SCREENING OF PROCESSING QUALITY POTATO VARIETIES FOR INDUSTRIAL PURPOSE AND ENHANCING THEIR QUALITY THROUGH VERMICOMPOST APPLICATION

MD. AYNUL HAQUE

DEPARTMENT OF AGRONOMY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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By

MD. AYNUL HAQUE

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Approved By:

____
Prof. Dr. Tuhin Suvra Roy
Chairman
Advisory Committee

____
Prof. Dr. Md. Shahidur Rashid Bhuiyan
Member
Advisory Committee

____
Prof. Dr. Parimal Kanti Biswas
Member
Advisory Committee

____
Prof. Dr. Md. Asaduzzaman Khan
Member
Advisory Committee

DEPARTMENT OF AGRONOMY
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207
Phone: +88 02 44814085

CERTIFICATE

This is to certify that the dissertation titled, "SCREENING OF PROCESSING QUALITY POTATO VARIETIES FOR INDUSTRIAL PURPOSE AND ENHANCING THEIR QUALITY THROUGH VERMICOMPOST APPLICATION" submitted to the ***DEPARTMENT OF AGRONOMY,*** *Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka in partial fulfillment of the requirements for the degree of* ***DOCTOR OF PHILOSOPHY (PhD)*** *in* ***AGRONOMY*** *embodies the result of a piece of bona fide research work carried out by* ***MD. AYNUL HAQUE, REG. NO: 15-06897*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated:
Place: Dhaka, Bangladesh

(Professor Dr. Tuhin Suvra Roy)
Chairman
Advisory Committee

Dedicated to

"My heavenly Parents"

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The Author

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ABSTRACT

Good quality potato is the main bottleneck for the expansion and improvement of potato processing industry in Bangladesh. Application of suitable organic manure *viz.*, vermicompost also with required fertilizers might be improved its processing quality. From the perspective, four years consecutive experiments were carried out in the research field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 from November, 2015 to April, 2018. Thirty six (36) potato varieties were used as treatment under experiment 1 namely: BARI Alu-25 (Asterix), Cardinal, Rojato, BARI Alu-70 (Destiny), Festa Pakri, Tel Pakri, Bot Pakri, Stick, Dora, Granolla, BARI Alu-68 (Atlantic), Raja, Binella, Dheera, Sagita, Patrones, BARI Alu-29 (Courage), Provento, Felsina, Multa, BARI Alu-28 (Lady Rosetta), Meridian, Forza, Saikat, Laura, Ailsa, Cumbica, Omera, Rumba, Jerla, Elgar, BARI Alu-71 (Doly), Agila, Quincy, Almerah and Steffi. The experiment 2 comprised of two factors *viz.*, factor A: 4 Variety; V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage), V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady Rosetta) and factor B: 5 Vermicompost levels; Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}. The experiment 3 comprised of three factors namely, factor A: 6 Variety; V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage), V_3= BARI Alu-28 (Lady Rosetta), V_4= Alu-25 (Asterix), V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly); factor B: 2 Vermicompost levels; Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1} and factor C: 2 Harvesting period; H_1= 90 days after planting (DAP) and H_2= 100 DAP. The experiment 4 comprised of three factors namely, factor A: 4 Variety; V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly), V_3= BARI Alu-28 (Lady Rosetta) and V_4= BARI Alu-25 (Asterix); factor B: 2 Vermicompost levels; Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1} and factor C: Harvesting period (2): H_1= 90 days after planting (DAP) and H_2= 100 DAP. The design used in the experiment 1, 2, 3 and 4 were RCBD, Split-plot, Split-split-plot and Split-split-plot design, respectively with three replications. The results revealed that, the variety and/or vermicompost and/or harvesting time have significantly influenced most of the parameters studied under all experiments. Among the thirty six potato varieties, Lady Rosetta, Asterix, Courage, Destiny, Doly and BARI Alu-68 exhibited the best results for tuber yield, specific gravity and dry matter content in experiment 1. In experiment 2, Lady rosetta and Asterix performed better for yield and processing qualities of potato. Vermicompost application at the rate of 9 t ha^{-1} and 12 t ha^{-1} also exhibited the best two doses for yield and processing qualities of potato over control. In experiment 3, Lady rosetta, Asterix, Destiny and Doly showed better for yield and processing qualities of potato compared to those other varieties. Vermicompost application at the rate of 9 t ha^{-1} showed the best one and potato harvested at 90 DAP exhibited the best performance for most of the parameters studied. In experiment 4, the Lady rosetta and Asterix showed better for yield, processing and sensory traits of potato in combination with vermicompost at the rate of 9 t ha^{-1} and tubers harvested at 90 DAP. Asterix in combination with vermicompost at the rate of 9 t ha^{-1} and tubers harvested at 90 DAP gave the highest monetary advantages (945,960 Tk). On the other hand, in case of lower reducing sugar and minimum sweetness, vermicompost at the rate of 12 t ha^{-1} and tubers harvested at 90 DAP produced good quality potato. Finally, it may be concluded that the potato growers may use the variety, Lady rosetta and Asterix for better yield and good processing qualities under the prevailing climatic condition of AEZ-28 (Madhupur Tract) with the combination of vermicompost at the rate of 9 t ha^{-1} and the tuber should be harvested at 90 DAP for producing good quality potato.

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LIST OF ACCRONYMS AND ABBREVIATIONS

AEZ	Agro-Ecological Zone
%	Percentage
@	At the rate of
Agric.	Agriculture
Agril.	Agricultural
Agron.	Agronomy
Appl.	Applied
Biol.	Biology
Chem.	Chemistry
cm	Centi-meter
CV	Coefficient of Variance
DAP	Days After Planting
Ecol.	Ecology
Environ.	Environmental
et al	et alii, And Others
Exptl.	Experimental
g	Gram
G	Growth duration
H	Haulm cutting
i.e.	*id est* (L), that is
J.	Journal
kg	Kilogram
L	Ratio of nitrogen and phosphorus
LSD	Least Significant Difference
M.S.	Master of Science
m^2	Meter squares
mg	Milligram
Nat.	Natural
Nutr.	Nutrition
Physiol.	Physiological
Res.	Research
PhD	Doctor of Philosophy
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
Soc.	Society
Tk.	Taka
t ha^{-1}	Ton per hectare
T	Time of nitrogen application
viz	*videlicet* (L.), Namely

CHAPTER I

INTRODUCTION

Potato (*Solanum tuberosum* L.F) is one of the most important vegetable crops and having a balanced food containing about 75 to 80% water, 16 to 20% carbohydrates, 2.5 to 3.2% crude protein, 1.2 to 2.2% true protein, 0.8 to 1.2% mineral matter, 0.1 to 0.2% crude fats, 0.6% crude fiber and some vitamins (Abbas *et al*., 2012). It is a staple diet in European countries and its utilization both in processed and fresh food form is increasing considerably in Asian countries (Brown, 2005). Human nutrition and food security is also contributed from potato cultivation and it has more potentiality to earn huge money from the export of processing and export quality produce especially to European countries (Karim *et al*., 2010). Among all crops, potato is one of the most important vegetables as well as cash crops in Bangladesh (Haque *et al*., 2012). Bangladesh is the 7th potato producing country in the world, 3rd biggest in Asia and in Bangladesh; it ranks 2nd after rice in production. Significance of potato crop was rightly assessed by FAO (Food and Agriculture Organization) before declaring 2008 as the International Year of Potato and indicating potato as future crop for fighting hunger and poverty. Impending food and nutritional security challenges in India and related policy implications have been aptly emphasized in various studies (Acharya, 2009; Bhavani *et al*., 2010; Chand and Jumrani, 2013; Kesavan, 2015).

Role of potato as food and income security crop for the global poor in general and the residents of developing countries in particulate, was adequately documented by Thiele *et al*. (2010) and Singh and Rana (2013). In fact, short cycle of potato frees the land for cultivating other crops (Walker *et al*., 1999). Per unit of land and time potato was more productive than any other food crops (Azimuddin *et al*., 2009). Potato production is highly profitable and it could provide cash money to farmer. In terms of profitability, potato production was more attractive than any other winter vegetables. Per unit yield and gross return of potato were found higher than other competitive crops (Akhter *et al*., 2001). The national average yield and total production in Bangladesh are 20.44 t ha^{-1} and 10,216,000.00 metric tons, respectively (FAOSTAT, 2017). Bangladesh experienced much progress in its potato production in the past decades as such consumption also rapidly increasing in Bangladesh. But, the yield of potato is very low in Bangladesh compared to other potato growing countries like New Zealand (49.31 t ha^{-1}), Netherlands (45.97 t ha^{-1}), USA (48.23 t ha^{-1}), Japan (29.27 t ha^{-1}), and even in India (22.30 t ha^{-1}) (FAOSTAT, 2017).

In Bangladesh major portion of the total produce did not find any space in the cold storage and a part of which is consumed (about 75 lacs MT) shortly after harvest and the rest is kept in traditional storage at home under room temperature and humidity at farm level (Appendix v). So, the surplus (about 40 lacs MT) has the potentiality to export to abroad. In most cases the excess production goes to waste. In Bangladesh most of the potatoes consumed is unprocessed. In the form of chips and crackers only 2% of the potatoes are processed mainly but the majority of Bangladesh's potato production is used for direct consumption. The varieties used for table potatoes are not appropriate for processing (the dry matter content, specific gravity is too low and more reducing sugar content) or export (foreign consumers have different tastes). Now a days, the most important features of potato production is tuber quality (Brown, 2005). So quality attributes should take into account to fulfill the customers and industry demand. The number of processing industries and potato products are increasing in Bangladesh with the demand of specific varieties. Besides culinary consumption, the use of potato has progressively increased as a raw material by the processing industry. Potato must meet a number of requirements including high dry matter content, high specific gravity, low reducing sugar and good color to fulfill the requirement of processing. Presently there is no promising variety for declaring as processing purpose, despite the increasing demand of acceptable yield and processing quality. The yield and processing characteristics of available potato genotypes are largely unidentified. Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI) has been working to develop some processing quality potato varieties. Keeping in view the consumers requirement, it is important to select and evaluate the varieties that possess traits to meet the domestic demand and provide growers the opportunity to meet the challenges of frequently changing market, production circumstances and improving their economic condition (Connor *et al*., 2001). Technical and managerial skills on cultivation practices and provision of technical knowledge to control diseases as well as proper allocation of inputs and available resources would help to increase profitability and productivity of potato (Bajracharya and Sapkota, 2017). Potato produced on the basis of low quality seeds and sub-optimal management (such as non-proper harvesting time, high uses of inorganic fertilizer etc.) is not preferred for processing and export. Though the record amount of potato is produced, the quantity of export is insignificant due to low export standard (Khandker and Basak, 2017).

The overproduction of potato is not a threat; rather it could be turned into an opportunity by utilizing the resources in the processing and export industry. The increasing demand for processed food products may drive the proper utilization of the excess potato which may lead to product diversification (such as potato french fry, mashed potato, caned potato and chips etc.) in Bangladesh as a whole. Processing is an important value addition function of marketing and is considered as a major source of income and employment in Asia, Africa and Latin America. Processed potato products have high demand in the markets (Khurana, 2005) and market value of processed products is far better than the value of raw products (Abbas, 2011). In the most developed and developing countries, an increasing proportion of potato crop is being processed prior to consumption. More than 50% potato crop is processed in USA and nearly 30% in the United Kingdom (Pandey *et al*., 2000). Since, global utilization of potatoes is shifting from table potato production towards production for processed products like French fries, chips from the normal dietary usage. Even in our country potato chips mostly has become popular. Potato chips are also gaining popularity among the Nepalese consumers due to the changing of food habits, rapid urbanization, and aptitude of new generations for easy to prepare and ready to serve fast food. This is likely to increase further more in the future. Establishment of more potato processing industry could help to solve the problem of unemployment and at the same time expand industrialization of the country.

Many factors like length of growing season, air-soil temperature, light intensity-duration, relative humidity, soil type, nutrients and organic manure influencing potato growth, development, tuber yield and quality parameters are largely uncontrollable. Among these factors nutrients play an important role in potato production as it is a nutrient exhaustive crop (Meena *et al*., 2016). Maximum tuber growth requires all essential nutrients to be supplied at optimal rate and time. Organic manures like farmyard manure (FYM), leaf compost (LC) and vermicompost (VC) play important role in potato productivity. These sources reduce the mining of soil nutrient and improve soil organic carbon, humus and overall soil productivity (Palm *et al*., 1997).

Khan and Ishaq (2011) stated that in Vermicompost, different nutrients were present *viz.*, Organic carbon (9.5-17.98%), Nitrogen (0.5-1.50%), Phosphorus (0.1-0.3%), Potassium (0.15-0.56%), Sodium (0.06-0.30%), Calcium and Magnesium (22.67-47.60 meq/100 g), Copper (2-9.50 mg kg^{-1}), Iron (2-9.30 mg kg^{-1}), Zinc (5.70-11.50 mg kg^{-1}) and Sulphur (128-548 mg kg^{-1}) . Balance supply of nutrient through vermicompost might have caused several physiological and metabolic ramifications that lead to the highest specific gravity (Pervez *et al*., 2000). The fertility levels of vermicompost also improved the number of large and medium sized tubers indicating the usefulness of organic manures (Upadhya *et al*., 2011). The plant height, foliage coverage, number of stems $hill^{-1}$, fresh weight of tuber, dry weight of shoot, number of tubers hill^{-1}, percent dry matter of tuber, weight of tubers hill^{-1}, tuber yield and dry weight of tuber were significantly affected by vermicompost at different growth periods (Alam *et al*., 2007). Application of 75% of full recommended dose of fertilizers (120:75:75 Kg NPK ha^{-1}) + 8 t ha^{-1} vermicompost proved significantly superior in terms of number of tubers hill^{-1}, harvest index, tuber yield (32.7 t ha^{-1}) and benefit: cost ratio (1.75) of potato over rest the treatments (Narayan *et al.*, 2014).

