a	94.00a

V8	10.33c	14.33cd	95.55ab	97.27abc	5.53abcd	81.00a
V9	12.33abc	17.33abc	97.78ab	87.53bcde	4.60cde	89.33a
V10	12.33abc	18.00ab	90.56abc	91.80bcd	4.10cde	88.33a
V11	14.33a	17.33abc	96.67ab	98.87abc	6.07abc	87.33a
V12	10.00c	15.33abcd	50.00d	83.00cde	4.93cde	86.67a
V13	11.67bc	15.00bcd	95.00ab	110.20a	4.33cde	87.67a
V14	11.33bc	17.67ab	86.67bc	98.13abc	4.87cde	89.33a
V15	11.33bc	15.33abcd	97.22ab	90.40bcde	3.73de	87.33a
CV (%)	6.47	6.44	4.59	5.66	14.68	6.67

Appendix XIV. Tukey HSD Pairwise Comparisons Test of yield and quality characters of different potato varieties

Variety	**Number of Tuber**	**Average tuber weight (Kg)**	**Yield t ha^{-1}**	**Dry matter (%)**	**Specific gravity**
V1	12.33a	365.33bc	24.35bc	16.87def	1.0570b
V2	5.67a	416.00abcdef	27.73ab	17.40bcdef	1.0550bc
V3	5.33a	225.33def	15.02def	17.07cdef	1.0557bc
V4	9.67a	204.33ef	13.62ef	18.01bcd	1.0507bc
V5	11.67a	445.33a	30.36a	16.27f	1.0507bc
V6	8.00a	238.67def	15.90def	18.40b	1.0637b
V7	8.67a	274.67de	18.31de	17.40bcdef	1.0547bc
V8	4.33a	384.00ab	25.60ab	18.29bc	1.0630b
V9	4.67a	203.00ef	13.53ef	16.21f	1.0527bc
V10	9.33a	193.00f	12.87f	13.56g	1.0420c
V11	5.67a	203.33ef	13.56ef	17.14cdef	1.0597b
V12	13.67a	301.00cd	20.07cd	17.07cdef	1.0540bc
V13	9.00a	299.67cd	19.98cd	17.67bcde	1.0633b
V14	6.33a	244.00def	16.26def	16.66ef	1.0537bc
V15	5.00a	262.33def	17.49def	22.10a	1.0827a
CV (%)	42.27	9.39	9.38	2.38	0.46

LIST OF PLATES

Plate 1: Experimental view

Plate 2: Data collection stage

Plate 3: Laboratory work