As a precondition, the farmers should consider to produce the suitable varieties for processing using high quality seeds. Cultivar selection is very important for growers trying to market quality product (Mohammadi *et al*., 2010). The farmers need varieties that show high performance for yield and other essential agronomic traits having reliable superiority over a wide range of environmental conditions and also over the years. The location, cultivar, date of harvest and tuber curing influences the physical and biochemical changes in the structural growth duration of tuber gives economic support to the farmers and also affects the processing quality (Marwaha *et al*., 2005). Tuber harvested at full maturity stage contains maximum dry matter and protein content and have the highest specific gravity than immature ones (Misra *et al*., 1993). Though dry matter and starch contents of potato affect mainly texture and nutritional value of the tubers, in addition to tuber chemical composition, texture of processed food products is affected also by the degree of tuber maturity (Murniece *et al*., 2010). According to Rytel (2004) and Lisinska (2006), delayed harvest results in increased starch and dry matter contents of potato but their accumulation depends on cultivar and growing conditions. Among the agricultural practices, total crop duration or harvesting time had the prominent effects on total yield and nutritional composition of crop plants so, it is necessary to collect the produce at its proper growth stage. In Bangladesh, potato farmers have been lacking on the proper information of appropriate potato production management, proper harvesting time and processing quality aspects. Hardly, some information's about inorganic fertilization on potato yield has been found in Bangladesh. But research works with vermicompost application as an organic management of potato plants, harvesting time and promising processing varieties of potato is not well flourish to us. Research work on processing of potato is needed in Bangladesh for which there is a dearth. Present study is a first step on this aspect. The potentiality of present potato processing varieties cultivation and their different products is studied to find out ways and means of utilization of our surplus potato and study on processing will help to expand this sector. Considering the above fact, the present study is under taken to fulfill the following objectives:-

i. To screen and evaluate the promising potato varieties for processing purposes,

ii. To know the influence of vermicompost on yield and processing quality of potato,

iii. To study the effect of vermicompost and proper time of harvesting for yield and processing quality of potato and

iv. To standardize the optimum combination of vermicompost and time of harvest for producing processing quality potato using suitable varieties with monetary advantages.

CHAPTER II
REVIEW OF LITERATURE

As a staple starchy food crop, potato playing a major role in many developed countries and it is mostly popular supplemental food crop in Bangladesh. To fulfill the food and nutritional demand of world's growing hungry people the improvement of productivity and quality attributes of potato is much more important along with proper attention towards exporting and processing industry. Compared to the other major potato growing developed countries the yield of potato tuber is much lowest in Bangladesh. Due to the elastic nature of potato, the yield potential of potato could be changed by nutritional management including mediated new cultivation systems *viz*., organic cultivation, mediated maturity period and harvesting time. More or less research is availed in our country on fertilizer applications to potato. Some research was found about different organic fertilizer management on potato. But a complete standardized production package is not well known to us along with vermicompost and possessing quality potato in light of proper maturity periods. So, some more related research findings regarding production of potato against promising varieties, vermicompost application, harvesting time and economic return have been reviewed under this chapter.

2.1 General back ground

The story of potato begins about 8000 years ago near Lake Titicaca, which lies at 3800 m in the Andes mountain range of South America, on the border between Bolivia and Peru (IYP, 2008). The first record of potatoes being exported from south America to Europe was in approximately 1570 A.D. Potato was distributed by traders and colonists and reached North America and most of Europe and Asia by the early 1700s (Stephen *et al*., 2003).

2.2 Potato botany

Potato (*Solanum tuberosum* L.) belongs to family Solanaceae. The genus *Solanum* consists of about 2000 species, but the cultivated species is *Solanum tuberosum*. This species is sub divided into two sub-species as *andigena* or Andean and *tuberosum*, or, Chilean (OEDE, 2012). These both species were derived from a single origin in the area of Southern Peru (Spooner *et al*., 2005) from a species of the *Solanum brevicaule* complex. The cultivated potato is a perennial herb (a tetraploid with 48 chromosomes). The leaves are alternate and irregularly pinnately compound. Flowest characteristics are actinomorphic, complete and superior. It bears white, pink, red, blue or purple flowests with yellow stamens. Generally the white flowests varieties have white skin colour of tubers, while coloured flowests tend to have pinkish skin (Winch, 2006). Potato is cross pollinated and the pollination was done mostly by insect, including bumble bees but substantial amount of self fertilization may also occur. Potato is mostly propagated vegetatively by planting tubers or pieces of tubers containing at least two eyes. Some cultivars bear small green fruits containing up to 300 seeds. These seeds are purely bota nical seeds called true seed and are being used for propagation. The edible part of potato is underground stem known as tuber (swollen part of a subterranean rhizome or stolen). The tuber bears auxiliary buds and scares of scale leaves.

2.3 Uses of potato and its product

In Bangladesh, potato is primarily used as a vegetable, although in many countries of the world it constitutes the staple food and contributes more than 90% of the carbohydrate food source. Millions tons of potatoes are processed annually in Europe into starch, alcohol, potato meal, flour, dextrose and other products. Some are processed into potato chips, dehydrated mashed potatoes, French fries and canned potatoes. Large quantities of potatoes in the Netherlands, Ireland, Germany and other countries of Europe are grown specifically for manufacture of alcohol, starch, potato meal or flour, and for livestock feeding. Europeans consume much larger quantities of potato than the North Americans. Asian countries consume more rice than potato for carbohydrate foods. In Bangladesh, although the principal use of potatoes is to make potato curry along with fish, meat, and eggs, there exists a great diversity in the consumption of potatoes. Notable among potato-based food items are the boiled potato, fried potato, mashed potato, baked potato, potato chop, potato vegetable mix, potato singara, potato chips, potato wedge, french fry etc. In recent years, bakeries and fast food shops have started preparing a wide variety of potato-based food delicacies.

2.4 Reason behind to the attention on processing quality

In 2017, total production was 10.15 million tons and the consumption capacity was 7.5 million tons, rest 4.0 million tons was surplus (FAOSTAT, 2017). So need to do something for this portion of potatoes other than table purpose. On this ground the export of processed potato products may be a best option for such amount of surplus potatoes in Bangladesh to foreign countries. But the major constraints for this is non-availability of sufficient suitable varieties with high dry matter (>21%) and low reducing sugar content (<0.01%). Identification of cropping zones, technology packages for production of processing quality varieties, non-availability of resistant varieties for bacterial wilt and technologies for long period storage are other limitations in developing export sectors in the country. To meet the instant need of the processing varieties, the variety introduction procedure may be liberalized under a crush programme to ensure quick inflow of processing varieties in the country (Roy *et al*., 2017a). Now-a-days, Bangladesh exporting only Granola variety to abroad but the quality of this variety is not coping up with the export and processing standard. The varieties released by TCRC, BARI, Bangladesh are not satisfying the processing marks to export orientation program by exporters. The exporters only purchasing non-quality tuber of Granola for making only chips. But, due to non judicial application of agronomic management the tuber of potatoes attaining bed qualities. So, as a result there has a huge gap left between the production benefit and processing return in term of money. Ultimately, processing of surplus potatoes may be an important avenue to expand utilization of potatoes grown in the country.

2.5 Varietal performance

Preetham *et al*. (2018) conducted an experiment to evaluate the performance of seven promising potato cultivars for growth, yield attributes, yield and grades. There is significant variation among the varieties in the growth, yield attributes, yield and grades of potato. The maximum per cent of plant emergence was reported in Kufri Chandramukhi and Kufri Jyothi (100%). Kufri Surya reported maximum plant height at 30, 60 and 90 DAP (45.23, 70.76 and 65.33 cm respectively). Kufri Chipsona-3 and Kufri Badshah reported maximum number of branches per plant at 60 and 90 DAP. Maximum number of compound leaves per plant were produced by Kufri Chipsona-3 at 60 and 90 DAP. Kufri Surya reported maximum fresh weight of tuber per plant (832 g) and tuber yield (29.86 t ha^{-1}). The highest per cent of Grade-B tubers were produced by Kufri Surya followed by Kufri Chandramukhi, Kufri Khyati and Kufri Chipsona-3. The results of the study indicate that Kufri Surya, Kufri Khyati and Kufri Chipsona-3 have the potential to grow successfully in Northern Telangana Zone.

Sadawarti *et al*. (2018) conducted three consecutive experiments to evaluate high yielding table and processing potato varieties for commercial. A total of 11 potato varieties *viz*., Kufri Chandramukhi, Kufri Lauvkar, Kufri Khyati, Kufri Surya, Kufri Pukharaj, Kufri Jyoti, Kufri Bahar, Kufri Badshah, Kufri Garima, Kufri Pushkar, and Kufri Chipsona-1 got tested. Dry matter % was recorded significantly better in the year 2015-16. Significantly highest marketable and total tuber (t ha^{-1}) yield were recorded in the crop year 2015-16 and 2016-17 over 2014-15. Among varieties, Kufri Pushkar (91.88) and Kufri Chipsona-1 (92.57) recorded significantly highest germination % over Kufri Bahar (86.76). Variation among varieties was recorded for growth parameters. Dry matter was significantly highest in Kufri Chipsona-1 were 19.04, 19.49% and 21.77% for 60, 75 and 90 days crop respectively among all the varieties under test. Similar trend for marketable and total tuber yield as well as highest net return and B: C ratio were recorded in Kufri Pukhraj, Kufri Khyati and Kufri Pushkar for 60, 75 and 90 days crop under varied climatic situations of three years. Hence, Kufri Chipsona-1 is identified for processing and Kufri Pukhraj, Kufri Khyati and Kufri Pushkar as table purpose varieties for cultivation.

Luitel *et al*. (2017) conducted an experiment to evaluate the yield of nutrient-rich potato clones in two districts of Nepal. Fourteen potato clones were tested as on-station and on-farm experiments at both districts, and those fourteen clones were compared to 'Lady Rosita' and 'Jumli Local' respectively as the check varieties in the first year experiment. Eight promising clones were selected from the first year experiment, and were evaluated and compared with same local varieties in the consecutive year. Two clones namely; CIP 395112.32 (19.3 t ha^{-1}) and CIP 393073.179 (17.8 t ha^{-1}) exhibited superior marketable tuber yield than that of 'BARI Alu-28 (Lady rosetta)'(14.2 t ha^{-1}) in Dolakha and five CIP clones namely; 395112.32 (25.5 t ha^{-1}), 393073.179 (22.5 t ha^{-1}), 394611.112 (20.9 t ha^{-1}), 390478.9 (19.9 t ha^{-1}) and 395017.229 (17.0 t ha^{-1}) showed highest marketable tuber yield than 'Jumli Local'(14.5 t ha^{-1}). Based on two years' phenotypic and tuber yield result, clones CIP 395112.32 and CIP 393073.179 are recommended to potato growers at high hills of Nepal for commercial cultivation.

Eaton *et al*. (2017) investigated the six modern varieties of potatoes (Diamant, Cardinal, Granola, Felsina, Provento and BARI Alu-25 (Asterix) for their growth parameters and yield to determine their suitability for production in Bangladesh. Results indicate significant variations among the varieties in the yield and morphological characteristics and no difference in the number of stems $hill^{-1}$. Among the six varieties, BARI Alu-25 (Asterix) produced the maximum yield (29.60 t ha^{-1}), the greatest number of tubers per hill (13 tubers hill^{-1}), the largest percentage (84%) of medium sized tubers (28-55 mm diameter), and the highest plant height (61.33 cm). Diamant performed second after BARI Alu-25 (Asterix) with a yield of 28.33 t ha^{-1}, and a plant height of 59.0 cm. Felsina produced the lowest yield (25.13 t ha^{-1}) and the lowest number of tubers per hill (8.67 tubers hill^{-1}). In a farmers' perception study, where farmers scored the yield and resistance to diseases and insect damage of the six varieties, from 1 to 6 (6 being the highest and 1 being the lowest), BARI Alu-25 (Asterix) was the most preferred variety by farmers with scores of 6, 5.67 and 5.83 for yield, disease resistance and insect resistance respectively. Provento was the least preferred by farmers with a score of overall performance of 4. The results of this study indicate that BARI Alu-25 (Asterix) and Diamant have the potential to be grown successfully by the farmers in Bangladesh.

Rahman *et al*. (2016) carried out a research study with a total of forty potato varieties grown in Bangladesh to evaluate the bio-chemical differences in their composition. The dry matter, starch, reducing sugar, non-reducing sugar and total sugar contents of different potato varieties studied in this experiment were ranged from 13.56 to 24.60%, 6.80 to 18.93%, 0.02 to 0.61%, 0.09 to 0.53% and 0.27 to 0.78%, respectively. The highest protein content was found in Ailsa (3.87%) followed by Caruso (3.77%) with no significant difference whereas minimum value was observed in varieties Espirit (0.79%) which was statistically at par with Saikat (0.81%), Sagitta (0.85%), Biella (0.85%) and Jam Alu (0.87%). The highest ash content was recorded in Tomensa (1.29%) and Sagitta (1.53%) and Connect showed the least ash content (0.76%) followed by Saikat (0.82%). Among the varieties, BARI Alu-28 (Lady rosetta), Ailsa, Caruso, Forza, Amanda, Ludmila, and Tomensa, had more than 20% and 17% of dry matter and starch content, respectively and reducing sugar content less than 0.20%. Seven potato varieties out of forty performed best in respect of their different bio-chemical properties and hence recommended for processing industry in Bangladesh.

Araujo *et al*. (2016) conducted an experiment to study the potato tuber yield and evaluate its frying potential for shoestrings and chips, of potato cultivars recently introduced in Brazil. Nine potato cultivars (Arizona, Caruso, Destiny, Excelence, Saviola, Agata, Almera, Fontane and Markies) were assessed in this experiment. 'Arizona' and 'Caruso' cultivars exhibited superior productive potential and along with 'Markies' the highest production of marketable tubers. 'Caruso' and 'Destiny' produced more than 20% of dry matter and the lowest reducing sugar levels. 'Caruso' exhibited the highest frying yield in both processing shapes and absorbed less fat as shoestring. 'Destiny' absorbed less fat when processed as chips. 'Excelence' presented intermediary performance for every evaluated attribute. 'Caruso', 'Destiny', and 'Excelence' produced chips with appropriate color for market. Among the assessed cultivars, 'Caruso', 'Destiny', and 'Excelence' were the most promising. These cultivars demonstrated appropriate processing ability in the shape of shoestrings. 'Destiny' could also be indicated to be processed as chips.

Abbas *et al*. (2012) conducted an experiment with thirty two potato genotypes for processing and yield quality traits were assessed for screening. Significant differences in all the quality parameters and various characteristics were found, while the genotypes; 394021-120, 9625, Kiran, NARC 2002- 1, NARC 1-2006/1 and VR 90-217 gave the highest results regarding yield and quality of potato tubers except Kiran, which has a high yield but low quality characters. The tuber sizes and weight was also significantly different among genotypes except weight of big size tubers. Variations existed among genotypes in tuber characteristics (skin color, tuber shape, eye depth, flesh color and general appearance).

Elfnesh *et al*. (2011) conducted an experiment to investigate the influence of growing environment and blanching on chips quality of five improved potato cultivars (Chiro, Zemen, Bedassa, Gabissa and Harchassa). The cultivars were grown at Langaie, Kulubi and Haramaya, all in the eastern part of Ethiopia.

The highest tuber dry matter content (27.33%) and specific gravity (1.110 gcm^{-3}) were produced by cultivar Harchassa while the lowest dry matter content (20.33%) and specific gravity (1.078 gcm^{-3}) were by cultivar Zemen both grown at Haramaya condition. All the cultivars at all locations produced tubers with a dry matter content greater than 20.0% and a specific gravity of 1.070 gcm^{-3} which are within the acceptable range for chip processing.

Marwaha *et al*. (2007) carried out a research study with tubers of four processing varieties along with one advanced hybrid and two popular Indian table varieties grown during spring season were evaluated for yield, chipping attributes and some important nutritional and antioxidant constituents immediately after harvest. Kufri Chipsona-1 produced maximum total tuber yield. Processing grade tuber yield was also the highest in Kufri Chipsona-1 followed by Kufri Chipsona-2. All the three chipsona varieties *viz*., Kufri Chipsona-1, Kufri Chipsona-2 and Kufri Chipsona-3 produced highest yield of chips (>27%) with acceptable chip colour (<3) and contained highest tuber dry matter (22.2-23.8%) and lowest levels of reducing sugars (76-103 mg/100 g fresh wt), total phenols and enzymic discoloration. Varieties Kufri Jyoti and Kufri Pukhraj as well as Kufri Surya were suitable for table consumption due to highest amounts of free amino acids, comparable levels of soluble protein and maximum contents of one or more antioxidants, *viz*., total phenols, vitamin C and total carotenes as compared with chipsona varieties. Based on processable tuber yield and processing characteristics, Kufri Chipsona-1 and Kufri Chipsona-2 were identified as most suitable for chipping.

2.6 Response of vermicompost

Ferdous *et al*. (2019) pointed out that the application of vermicompost may improve the quality of potato. The present study revealed that vermicompost had a significant effect on most of the quality contributing parameters studied under the experiment. Results demonstrated that quality parameters increased with increasing vermicompost level. Among the sixteen treatments combination, BARI Alu-25 (Asterix)) with vermicompost at the rate of 6 t/ha showed the highest ascorbic acid (Vitamin C), antioxidant and polyphenol content. In the case of ambient storage condition; ascorbic acid and polyphenol decreased with an increasing storing period while antioxidant content increased with the increasing storing period up to 60 days after storage (DAS). BARI Alu-25 (Asterix)) and BARI Alu-29 (Courage)) may store under ambient storage condition up to 60 DAS without imparting any significant quality losses just prior to the sprouting of the tuber. It may be concluded that the potato growers of Bangladesh may apply vermicompost on their field at the rate of 6 t ha^{-1} for maintaining the good quality of potato.

Mostofa *et al.* (2018) conducted an experiment to assess the effect of vermicompost and tuber size on processing quality of potato during ambient storage condition. They reported that vermicompost had a significant effect on most of the storage parameters. Results also showed that storage quality parameters increased with increasing vermicompost level irrespective of tuber size. Among the twenty (20) treatment combinations, vermicompost at the rate of 9 t ha^{-1} with tuber size >40 g showed the highest firmness (44.349 N), specific gravity (1.084 g cm^{-3}), dry matter (22.77%), flesh color (L*- 75.60; a*- 11.76; b*- 24.96). In respect of ambient storage condition; weight loss increased with increasing storage time, while firmness, specific gravity, dry matter, flesh color decreased with increasing storage time. Quality parameters slowly decreased with increasing storage time up to 40 days after storage (DAS) and thereafter sharply decreased and finally became non-suitable both for table and processing purpose.

Dezfully *et al*. (2017) conducted an experiment to evaluate the effect of vermicompost fertilizer on quantitative characteristics of potato. The experiment was carried out based on randomized complete block design with 3 replications and 3 treatments: vermicompost, (cow + sheep manure), and chicken manure. Results showed that fertilizer treatments had significant effect on large size tubers yield and large size tubers number at 1% probability level and on medium size tubers yield, total tubers yield, medium size tubers number, total number of tubers and tubers nitrate percentage at 5% probability level. Based on the results obtained, the most effective treatments on total yield of potato were vermicompost cow+ sheep manure, and chicken manure, respectively. The total yield of potato by application of vermicompost was 1.3% more than the yield by application of cow +sheep manure and 20.6% more than the yield by application of chicken manure. The results showed that application of vermicompost was not only economic and effective on potato yield, but also was better than other treatments for human health and environmental pollution.

Meena *et al*. (2016) conducted a field experiment to investigate the effect of organic sources of nutrients on tuber bulking rate, grades and specific gravity of potato tubers. The experiment consisted 24 treatment combinations with 8 treatment in popcorn [control, recommended dose of fertilizers ($N_{120}P_{25}K_{35}$ kg ha^{-1}), farmyard manure equivalent to 120 kg N ha^{-1}, leaf compost equivalent to 120 kg N ha^{-1} , vermicompost equivalent to 120 kg N ha^{-1}, farmyard manure equivalent to 90 kg N ha^{-1}, leaf compost equivalent to 90 kg N ha^{-1} vermicompost equivalent to 90 kg N ha^{-1} in succeeding crop of potato, three treatments [control, farmyard manure equivalent to 60 kg N ha^{-1} and farmyard manure equivalent to 90 kg N ha^{-1}] were superimposed on the different treatments of pop corn. It was found that the application of farmyard manure equivalent to120 kg N ha^{-1} to pop corn and farmyard manure equivalent in 90 kg N ha^{-1} in potato gave.

Zandian and Farina (2016) conducted an experiment to determine the effect of vermicompost and chicken manure on potato yield and yield components in Kermanshah climate condition, a factorial experiment based on randomized complete block design with three replications was conducted with four vermicompost rates of 0 as control, 3, 6 and 9 t ha^{-1} and poultry manure rates of 0, 10, 12 and 14 t ha^{-1}. Number of stems and tubers per plant, tuber weight and tuber yield significantly increased with chicken manure and vermicompost application. Interaction between vermicompost and chicken manure showed that the potato received 3 t/ha of vermicompost and 10 t ha^{-1} of chicken manure caused the highest yield two times more than control. This treatment had the highest effect on the number of tubers $plant^{-1}$. Also, the highest tuber weight and number of stems $plant^{-1}$ were obtained in 3 t ha^{-1} of chicken manure and 12 vermicompost and 12 t ha^{-1}, respectively. Correlation evaluation showed that there was a significant positive relationship between the number of stems $plant^{-1}$ and final yield. Generally, 3 t ha^{-1} of vermicompost and 10 t ha^{-1} of chicken manure was recommended to increase potato yield production.

Yang *et al*. (2015) reported that vermicompost has great commercial potential in the horticultural industry and its effectiveness is affected by soil water regimes. The effects of vermicompost (VM) on tomato yield and quality and soilfertility were compared with chick compost (CM), horse compost (HM) and chemical fertilizer (CF) in a greenhouse under the three soil water regimes (50–60, 60–70 and 70–80% Qf, QF is field capacity). Additionally a control treatment (CK, no fertilization) was included. Under 60–70%f, VM increased the yield by 16.3, 9.6, 52.0 and 69.3%, and the vitamin C (VC) content by 8.2, 59.2, 15.2 and 80.3% when compared to CM, HM, CF and CK, respectively. However, VM decreased the soluble solids and total acidity under three soil water regimes. Total acidity in VM was 17.8, 4.8, 26.4 and 9.1% lowest than that in CM, HM,CF and CK, respectively, and the sugar/acid ratio (the ratio of soluble solids to total acidity) in VM was also lowest than the other two composts, but highest than CF and CK. VM had the highest sugar/acid ratio under 50–60%f. The sugar/acid ratio in VM decreased with the increase of soil water content. VM had lowest soil organic matter content than CM and HM, but highest than CF and CK under the three soil water regimes. The soil organic matter content in VM was 17.0 and 12.7% lowest than that in CM and HM, but12.9 and 10.1% highest than that in CF and CK. VM had highest available N and P contents in soil than the other treatments under 70–80%f. VM increased the activities of acid phosphatase, catalase and urease in soil compared to the other treatments under the three soil water regimes. Thus vermicompost increased tomato yield and VC under 60–70% of field capacity and the effects of vermicompost on soil fertility varied with soil water regime.

Ahirwar and Hussain (2015) reported that vermicomposting is a promising method of transforming unwanted and virtually unlimited supplies of organic wastes into usable substrates. In this process, the digestive tracts of certain earthworm species (e.g., *Eisenia fetida*) are used to stabilize organic wastes. The final product is an odorless peatlike substance, which has good structure, moisture-holding capacity, relatively large amounts of available nutrients, and microbial metabolites that may act as plant growth regulators. For these reasons, vermicompost has the potential to make a valuable contribution to soilless potting media. The objective of this study was to evaluate the transplant quality and field performance of vegetable transplants grown in vermicompost. Tomato (*Lycopersicon esculentum* Mill.), Eggplant (*Solanum melongena* L.), Pepper (*Capsicum annuum* L.), Potato, Sweet corn hybrids, Pak choi, Spinach and Turnip. Growth of vegetable transplants was positively affected by addition of vermicompost, perhaps by altering the nutritional balance of the medium. Transplant quality was improved in peppers and eggplants while tomato transplant quality was slightly reduced. There were no significant differences in field performance. Hence, vermicomposting is a sustainable technique for solid waste disposal. Vermicomposting is the science of producing compost from biodegradable organic matters through earthworms. Vermicompost contains significant quantities of nutrients, a large beneficial microbial population and biologically active metabolites, particularly gibberellins, cytokines, auxins and group B vitamins which can be applied alone or in combination with organic or inorganic fertilizers so as to get better yield and quality of diverse crops.

Yourtchi *et al*. (2013) conducted an experiment to study the effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato. Experimental factors included nitrogen fertilizer with three levels (50, 100 and 150 kg ha^{-1} as urea) and vermicompost with 4 levels 0 (control), 4.5, 9, and 12 ton ha^{-1}). Results illustrated that the highest amount of plant height, leaf and stem dry weight, Leaf Area Index(LAI), fresh and dry weight of tuber , total tuber weight, total number of tuber, tuber diameter ,nitrogen percent of tuber , potassium percent of tuber and phosphorous percent of tuber were found from application of 150 kg N ha^{-1}. Data also demonstrated that vermicompost application at the rate of 12 t ha^{-1} promoted all above traits except plant height in compared to control treatment. Furthermore, the interaction effects between different nitrogen rates and vermicompost application significantly improved growth parameters, yield and NPK content of tuber compared with nitrogen and/or vermicompost alone treatments. To gain highest yield and avoidance of environments pollution use of 150 kg N ha^{-1} nitrogen fertilizer and vermicompost application of 12 t ha^{-1} are suggested.

Alam (2011) conducted an experiment to evaluate the efficiency of conventional compost (CC) and vermicompost (VC) on the yield of tomato and thereafter to estimate their cost-return. There were ten treatments replicated three times. It was observed that 75% RDCF (Recommended Dose of Chemical Fertilizer) +VC at 2.0 t ha^{-1} gave the tallest plant and maximum number of fruit per plant and thereby produced the highest yield (61.1 t ha^{-1}) of tomato. The yield was statistically identical with 100% RDCF (58.1 t ha^{-1}); and 75% RDCF+CC at 2.0 t ha^{-1} (56.6 t ha^{-1}). The lowest yield (19.0 t ha^{-1}) was observed in native fertility (no fertilizer) which was followed by 0% RDCF+CC at 10 t ha^{-1} (38.9 t ha^{-1}). Vermicompost exhibited better performance than conventional compost in all studied parameters except individual fruit weight. The highest (2.59) benefit cost ratio (BCR) was recorded in 75% RDCF+VC at 2.0 t ha^{-1} fertilizer combination which was followed by 100% RDCF (2.45); and 75% RDCF+CC at 2.0 t ha^{-1} (2.34) respectively. The least BCR (0.58) was obtained from the control (no fertilizer) which was followed by 0% RDCF+CC at 10 t ha^{-1} (1.10) and 0% RDCF+VC at 10 t ha^{-1} (1.21). Although the sole use of VC and CC gave lowest BCR, they play a vital role in organic and chemical-free production system. In that case, they (sole VC and CC at 10 t ha^{-1}) have potential to give highest BCR due to highest market value of chemical-free products.

Ansari (2008) conducted experiments to study the effect of vermicompost application in reclaimed sodic soils on the productivity of potato (*Solanum tuberosum*), spinach (*Spinacia oleracea*) and turnip (*Brassica campestris*). The treatments were 4, 5 and 6 t ha^{-1} of vermicompost as soil application in plots already reclaimed by Vermitechnology. Among the different dosages of vermicompost applied there has been a significant improvement in the soil quality of plots amended with vermicompost @ 6 t ha^{-1}. The overall productivity of vegetable crops during the two years of the trial was significantly greater in plots treated with vermicompost @ 6 t ha^{-1}. The present investigation showed that the requirement of vermicompost for leafy crops like spinach was lowest (4 t ha^{-1}), whereas that for tuber crops like potato and turnip was highest (6 t ha^{-1}).

Azarmi *et al*. (2008) conducted an experiment to determine the effects of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum* var. Super Beta) in a field condition. The experiment was a randomized complete block design with four replications. The different rate of vermicompost (0, 5, 10 and 15 t ha^{-1}) was incorporated into the top 15 cm of soil. During experiment period, fruits were harvested twice in a week and total yield were recorded for two months. At the end of experiment, growth characteristics such as leaf number, leaf area and shoot dry weights were determined. The results revealed that addition of vermicompost at rate of 15 t ha^{-1} significantly (at $p<0.05$) increased growth and yield compared to control. Vermicompost with rate of 15 t ha^{-1} increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55, 73, 32 and 36% compared to untreated plots respectively. The result of our experiment showed addition of vermicompost had significant ($p<0.05$) positive effects on growth, yield and elemental content of plant as compared to control.

Gutierrez-Miceli *et al*. (2007) investigated a greenhouse experiment to study the effects of earthworm-processed sheep-manure (vermicompost) on the growth, productivity and chemical characteristics of tomatoes (*Lycopersicum esculentum*) (c.v. Rio Grande). Five treatments were applied combining vermicompost and soil in proportions of 0:1, 1:1, 1:2, 1:3, 1:4 and 1:5 (v/v). Growth and yield parameters were measured 85 days and 100 days after transplanting. Addition of vermicompost increased plant heights significantly, but had no significant effect on the numbers of leaves or yields 85 days after transplanting. Yields of tomatoes were significantly greater when the relationship vermicompost:soil was 1:1, 1:2 or 1:3, 100 days after transplanting. Addition of sheep-manure vermicompost decreased soil pH, titratable acidity and increased soluble and insoluble solids, in tomato fruits compared to those harvested from plants cultivated in unamended soil. Sheep-manure vermicompost as a soil supplement increased tomato yields and soluble, insoluble solids and carbohydrate concentrations.

Arancon *et al*. (2003) pointed out that vermicomposts produced commercially from cattle manure, market food waste and recycled paper waste, were applied to small replicated field plots planted with tomatoes (*Lycopersicon esculentum*) and bell peppers (*Capsicum anuum grossum*) at rates of 10 t ha^{-1} or 20 t ha^{-1} in 1999 and at rates of 5 t ha^{-1} or 10 t ha^{-1} in 2000. Food waste and recycled paper vermicomposts were applied at the rates of 5 t ha^{-1} or 10 t ha^{-1} in 2000 to replicated plots planted with strawberries (*Fragaria spp*.). Inorganic control plots were treated with recommended rates of fertilizers only and all of the vermicompost-treated plots were supplemented with amounts of inorganic fertilizers to equalize the initial N levels available to plants in all plots at transplanting. The marketable tomato yields in all vermicompost-treated plots were consistently greater than yields from the inorganic fertilizer-treated plots. There were significant increases in shoot weights, leaf areas and total and marketable fruit yields of pepper plants from plots treated with vermicomposts compared to those from plots treated with inorganic fertilizer only. Leaf areas, numbers of strawberry suckers, numbers of flowests, shoot weights, and total marketable strawberry yields increased significantly in plots treated with vermicompost compared to those that received inorganic fertilizers only. The improvements in plant growth and increases in fruit yields could be due partially to large increases in soil microbial biomass after vermicompost applications, leading to production of hormones or humates in the vermicomposts acting as plant-growth regulators independent of nutrient supply.

2.7 Response of harvesting time

Sharkar *et al*. (2019) conducted an experiment to study the effect of harvesting times and variety on the yield and processing quality of potato tuber. Three processing potato varieties BARI Alu-25 (Asterix); BARI Alu-28 (Lady rosetta) and BARI Alu-29 (Courage) were used as test crops and they were harvested at different days after planting [80, 90, and 100 days after planting (DAP)]. The three processing potato varieties showed highest tuber yield of Grade A (9.12 t ha^{-1}) and B (13.64 t ha^{-1}). The highest tuber yield (Grade A+B) [29.62 t ha^{-1}] and total tuber yield (35.97 t ha^{-1}) was found in BARI Alu-29 (Courage) at 90 and 100 DAP harvest, respectively. The variety BARI Alu-28 (Lady rosetta) attained the highest percent of processable tuber yield (86.8% of the total tuber yield), the maximum dry matter content (26.37%), specific gravity (1.102) at 90 DAP harvest and this variety also contained the highest mean starch content (111.75 mg g^{-1} FW) followed by BARI Alu-29 (Courage) (111.17 mg g^{-1} FW) and BARI Alu-25 (Asterix) (103.95 mg g^{-1} FW). Optimum dry matter content (24.07%), specific gravity (1.091), starch content (110.15 mg g^{-1} FW), processable tuber yield (26.62 t ha^{-1}) and total tuber yield (32.76 t ha^{-1}) was found at 90 DAP harvest and therefore, it could be mentioned as suitable harvesting time for processing purposes. Among the varieties, BARI Alu-28 (Lady rosetta) and BARI Alu-29 (Courage) were found preferable potato varieties that could be used for processing of potato products.

Curcic *et al.* (2018) reported that climate changes are affecting the plant production, including sugar beet growing especially in the southern and central parts of the Europe. Modifying the sowing and harvesting times are one of the most often used adaptations in sugar beet cultivation. The aim of this study was to assess the interactions between planting date and sugar beet genotypes for different harvest dates with recommendation for duration of vegetation period for specific hybrids in order to achieve the best performance and to evaluate influence of climatic factors on sugar yield. Three-way analysis of variance and AMMI (Additive main effect and multiple interactions) analysis were performed to investigate interaction between main factors. Analysis of variance revealed that genotypes (G), planting date (PD), harvest date (HD) and interaction G×PD significantly affected sugar yield in 2016. In 2017 genotypes, planting date, harvest date and G x PD interaction significantly affected sugar yield on probability level of 1%, while PD×HD interaction had significant effect on probability level of 5%. Results of AMMI analysis enabled discrimination of genotypes with the highest level of stability in certain planting dates. Hybrids with combined yield and sugar content (NZ type) should have the advantage in earlier planting dates compared to of sugar beet hybrids with highest sugar content (Z type). However, in shortened vegetation period Z type hybrids are more stable and with better sugar yield results. Results of our study suggest that delaying the harvest date decreases differences between sugar yields obtained from hybrids sown in different planting dates. Major factors in the study affecting sugar yield were growing degree days, insulation and number of days from planting to harvest.

Pavlu *et al*. (2017) conducted several experiments to study the impact of longer vegetation periods (by means of earlier drilling and/or later harvest) on production results of two sugar beet cultivars-one nematode-tolerant cultivar and one cultivar without such tolerance. The trials took place at two sites with different *Heterodera schachtii* infestation levels. In all trial seasons, root yield was significantly highest in the earlier drilled plots. On average, prolongation of the vegetation period in spring by 13 days increased root yield by 10.9%. Therefore, each day by which drilling is postponed represents a 0.7–0.8% loss of yield. As to sugar content, no statistically significant benefit of vegetation period prolongation by early drilling was found. The spring gain was slightly highest for the non-tolerant cultivar than for the tolerant one on average over all trial seasons. This result confirms the theory that nematodes impact the crop mainly in later stages of vegetation, and early drilling can thus help eliminating, to a certain degree, the risk of nematode damage. In the autumn, root yield increased by 14.3% on average over 39 days. The autumn daily gain was about half of the rate found in the spring. The increase in sugar content was between 0.6% and 1% (abs.) on average. Autumn growth achieved at the non-infested site was much highest than at the infested site.

Schnepel and Hoffmann (2016) conducted an experiment to study the yield formation and sugar storage of sugar beet plants during an extended growing period to estimate whether sugar beet has the potential to generate the theoretically expected yield increase. Root fresh matter yield continuously increased till the latest harvest. In contrast, the sugar concentration reached an optimum value between 3400 and 5000 ° and then decreased with time. Despite longer growing periods, the number of cambium rings, which are regarded as essential for sugar storage, did not change. This point to an early and genetically fixed determination of the formation of cambium rings. Additionally, the rate of photosynthesis decreased concomitantly with the sugar concentration. In conclusion, there is some evidence that the sugar concentration of the storage root is limited by the sink capacity, which in turn controls the source activity by a feedback regulation of photosynthesis and leaf formation. The dry matter composition of the storage root changed towards lowest sugar concentration and concurrent highest concentration of cell wall compounds (marc). The sugar yield still increased beyond a thermal time at which winter beets will probably be harvested in practice. Hence, the theoretical yield increase in autumn sown sugar beets can be realized, provided that the plants show sufficient winter hardiness and bolting resistance.

Okutsu *et al*. (2016) conducted an experiment to evaluate the effects of the cultivation period of sweet potatoes on sensory characteristics and composition of volatile compounds of imo-shochu was investigated. Sweet potatoes (cv. Koganesengan) used in this study were harvested at 120, 150 or 180 days after planting, and each sample was used to prepare imo-shochu. The imo-shochu samples were evaluated by eight panelists in a blind study, who ranked them on the basis of various odor and taste attributes. Rank sums were calculated and data were analyzed using the Friedman test. The compositions of the volatile compounds in the imo-shochu samples were analyzed using gas chromatography–mass spectrometry (GC-MS). Sensory evaluations showed that a longer cultivation period of the sweet potatoes enhanced the floral aroma and characteristic taste of imo-shochu. In addition, imo-shochu prepared with the sample cultivated for 150 days was evaluated to have a sweeter taste than that prepared with the other samples.

Rębarz *et al*. (2015) conducted an experiment to evaluate the effects of cover type (control, agro-textile or perforated plastic film) and harvest date (60 or 75 days after planting and at full physiological maturity) on the yield, quality and cost-effectiveness of early harvest potato cultivation. Covers increased the total and marketable tuber yields at early harvest dates, in particular on the 60th day after planting, compared to the reference. Tubers cultivated under covers were also found to contain highest amounts of dry matter and starch than those which were not covered. The proportion of tuber fractions with a diameter between 4.6 and 5.5 cm and above in the total yield was found to be strongly dependent on cover type. The proportion of these fractions was significantly lowest under plastic film than under Agro-textile. Over the 3 years cycle, high gross margins were achieved on the 60th and 75th days after planting with perforated film and agro-textile.

Solaiman *et al*. (2015) carried out an experiment and reported that stage of maturity often affects the yield, dry matter, specific gravity and color of potato tubers. Comparative account of some processing traits of three local varieties of potato (*viz*., ‘Fata Pakri’, ‘Sada Pakri’ and ‘Rumana)’ harvested at 80, 90, 100 and 110 days after planting with those of True Potato Seed variety ‘BARI TPS-I’ is given in this study tuber samples were harvested after 10-days of tuber skin-curing in the soil. Yield increased significantly up to the last date of harvest. Mature tubers exhibited significantly highest dry matter and specific gravity compared to immature ones. Tuber color was also significantly affected by time of harvest irrespective of varieties. The ‘BARI TPS-I’ gave highest tuber yield. ‘Fata pakri’ exhibited highest specific gravity and dry matter content. On basis of flesh color, ‘BARI TPS-I’, ‘Fata pakri’ and ‘Sadapakri’ were found suitable for chips. Bangladeshi potato farmers and processors will get benefited from the information generated regarding the appropriate harvesting time of local potatoes for processing industries.

Hemayati *et al*. (2012) reported that there was a significant effect of sowing and harvesting times on white sugar yield in sugar beet. The effects of sowing date variations were greater than those of harvesting time so that growth period shortened by two months (due to delayed sowing date) decreased white sugar yield by 72.5% whereas and growth period prolonged by the same amount (due to delayed harvesting time) increased the white sugar yield by 55.1%. The highest white sugar yield (13.71 t ha^{-1}) was obtained by early sowing (September 6) of SBSI002 and harvesting in May 5(with 240 days growth period).

Considering favorable agro-climatic conditions in Jiroft region belonging to warm zone of Province of Kerman, it seems that the region has the potential for fall cultivation of sugar beet.

Sogut and Ozturk (2011) investigated the effect of harvesting time was on yield and quality traits for spring season production in different maturing potato (*Solanum tuberosum* L.) cultivars. The cultivars tested were adora (early), carrera (early), felsina (mid-early), marfona (mid-early), mondial (mid-late) and vangogh (mid-late). Samples of tubers were harvested at 75, 90, 105 and 120 days after planting (DAP) in spring crop. Early cultivars carrera and felsina gave more than 2 t ha^{-1} tuber yield at 120 DAP. However, vangogh and mondial (mid-late cultivars) proved to be superior cultivars in relation to dry matter, specific gravity or starch content at 105 DAP.

Kawakami *et al*. (2004) reported that potato plants of early cultivars grown from microtubers have much lowest growth vigor and produce lowest yields than microtubers of late cultivars. This study intended to clarify the field performance of plants grown from directly planted microtubers of cultivars with different maturity periods, with a special attention to early cultivars. The experiments were conducted at Hokkaldo University, Japan, over four years. Microtubers and conventional seed tubers of the early cultivar Kitaakari, late cultivars Konafubuki and Norin 1, and very late breeding line IWA-1 were planted, and the plant growth and tuber yields were analyzed. The microtuber plants of Kitaakari had a lowest initial increase in leaf area index than conventional seed tuber plants, but at the maximum shoot growth had the same leaf area index. This pattern was also observed in the other cultivars. Tuber initiation and tuber bulking occurred on average five days later in microtuber plants than in conventional seed tuber plants of cultivar Kitaakari. At maximum shoot growth, microtuber plants had on average 65% of tuber dry weight of conventional seed tuber plants, with small variation among cultivars. Irrespective of maturity period, microtuber plants showed a highest tuber increase after maximum shoot growth, achieving around 86% of tuber dry weight of conventional seed tuber plants at harvest. From the results of this study we conclude that microtuber plants of early and late cultivars have a similar yield potential relative to conventional seed tuber plants, and microtubers of both early and late cultivars might be used as an alternative seed tuber source for potato production, if necessary.

O'Donovan (2002) showed that a delay in harvesting increased root yield, sugar yield and extractable sugar yield in sugar beet.

2.8 Economic benefit

Begum *et al.* (2017) conducted a study to assess the profitability of potato cultivation in some selected areas of Sylhet district in Bangladesh. On an average ha^{-1} cost of production of potato was Tk. 1, 94,114. The average yield of potato ha^{-1} was 17194 kg. The highest yield was obtained by large farms (18291 kg ha^{-1}) while it was the lowest in small farms (16804 kg ha^{-1}). When all costs were taken into account the average net return was observed to be Tk. 81336. On an average BCR (Benefit Cost Ratio) was the highest in large farms (1.68) appearing lowest in small farms (1.34). The study identified some major problems like non-availability of quality seeds and high price, low market price, shortage of human labor, lack of storage facilities etc. The farmers opined that potato production would be economically viable if quality seeds with affordable price, marketing facilities with standard price, storage facilities, fertilizer and insecticides with reasonable price are ensured.

Sujan *et al*. (2017) conducted a study to examine the profitability and resource use efficiency of potato cultivation in five upazilas of Munshiganj district of Bangladesh. A total of 52 farmers were selected randomly from the study area. Average gross return, gross margin and net return were found Tk. 3,47,200, Tk. 1,47,125 and Tk. 1,17,300, respectively. Benefit-cost ratio was found 1.51 and 1.74 on full cost and variable cost basis, respectively. The key production factors, *i.e*. human labour, land preparation, seed, fertilizer, insecticides and irrigations had significant effect on gross return of potato. Human labor, land preparation, insecticide and irrigation were under-utilized and therefore increasing use of those resources could maximize the profitability. Seed and fertilizer constituted major parts of the cost of production hence optimum use of those resources could also enhance the profitability and resource use efficiency of potato cultivation in Munshiganj district.

By reviewing the different sources of information regarding the present experiments it were found and taken that, the different potato varieties, organic fertilizers application and days of maturity has the capacity to response against different traits of potato and other crops. So, different potato varieties, vermicompost as organic fertilizer in interacting with different periods of tuber harvesting were taken for the present study to investigate the effects on tuber yield and processing quality of potato.

CHAPTER III
MATERIALS AND METHODS

In this chapter, a brief description about research location, edaphic condition, crop traits, treatments, experimental design and layout, crop husbandry, different intercultural operations, data recording and statistical analysis were described. The details of experimental materials and methods are described below:

3.1 Experimental period and site (Expt. 1 to 4)

All the experiments were carried out in the research field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207. The expt. 1 was conducted during the period from November, 2015 to March, 2016; expt. 2 and expt. 3 were conducted during the period from November, 2016 to April, 2017; expt. 4 was carried during the period from November, 2017 to April, 2018. The experimental area was belonged to $23^{o}7'$N latitude and 93^{o}E' longitude at an altitude of 8.6 meter above the sea level (Anon., 2004) and research area was also belonged to agro-ecological zone of “Madhupur Tract”, AEZ-28. The experimental site is shown in the map of AEZ of Bangladesh in (Appendix-I).

3.2 Climate and soil

The experimental site is characterized by winter with a significant monsoon climate with sub-tropical cropping zone during the months from November, 2015 to April, 2018 (*Rabi* season). The soil above the sub-surface soil are termed as “Surface soil” which was characterized by silty clay with slight sandy loam in texture, olive-slight grayish white with common fine to medium distinct dark whitish brownish-light brown mottles was seen on the top soil. The details analytical constituent of soil was presented in Appendix-III. The experimental area was medium flat and medium high topography with available easy irrigation and drainage system. During the study period, the weather data of the experimental site including maximum the experiments the maximum and minimum temperature, total rainfall and relative humidity were shown in (Appendix-II).

3.3 Planting materials

Potato (*Solanum tuberosum* L.) was used as test crop under present study. Different varieties and local cultivars were collected from Tuber Crops Research Centre (TCRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur; Bangladesh Agricultural Development Corporation (BADC), Domar farm, Nilphamari and BARI, Debigonj farm, Panchagarh. As a whole, in view of assessing the processing quality in released and local potatoes to standardize a sustainable production package through vermicompost application adjusted with harvesting time and for improving the income status of potato farmers in Bangladesh these varieties and cultivars were selected.

3.4 Experimental treatments

Experiment 1. Screening of potato varieties in relation to yield and processing quality

Thirty six (36) potato varieties and cultivars' were used as treatment under present study namely: BARI Alu-25 (Asterix), Cardinal, Rojato, BARI Alu-70 (Destiny), Festa Pakri, Tel Pakri, Bot Pakri, Stick, Dora, Granolla, BARI Alu-68 (Atlantic), Raja, Binella, Dheera, Sagita, Patrones, BARI Alu-29 (BARI Alu-29 (Courage), Provento, Felsina, Multa, BARI Alu-28 (Lady rosetta), Meridian, Forza, Saikat, Laura, Ailsa, Cumbica, Omera, Rumba, Jerla, Elgar, BARI Alu-71 (Doly), Agila, Quincy, Almerah and Steffi.

Experiment 2. Influence of vermicompost on yield and processing quality of selected potato varieties

The experiment comprised of two factors:

Factor A: 4 Variety

V_1= BARI Alu-68 (Atlantic)

V_2= BARI Alu-29 (Courage)

V_3= BARI Alu-25 (Asterix)) and

V_4= BARI Alu-28 (Lady rosetta)

Factor B: 5 **Vermicompost level**

Vm_1= 0 t ha^{-1}

Vm_2= 3 t ha^{-1}

Vm_3= 6 t ha^{-1}

Vm_4= 9 t ha^{-1} and

Vm_5= 12 t ha^{-1}

Experiment 3. Study the effect of vermicompost and harvesting period on yield and processing quality of potato

The experiment comprised of three factors:

Factor A: 6 Variety

V_1= BARI Alu-68 (Atlantic)

V_2= BARI Alu-29 (Courage)

V_3= BARI Alu-28 (Lady rosetta)

V_4= BARI Alu-25 (Asterix)

V_5= BARI Alu-70 (Destiny) and

V_6= BARI Alu-71 (Doly)

Factor B: 2 **Vermicompost level**

Vm_1= 9 t ha^{-1}

Vm_2= 12 t ha^{-1}

Factor C: 2 Harvesting period

H_1= 90 days after planting (DAP) and

H_2= 100 days after planting (DAP)

Experiment 4. Standardization of processing quality potato production as influenced by vermicompost and harvesting period

The experiment comprised of three factors:

Factor A: 4 Variety

V_1= BARI Alu-70 (Destiny)

V_2= BARI Alu-71 (Doly))

V_3= BARI Alu-28 (Lady rosetta) and

V_4= BARI Alu-25 (Asterix)

Factor B: 2 **Vermicompost level**

Vm_1= 9 t ha^{-1}

Vm_2= 12 t ha^{-1}

Factor C: 2 Harvesting period

H_1= 90 days after planting (DAP) and

H_2= 100 DAP

3.5 Experimental design and layout

Experiment 1: The experiment was laid out in a simple Randomized Complete Block Design design (RCBD) with three replications. The total number of unit plots was 108. The size of unit plot was 2.5 m × 2.5 m. The final layout of the experimental plots was shown in Appendix-IVa.

Experiment 2: The experiment was laid out in a 2 factors split-plot design with three replications, where the variety was assigned to main plots and vermicompost to sub-plots. The total number of unit plots was 60. The size of unit plot was 2.5 m × 2.5 m. The final layout of the experimental plots was shown in Appendix-IVb.

Experiment 3: The experiment was laid out in a 3 factors split-split-plot design with three replications, where variety was assigned to main plots, vermicompost to sub-plots and harvesting time to sub-sub plots. The total number of unit plots was 72. The size of unit plot was 2.5 m × 2.5 m. The final layout of the experimental plots was shown in Appendix-IVc.

Experiment 4:

The experiment was laid out in a 3 factors split-split-plot design with three replications, where variety was assigned to main plots, vermicompost to sub-plots and harvesting time to sub-sub plots. The total number of unit plots was 48. The size of unit plot was 2.5 m × 2.5 m. The final layout of the experimental plots was shown in Appendix-IVd.

3.6 Preparation of seed

Tubers of uniform size (50-60 g) were used for planting and kept in room temperature to facilitate good sprouting. Finally full sprouted potato tubers were used as planting material in a pit of allocated plot.

3.7 Land preparation

The land of the experimental site was first opened in the second week of November with power tiller and to obtain the desirable tilth the land was ploughed and cross-ploughed four times followed by laddering. Weeds and stubbles were removed from the corners of field using spade. The land was finally prepared on 3rd week of November for every experiment just three days before of the planting of whole seed tuber. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @ 20 kg ha^{-1} when the plot was finally ploughed to protect the young plant from the attack of cut worm.

3.8 Fertilizer and manure application

The crop was fertilized by using recommended dose of fertilizers at the rate of 350-220-250-120-10 Kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively (Azad *et al.*, 2017). Vermicompost was used as per treatment as manure. Zinc sulphate and vermicompost was applied during last ploughing time of experimental land. Half urea along with full TSP, MoP and gypsum was applied in furrow during planting of tuber. The rest amount of Urea was applied at 35 DAP as top dressing.

3.9 Planting of seed tuber

The well sprouted healthy and uniform sized potato tubers were planted according to requirement. Seed potatoes were planted at a depth of 5-6 cm on November 15 for each experiment maintaining 50 cm × 25 cm spacing.

3.10 Intercultural operations

3.10.1 Earthing up

Direct sunlight resulted “Solonization of potato tubers” which is very much harmful and decreased the stolon number and finally reduced the tuber. So, earthing up reduce such problems. Earthing up was done at 35 DAP and second was at 50 DAP with a narrow spade for the development of tubers.

3.10.2 Removal of weed

First weeding was done two weeks after emergence. Another weeding was done before 2nd top dressing of urea. It was also done as and when required to keep the crop free from weeds and to keep the soil loose for proper aeration and development of tubers.

3.10.3 Watering and drainage

Three irrigations were provided throughout the growing period in controlled way. The first irrigation was given at 35 DAP. Subsequently, another two irrigations were given at 50 and 65 DAP. Top dressing of urea was followed by irrigation for proper utilization of fertilizers.

3.10.4 Control of insects and diseases

All possible phytosanitary measures were adopted to keep plant healthy. Dursban @ 7.5 litre ha^{-1} was drenched on both sides of ridges at 30 DAP to control the cutworm. Dimecron 100 EC @ 2% and Admire 200 SL @ 0.5% were applied to control aphid and jassid. To prevent incidence of late blight of potato, Dithane M-45 @ 2g $litre^{-1}$ was applied at the advent of moist condition of weather and Ridomil Gold MZ @ 1g $litre^{-1}$ was applied at an interval of 7 days after seeing the late blight of potato disease for good harvest and healthy of tuber.

3.11 Haulm cutting

For each experiment, haulm cutting was done at second week of March when 60-70% plants showed senescence and these potatoes were harvested after 7 days of haulm cutting for skin hardening and tuber bulking. Then the tuber was collected, bagged and tagged separately for taking quality data further in laboratory.

3.12 Recording of data

Different types of data were collected on the basis of the aims of the different studies. Some of the data was taken after harvesting of tuber by using digital electronic balance; some of the data was taken by different biochemical processes in laboratory and by using different instruments. Finally, the means were calculated by using a digital calculator for quality analysis.

3.12.1 For experiment 1

i. Tuber yield (t ha^{-1})

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

iii. Dry matter content (%)

3.12.2 For experiment 2

i. Number of tubers $hill^{-1}$

ii. Weight of tubers $hill^{-1}$ (g)

iii. Average weight of tuber (g)

iv. Tuber yield (t ha^{-1})

v. Marketable yield (t ha^{-1})

vi. Non-marketable yield (t ha^{-1})

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

viii. Dry matter content (%)

ix. Total soluble solid (^{o}brix)

x. Starch content (mg g^{-1} FW)

xi. Reducing sugar (mg g^{-1} FW)

3.12.3 For experiment 3

i. Tuber yield (t ha^{-1})

ii. Marketable yield (t ha^{-1})

iii. Non-marketable yield (t ha^{-1})

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

v. Dry matter content (%)

vi. Total soluble solid (^{o}brix)

vii. Starch content (mg g^{-1} FW)

viii. Reducing sugar (mg g^{-1} FW)

ix. Yield for chips production (45-75 mm)

x. Yield for French fry production (>75 mm)

xi. Yield for flakes production (30-45 mm)

xii. Yield for canned production (<30 mm)

3.12.4 For experiment 4

i. Tuber yield (t ha^{-1})

ii. Marketable yield (t ha^{-1})

iii. Non-marketable yield (t ha^{-1})

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

v. Dry matter content (%)

vi. Total soluble solid (^{o}brix)

vii. Starch content (mg g^{-1} FW)

viii. Reducing sugar (mg g^{-1} FW)

ix. Texture of chips (N)

x. Bitterness of chips (1= not bitter and 2 = less bitter)

xi. Sweetness of chips (1=not sweet and 5 = very sweet)

xii. Sourness of chips (1= not sour and 2 = less sour)

xiii. Yield for chips production (45-75 mm)

xiv. Yield for French fry production (>75 mm)

xv. Yield for flakes production (30-45 mm)

xvi. Yield for canned production (<30 mm)

3.13 Procedure of data recording

i. Number of tubers $hill^{-1}$

Five hills were selected from each plot. The entire tuber was counted from five hills and then the mean values of tuber per hill were calculated.

ii. Weight of tubers $hill^{-1}$ (g)

Five hills were selected from each plot. The entire tuber was weighted from five hills by using an electronic balance and then the mean values of tuber weight per hill were calculated in gram unit.

iii. Average weight of tuber (g)

Five hills were selected from each plot. The entire tuber (>20g) was counted and weighted from five hills by using an electronic balance. Then to calculate the average tuber weight, the weight of total tuber hill was divided by the numbers of tuber per hill and then means were taken in gram unit.

iv. Tuber yield (t ha^{-1})

The entire tuber weighted by using an electronic balance from 1 m^2 harvested area of each plot. Then the weight of tuber per meter square was converted to per plot and then again converted to t ha^{-1}.

v. Marketable yield (t ha^{-1})

The tubers, those are >20 g of their weight were considered for marketable tuber and then the entire tuber weighted by using an electronic balance from 1

m^2 harvested area of each plot. Then the means were taken in ton per hectare unit.

vi. Non-marketable yield (t ha^{-1})

The tubers, those are <20 g of their weight were considered for non-marketable tuber and then the entire tuber weighted by using an electronic balance from 1 m^2 harvested area of each plot. Then the means were taken in ton per hectare unit.

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

Specific gravity was measured by using the following formula (Gould, 1995). Five tubers were taken from each plot after harvest of treatment and then the means were taken.

$$\text{Specicifc gravity } \left(\frac{\text{g}}{\text{cubic centimeter}}\right) = \frac{\text{Weight of tuber in air}}{\text{Weight of equal volume of water at } 4°\text{C}}$$

viii. Dry matter content (%)

The potato tuber samples were kept in separated envelopes for each plot and five potato tubers were taken after harvest to calculate the DMC and were oven dried at 70^0C for 72 hours. Dry weight was determined with a digital balance and means were calculated in percent unit.

$$\textbf{DMC} = \frac{\textbf{Dry weight}}{\textbf{Fresh weight}} \times 100$$

ix. Total soluble solid (TSS) (^{0}brix)

Total Soluble solid (TSS) of harvested tubers was determined after harvest in a drop of potato juice by using Hand Sugar Refractometer "ERMA" Japan, Range: 0-32% according to (AOAC, 1990) and recorded as ^{0}brix from direct reading of the instrument.

x. Starch content (mg g^{-1} FW)

Starch content of tubers was determined after harvest by Somogyi-Nelson method (Nelson, 1944). Phosphate buffer solution was prepared through diluted 0.74g $NaH_2PO_4 \cdot 2H_2O$ and 0.09g $Na_2HPO_4 \cdot 12H_2O$ into 100 ml Distilled water. Added 0.1 g Enzyme (Amyloglucosidase) and mixed well. Kept at -20°C for the preservation. The residue remained after extraction for sugar was washed for several times with water to ensure that there was no more soluble sugar in the residues. After that using tap water and mark up to 250 ml beaker. Stirred well on a magnetic stirrer. Then 0.5 mL solution was taken from the beaker during stirring into 3 test tubes. Boil the test tubes for 10 min at 100˚C. Add 1 ml Amyloglucosidase solution, mix well, and heat at 50-60˚C for 2 hours in hot water. After cooling, add 0.5 ml Copper solution, mix well, heat at 100°C for 10 min., cool in tap water, add 0.5 ml Nelson solution, mix well, add 7 ml distilled water, mix well (Final volume = 9.5 ml), and measure the absorbance at 660 nm (Abs). Starch content was calculated using the glucose standard curve.

xi. Reducing sugar (mg g^{-1} FW)

For the analysis of sugar content like reducing sugar (glucose) potato flesh was extracted. For each extraction, 1 g fresh sample of chopped potato was taken from uniform tuber samples and smashed well in a motor. Sugar was extracted using 5 ml of 80% ethanol heat at 80°c for 30 min using a dry block heat bath and the extracts was centrifuged at 5000 rpm for 10 min and decanted the supernatant. 8 mL 80% EtOH, was added and it was repeated 4 and 5 times in total. All the supernatants were mixed well and the final volume was made up to 25 mL using 80% EtOH. The residue is used for sugar analysis. Reducing sugar was estimated by the photometric adaptation of the Somogyi method (Nelson, 1944) with some modification. Copper solution and Nelson reagent and standard glucose solution (0.5 mL) were used. 3 mL sample solution was put into a small glass container. Then it was completely dried up on an electric heater, 3 mL distilled water was added and then mixed well. Then 0.5 ml solution was taken from that, two times and was put in different test tubes. In one test tube, 0.5 mL Copper solution was added and was boiled (100° C) for 10 min. After boiling, immediately the test tube was cooled in tap water. 0.5 mL

Nelson reagent in the test tube was added, and mixed them well. After 20 min, 8 mL distilled water was added and mixed well (Total volume = 9.5 mL). After that the absorbance at 660 nm (Abs1) was measured and the reducing sugar content was calculated.

xii. Chips making process

Chips from fresh tubers were prepared as per standard procedure given by CPRI, Shimla (Marwaha *et al*., 2008). After harvest the tubers were processed to evaluate potato chip color which was taken from well cured uniform size tubers of weight 100 g to 150 g from each variety for chips preparation. For each sample ten tubers were washed, peeled in an abrasive peeler, and hand trimmed. Approximately 6-8 cross sections from the central portion of each tuber were taken using a rotary food slicer. Preliminary trials were conducted for optimization of chips preparation using slicer with adjustable blade for slice width. A slice of 1.8 mm thickness after removing excess water with paper towels was used for frying in an automatic microwave oven at temperature 175°C for 3 minutes to yield potato chips of optimum quality (Work, 1981).

xiii. Texture of chips (N)

The texture of potato chips was determined according to Moreno-Perez *et al*. (1996). The texture of potato chips was evaluated using hardness taster (Kiya Seisakusho. Ltd. Tokyo, Japan). The chips were placed on a hollow planar base and force was applied to the samples until the samples were broken.

xiv. Bitterness, sweetness and sourness of chips

Bitterness, sweetness and sourness test of chips was conducted in agronomy laboratory, following the procedure of Watts *et al*. (1989). A 5-member, untrained but experienced panelists consisting of students were selected to rate these quality attributes. A five point test was employed to measure taste, sourness (1= not sour and 2 = less sour), bitterness (1= not bitter and 2 = less bitter) and sweetness (1=not sweet and 5 = very sweet) according to Yost *et al*. (2006). Coded samples (samples of one treatment) were served for each panelist separately in similar plastic trays at a time. Water was provided to the panelists to rinse their mouth before and between testing samples as suggested by Watts *et al*. (1989) and the evaluation was repeated 3 times for each sample.

xv. Yield for chips production (45-75 mm)

The tubers, those are 45-75 mm of their diameter size (Marwaha *et al*., 2010) were considered for chips tuber and then the entire tuber weighted by using an electronic balance from total tuber yield against each plot. Then the means were taken in ton per hectare unit.

xvi. Yield for French fry production (>75 mm)

The tubers, those are >75 mm of their length (Marwaha *et al*., 2010) were considered for French fry tuber and then the entire tuber weighted by using an electronic balance from total tuber yield against each plot. Then the means were taken in ton per hectare unit.

xvii. Yield for flakes production (30-45 mm)

The tubers, those are 30-45 mm of their diameter size (Marwaha *et al*., 2010) were considered for flakes tuber and then the entire tuber weighted by using an electronic balance from total tuber yield against each plot. Then the means were taken in ton per hectare unit.

xviii. Yield for canned production (<30 mm)

The tubers, those are <30 mm of their diameter size (Marwaha *et al*., 2010) were considered for canned tuber and then the entire tuber weighted by using an electronic balance from total tuber yield against each plot. Then the means were taken in ton per hectare unit.

3.14 Tuber yield merit (%)

The tuber yield merit means, how much tuber yield was increased for using vermicompst over checked. The tuber yield merit was calculated for final experiment by as follow as:

Tuber yield merit (%) = (Yield obtained from expected treatment–yield obtained from checked treatment) × 100/ Yield obtained from checked treatment.

3.15 Monetary advantage (From Marketable Yield)

= Total tuber yield (t ha^{-1})

= Total tuber yield (kg ha^{-1}) × 1000 [1 ton=1000 kg.]

= Total tuber yield (kg ha^{-1}) × 30 [price kg^{-1} potato tuber, 30 Tk.]

3.16 Correlation coefficient (r)

Correlation coefficient between different yield and quality contributing traits were calculated by using the MS excel spread sheet.

3.17 Statistical Analysis

Collected data on different parameters were analyzed statistically using the analysis of variance (ANOVA) technique with the help of WASP (Web Agri Stat Package: version-1) computer program and means were adjusted by using LSD (Least Significant Difference) at 5 % level of probability. Raw data management and graphical representation were done by using Microsoft excel spread sheet.

CHAPTER IV

RESULTS AND DISCUSSION

The present studies were aimed to investigate the effects of vermicopost in combination with harvesting time on the processing qualities of potato. In this chapter; figures, tables and appendices have been used to present, discuss and compare the findings obtained from the studies. The ANOVA (analysis of variance) of data in aspects of all the visual and measurable characteristics have been presented in Appendix (VI-XIX). All possible reveals and interpretations were given under the following headings:

4. A Experiment 1

4.1 Tuber Yield (t ha^{-1})

A significant variation ($p \leq 0.01$) was found among the different varieties of potatoes in respect of yield of tuber (Appendix-VI and Table-1). The highest tuber yield (34.57 t ha^{-1}) was produced by BARI Alu-28 (Lady rosetta) which was statistically similar to BARI Alu-25 (Asterix) (32.54 t ha^{-1}) followed by BARI Alu-29 (Courage) (31.52 t ha^{-1}), BARI Alu-71 (BARI Alu-71 (Doly)) (31.47 t ha^{-1}), BARI Alu-70 (Destiny)(28.55 t ha^{-1}) and BARI Alu-68 (Atlantic) (26.25 t ha^{-1}). The lowest tuber yield (19.56 t ha^{-1}) was found from Stick which was statistically similar to Granolla, Binella, Dora, Dheera, Sagita, Provento, Felsina, Multa, Meridian, Forza, Saikat, Laura, Ailsa, Cumbica, Omera, Rumba, Agila, Quincy, Almerah, Festa Pakri, Tel Pakri and Bot Pakri. Yield was significantly influenced by variety and season of production (Sinha *et al*., 1992). Gupta *et al*. (2009) also confirmed that there were significant effects of the season on total tuber yield, which might be due to different responses of different genotypes to environmental conditions. Patel *et al*. (2008) provided that higher tuber yield might be due to better plant growth, genotype, adaptability in wide range of environment and combined effect of all other growth and yield attributes.

4.2 Specific gravity (g cm^{-3})

Profound variation ($p \leq 0.01$) found among the different varieties of potatoes in respect of specific gravity (Appendix-VI and Table-1). The maximum (1.1033 g cm^{-3}) specific gravity was exhibited by BARI Alu-28 (Lady rosetta) which was statistically similar to the BARI Alu-25 (Asterix) (1.0833 g cm^{-3}) and BARI Alu-29 (Courage) (1.0933 g cm^{-3}) followed by Cardinal, BARI Alu-71 (Doly) , BARI Alu-70 (Destiny)and BARI Alu-68 (Atlantic). The minimum (1.0087 g cm^{-3}) specific gravity was found from Malta which wa statically similar to Rojato, Dora, Granolla, Raja, Binella, Dheera, Sagita, Patrones, Provento, Felsina, Meridian, Forza, Saikat, Laura, Ailsa, Cumbika, Quincy, Almerah, Steffi. The present result is in agreement with the findings of Roy *et al*., (2017b). They said that the lower dry matter content of tuber and lower weight of tuber resulted the lower specific gravity and vice-versa.

4.3 Dry Matter (%)

Dry matter content of tuber was found significant ($p \leq 0.01$) due to different varieties of potatoes (Appendix-VI and Table-1). The highest dry matter content (22.090 %) was partitioned by BARI Alu-28 (Lady rosetta) which was statistically similar to the BARI Alu-29 (Courage) (21.623 %) and BARI Alu-25 (Asterix) (20.527 %) and followed by BARI Alu-71 (Doly) , Destiny, and BARI ALU-68 (ATLANTIC). The lowest dry matter (15.220 %) was partitioned in Dora which was statistically similar to Raja, Binella, Dheera, Granolla, Stick, Provento, Felsina, Multa, Meridian, Forza, Cumbica, Omera, Rumba, Jerla, Elgar, Almerah. Present result is in agreement with the findings of Rahman *et al*. (2016). They reported that potato varieties having dry matter percentage more than 20% are suitable for processing.

Table 1. Yield, specific gravity and dry matter percentage of thirty six potato varieties

Varieties	Tuber Yield ($t\ ha^{-1}$)	Specific gravity ($g\ cm^{-3}$)	Dry Matter (%)
BARI Alu-25 (Asterix)	32.45 ab	1.0833 ab	20.527 ab
Cardinal	24.44 de	1.0633 b-d	17.367 d-j
Rojato	22.48 ef	1.0267 e-i	17.973 c-g
BARI ALu-70 (Destiny)	28.55 c	1.0433 d-e	18.560 cd
Festa Pakri	21.83 e-g	1.0367 e-g	16.897 d-k
Tel Pakri	21.56 fg	1.0467 c-e	18.037 c-g
Bot Pakri	21.06 fg	1.0333 e-h	15.973 h-k
Stick	19.56 g	1.0400 ef	16.183 g-k
Dora	22.23 e-g	1.0300 e-i	15.220 k
Granolla	21.21 fg	1.0267 e-i	15.617 jk
BARI Alu-68 (Atlantic)	26.25 cd	1.0433 d-f	18.147 c-f
Raja	22.36 ef	1.0227 f-i	16.823 d-k
Binella	21.62 fg	1.0257 e-i	16.580 e-k
Dheera	22.01 e-g	1.0150 g-i	16.747 d-k
Sagita	21.09 fg	1.0150 g-i	17.473 d-j
Patrones	22.40 ef	1.0257 e-i	18.137 c-f
BARI Alu-29 (Courage)	31.52 b	1.0933 a	21.623 a
Provento	22.09 e-g	1.0213 f-i	16.780 d-k
Felsina	20.92 fg	1.0177 g-i	16.807 d-k
Multa	21.45 fg	1.0087 i	15.870 i-k
BARI Alu-28 (Lady rosetta)	34.57 a	1.1033 a	22.090 a
Meridian	21.58 fg	1.0140 hi	16.047 h-k
Forza	20.76 fg	1.0163 g-i	16.173 g-k
Saikat	20.51 fg	1.0160 g-i	17.147 d-j
Laura	21.19 fg	1.0153 g-i	17.403 d-j
Ailsa	22.18 e-g	1.0173 g-i	17.570 d-j
Cumbica	21.27 fg	1.0237 f-i	16.477 f-k
Omera	20.77 fg	1.0330 e-h	16.840 d-k
Rumba	22.18 e-g	1.0347 e-h	16.703 d-k
Jerla	22.46 ef	1.0330 e-h	16.440 f-k
Elgar	22.40 ef	1.0323 e-h	16.850 d-k
BARI Alu-71 (Doly)	31.47 b	1.0667 bc	19.600 bc
Agila	20.98 fg	1.0363 e-g	17.817 c-h
Quincy	20.69 fg	1.0277 e-i	17.807 c-h
Almerah	22.02 e-g	1.0283 e-i	16.870 d-k
Steffi	22.46 ef	1.0303 e-i	18.447 c-e
CV (%)	7.35	1.33	6.63
LSD $_{(0.05)}$	2.774	0.022	1.882
Significance Level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability

4.4 Correlation co-efficient (r)

A strong positive relation (r=0.872) was found between tuber yield and specific gravity of potato tuber-Figure 1. In Figure-2, a strong positive relation (r=0.861) was found between tuber yield and dry matter content of potato tuber. Specific gravity and dry matter content of potato tuber was strongly (r=0.819) related with each other (Figure-3). Rastovski *et al.* (1981) also noticed that there is a significant relationship exists between dry matter content and specific gravity.

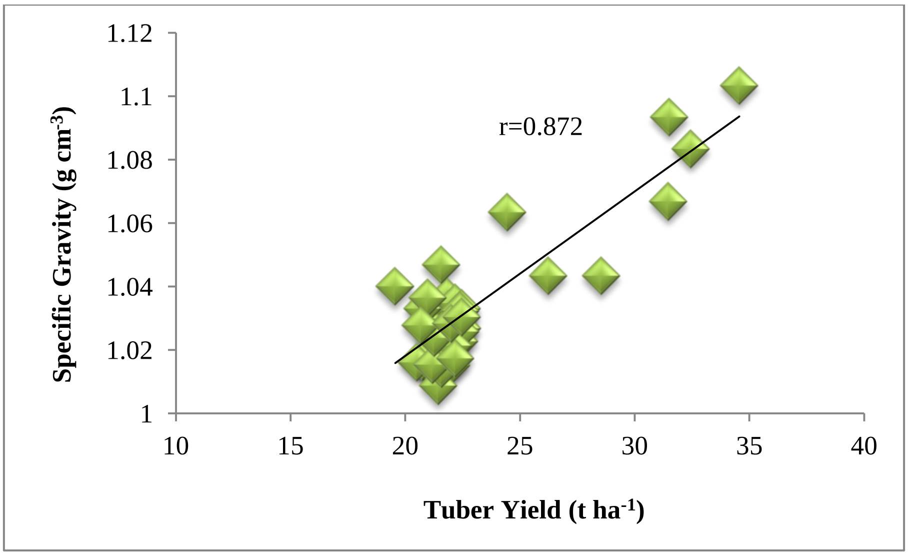

Figure 1. Relationship between tuber yield ($t\ ha^{-1}$) and specific gravity ($g\ cm^{-3}$) of potato

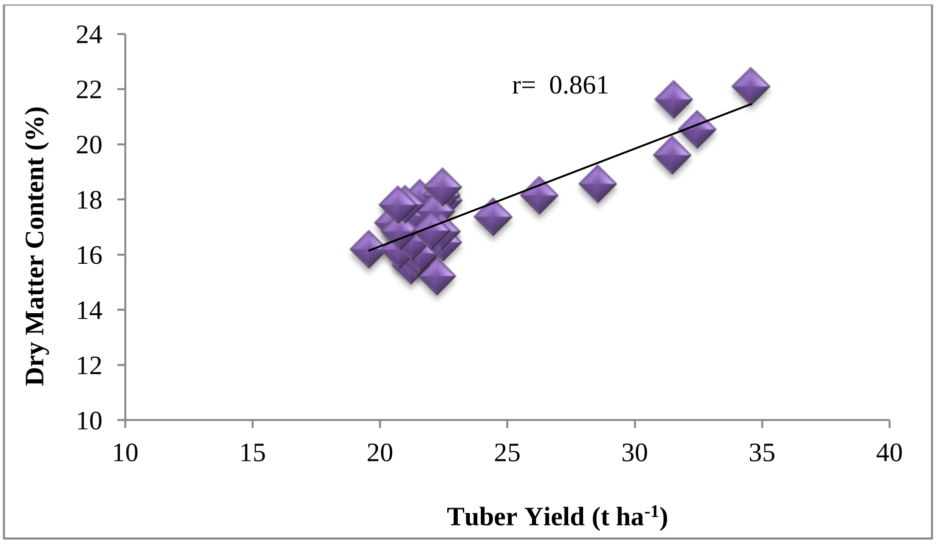

Figure 2. Relationship between tuber yield and dry matter content of potato

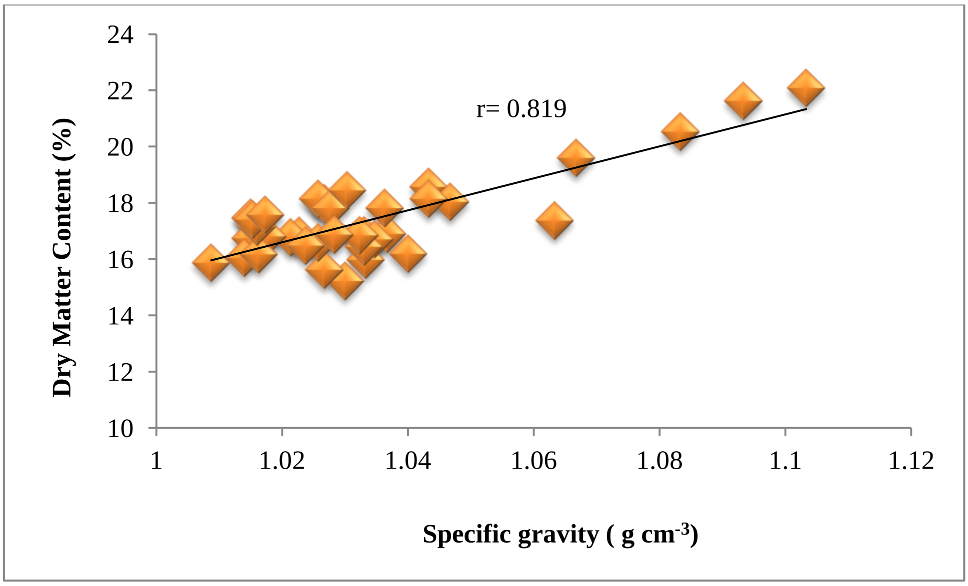

Figure 3. Relationship between tuber specific gravity (g cm^{-3}) and dry matter content of potato

4.B Experiment 2

4.5 Number of tubers $hill^{-1}$

The number of tubers $hill^{-1}$ was found significant ($p \leq 0.01$) due to different potato varieties (Appendix-VII and Table-2). The maximum number (13.484) was found in case of V_1 which was statistically similar to V_2 (13.327) followed by V_3 and minimum was in V_4 (10.273). A significant ($p \leq 0.01$) effect was found from vermicompost application on number of tubers $hill^{-1}$ (Appendix-VII and Table-3). A decreasing trend was found with increasing of vermicompost in case of number of tubers $hill^{-1}$. The maximum number (13.062) was found in Vm_3 which was statistically similar to Vm_1 and Vm_2. The minimum number (10.944) was found in Vm_4 which was statistically similar to Vm_5. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against average weight of potato tubers (Appendix-VII and Table-4). Combinedly, the maximum number (14.113) was found in V_1Vm_1 which was statistically similar to maximum treatment combinations while the minimum number (7.877) was found in V_3Vm_4 which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5 (Table-4).

According to the available reports the increase of stem numbers is led to the increase of tubers and on the other hand the yield of Potato is related to the tubers and the average weight of them (Yourtchi *et al*., 2013). Atiye *et al*. (2000) stated that the use of compost and vermicompost significantly led to the tuber increase and the number of main and sub stems.

4.6 Average weight of tuber (g)

Average weight of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-VII and Table-2). The highest average weight (49.069 g) of tuber was found from V_3 treatment which was statistically similar to V_4 and the lowest (30.693 g) was found in V_1. In respects of average weight of potato tubers a remarkable variation ($p \leq 0.01$) was noted (Appendix-VII and Table-3) against different level of vermicompost application. Average weight of tuber increased with increasing of vermicompost level. The highest average weight (47.747 g) of tuber was found from Vm_5 treatment which was statistically similar to Vm_4 and the lowest (36.969 g) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against average weight of potato tubers (Appendix-VII and Table-4). The highest average weight (60.247 g) of tuber was found from V_3Vm_4 treatment combination which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5. The lowest average (29.207 g) was in V_1Vm_1 treatment combination which was statistically similar to rest of the treatment combinations (Table-4). More absorption of soil nitrogen from vermicompost application induced more protein partitioning into the growing tubers may be the main reason for the highest average weight of tuber.

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

Weight of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-VII and Table-2). The highest weight (472.15 g) of tuber was found from V_3 treatment which was statistically similar to V_4 and the lowest (418.78 g) was in V_1. In respects of weight of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-VII and Table-3). The highest weight (479.57 g) of tuber was found from Vm_5 which was statistically similar to treatment Vm_4 and the lowest weight (427.33 g) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against weight of potato tubers (Appendix-VII and Table-4). The highest weight (544.49 g) of tuber was found from V_4Vm_5 treatment combination which was statistically similar to V_4Vm_4, V_3Vm_4 and V_3Vm_5. The lowest (408.12 g) was in V_1Vm_1 treatment combination. Higher average tuber weight hill^{-1} may be the reason for higher weight of tuber hill^{-1}. Bongkyoon (2004) mentioned that the application of NPK and vermicompost showed an increment in the average tuber weight per plant. Naher (1999) also reported that maximum weight of tubers (396 g hill^{-1}) was recorded when organic fertilizer managements were applied.

4.8 Tuber Yield (t ha^{-1})

Yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-VIII and Table-2). The highest (28.79 t ha^{-1}) tuber yield was found from V_4 treatment which was statistically similar to V_4 treatment and the lowest (24.63 t ha^{-1}) was in V_1. In respects of yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-VIII and Table-3). The highest (30.97 t ha^{-1}) tuber yield was found from Vm_4 treatment which was statistically similar to Vm_5 treatment and the lowest (25.25 t ha^{-1}) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers (Appendix-VIII and Table-4). The highest tuber yield (33.56 t ha^{-1}) was found from V_2Vm_4 treatment combination which was statistically similar to V_3Vm_4, V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (24.38 t ha^{-1}) was in V_1Vm_2. The highest weight of tuber hill^{-1} and highest average weight of tuber might be the main reason for highest tuber yield ha^{-1}. The increase in average tuber weight of potato with the supply of fertilizer nutrients could be due to more luxuriant growth, more foliage and leaf area and highest supply of photosynthesis, which helped in producing bigger tubers, hence resulting in highest yields.

4.9 Marketable yield (t ha^{-1})

Marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-VIII and Table-2). The highest (26.64 t ha^{-1}) yield was found from V_3 treatment followed by V_2 treatment and the lowest (21.88 t ha^{-1}) was in V_1. In respects of marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-VIII and Table-3). The highest yield (29.06 t ha^{-1}) was found from Vm_4 treatment which was statistically similar to Vm_5 treatment and the lowest (22.59 t ha^{-1}) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against marketable yield of potato tubers (Appendix-VIII and Table-4). The highest yield (31.34 t ha^{-1}) was found from V_4Vm_5 treatment combination which was statistically similar to V_4Vm_4, V_3Vm_4, V_3Vm_5, V_2Vm_5 and V_2Vm_4 while the lowest (21.60 t ha^{-1}) was in V_1Vm_2.

4.10 Non-marketable yield (t ha^{-1})

Non-marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-VIII and Table-2). The highest (2.75 t ha^{-1}) yield was found from V_1 treatment which was statistically similar to V_2 and V_4 and the lowest (1.75 t ha^{-1}) was in V_3. In respects of non-marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-VIII and Table-3). The highest yield (2.66 t ha^{-1}) was found from Vm_1 treatment which was statistically similar to Vm_2 and Vm_3 treatment and the lowest (1.91 and 1.83 t ha^{-1}) was found in Vm_4 and Vm_5, respectively. Combindly, a non-significant (p=NS) variation was found among the treatment against non-marketable yield of potato tubers (Appendix-VIII and Table-4). But, numerically the highest yield (3.21 t ha^{-1})

was found from V_4Vm_1 treatment combination while the lowest (1.44 t ha^{-1}) was in V_4Vm_5 which was similar to numerically V_4Vm_4, V_3Vm_5, V_3Vm_4, V_2Vm_5 and V_2Vm_4.

Table 2. Performance of varieties on the yield and yield contributing traits of potato

Varieties	Number of tubers $hill^{-1}$	Average weight of tuber (g)	Weight of tubers $hill^{-1}$ (g)	Tuber yield (t ha^{-1})	Marketable yield (t ha^{-1})	Non-marketable yield (t ha^{-1})
V_1	13.484 a	30.693 c	418.78 c	24.63 b	21.88 d	2.75 a
V_2	13.327 a	33.871 b	438.55 b	28.87 a	26.59 b	2.28 a
V_3	11.155 b	49.069 a	472.15 a	28.38 a	26.64 a	1.74 b
V_4	10.273 c	48.365 a	461.16 a	28.79 a	26.41 c	2.38 a
CV (%)	3.71	3.08	2.89	8.46	2.57	25.64
LSD $_{(0.05)}$	0.4003	1.1148	11.559	2.0926	0.4252	2.1007
Significance level	**	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage), V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady rosetta)

Table 3. Performance of varieties on the yield and yield contributing traits of potato

Vermicompost	Number of tubers $hill^{-1}$	Average weight of tuber (g)	Weight of tubers $hill^{-1}$ (g)	Tuber yield (t ha^{-1})	Marketable yield (t ha^{-1})	Non-marketable yield (t ha^{-1})
Vm_1	12.871 a	36.969 b	427.33 b	25.25 b	22.59 c	2.66 a
Vm_2	12.664 a	37.207 b	433.17 b	25.72 b	23.13 bc	2.58 a
Vm_3	13.062 a	34.747 b	420.12 b	25.66 b	23.19 b	2.46 a
Vm_4	10.944 b	45.827 a	478.08 a	30.97 a	29.06 a	1.91 b
Vm_5	10.757 b	47.747 a	479.57 a	30.75 a	28.92 a	1.83 b
CV (%)	7.29	7.54	6.61	5.70	7.11	20.22
LSD $_{(0.05)}$	0.7314	2.5407	24.599	1.3125	1.0943	1.5416
Significance level	**	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability
Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}

Table 4. Interaction effect of variety and vermicompost on the yield and yield contributing traits of potato

Combination	Number of tubers hill^{-1}	Average weight of tuber (g)	Weight of tubers hill^{-1} (g)	Tuber yield (t ha^{-1})	Marketable yield (t ha^{-1})	Non-marketable yield (t ha^{-1})
V_1Vm_1	14.113 a	29.207 d	408.12 de	24.78 b	21.84 e	2.94
V_1Vm_2	13.547 ab	30.117 d	415.44 cd	24.38 b	21.60 e	2.77
V_1Vm_3	13.617 ab	31.107 d	423.72 cd	24.59 b	21.87 de	2.72
V_1Vm_4	13.037 ab	30.887 d	425.11 cd	24.98 b	22.21 de	2.77
V_1Vm_5	13.107 ab	32.147 d	421.49 cd	24.45 b	21.86 de	2.58
V_2Vm_1	12.977 ab	32.107 d	416.79 cd	24.69 b	22.07 de	2.61
V_2Vm_2	13.287 ab	32.587 d	436.45 cd	25.99 b	23.31 cd	2.67
V_2Vm_3	14.017 a	33.187 d	439.21 cd	26.72 b	23.92 cd	2.79
V_2Vm_4	14.007 a	32.887 d	460.79 bc	33.56 a	31.89 a	1.66
V_2Vm_5	12.347 bc	38.587 c	439.49 cd	33.42 a	31.75 a	1.66
V_3Vm_1	13.147 ab	40.247 c	451.15 cd	24.76 b	22.88 bc	1.87
V_3Vm_2	12.877 ab	43.117 bc	444.44 cd	26.33 b	24.45 b	1.88
V_3Vm_3	13.207 ab	42.587 bc	451.19 cd	25.95 b	24.21 b	1.73
V_3Vm_4	7.877 e	60.247 a	501.12 ab	32.53 a	30.95 a	1.58
V_3Vm_5	8.667 e	59.147 a	512.83 a	32.35 a	30.70 a	1.64
V_4Vm_1	11.247 cd	46.317 b	433.25 cd	26.78 b	23.56 de	3.21
V_4Vm_2	10.947 d	43.007 bc	436.36 cd	26.17 b	23.15 de	3.02
V_4Vm_3	11.407 cd	32.107 d	366.38 e	25.39 b	22.77 de	2.61
V_4Vm_4	8.857 e	59.287 a	525.31 a	32.82 a	31.20 a	1.62
V_4Vm_5	8.907 e	61.107 a	544.49 a	32.79 a	31.34 a	1.44
CV (%)	7.29	7.54	6.61	5.70	7.11	2.9425
LSD $_{(0.05)}$	1.3668	4.6761	45.457	3.1324	2.0020	-------
Significance level	**	**	**	**	**	NS

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability; NS=Non-significant
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady rosetta)
Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}

4.11 Specific gravity (g cm^{-3})

Specific gravity of tubers was found non-significant (p=NS) against different potato varieties (Appendix-IX and Table-5). In respects of specific gravity of potato tubers also a non-significant (p=NS) response was noted against different levels of vermicompost applications (Appendix-IX and Table-6). Combindly, a significant variation ($p \leq 0.05$) was found among the treatment against specific gravity of potato tubers (Appendix-IX and Table-7). The maximum specific gravity (1.1127 g cm^{-3}) of tuber was found from V_3Vm_5 treatment combination which was statistically similar to rest all treatment combinations while the lowest (0.7247 g cm^{-3}) specific gravity was found in V_1Vm_1 treatment combination. High specific gravity is an essential processing quality factor for potato and increased with increasing vermicompost level (Mostofa *et al*., 2018). So, the present result is in agreement with this citation.

4.12 Dry matter content (%)

A significant ($p \leq 0.01$) difference was found among the varieties against dry matter content of potato tuber (Appendix-IX and Table-5). The highest (20.165 %) dry matter content was found in V_2 treatment which was statistically similar to V_3 and V_4 treatment while the lowest (17.267 %) dry matter was in V_1. In respects of dry matter content of potato tubers also a significant ($p \leq 0.01$) response was noted against different levels of vermicompost applications (Appendix-IX and Table-6). The highest dry matter (21.287 %) was found from Vm_5 treatment which was statistically similar to Vm_4 treatment and the lowest (17.367 %) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-IX and Table-7) among the treatment against dry matter content of potato tubers. The highest dry matter (22.803 %) of tuber was found from V_2Vm_5 treatment combination which was statistically similar to V_2Vm_4, V_3Vm_4, V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (16.120 %) dry matter was found in V_1Vm_1 treatment combination. High dry matter content (%) was observed which might be due to the application of high rate of vermicompost which played an important role in affecting the dry matter of tubers (Mostofa *et al*., 2018).

4.13 TSS (Total soluble solid, ^{o}brix)

A significant ($p \leq 0.01$) difference was found among the varieties against total soluble solid of potato tuber (Appendix-IX and Table-5). The highest (6.478°) TSS was found in V_4 treatment while the lowest (4.612°) TSS was in V_1. In respects of TSS of potato tubers also a significant response was noted against different levels of vermicompost applications (Appendix-IX and Table-6). The highest TSS (6.111°) was found from Vm_5 treatment which was statistically similar to Vm_4 treatment and the lowest (5.271°) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against TSS of potato tubers (Appendix-IX and Table-7). The highest TSS (7.1067°) of tuber was found from V_4Vm_4 treatment combination which was statistically similar to V_4Vm_5, V_3Vm_4 and V_3Vm_5 while the lowest (4.146°) TSS was found in V_1Vm_1 treatment combination. Higher portioning of photosynthate to tuber resulted in high dry matter content may be main reason for maximum total soluble solid content in tuber.

4.14 Starch content (mg g^{-1} FW)

A significant ($p \leq 0.01$) difference was found among the varieties against starch content of potato tuber (Appendix-X and Table-5). The highest (22.719 mg g^{-1} FW) starch content was found in V_3 treatment followed by V_3 while the lowest (16.67 mg g^{-1} FW) was in V_1. In respects of starch content of potato tubers also a significant response ($p \leq 0.01$) was noted against different levels of vermicompost applications (Appendix-X and Table-6). The highest starch (22.244 mg g^{-1} FW) was found from Vm_5 treatment which was statistically similar to Vm_4 treatment and the lowest (18.287 mg g^{-1} FW) was in Vm_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against starch content of potato tubers (Appendix-X and Table-7). The highest starch (26.007 mg g^{-1} FW) of tuber was found from V_3Vm_4 treatment combination which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (16.337 mg g^{-1} FW) starch was found in V_1Vm_1 treatment.

4.15 Reducing sugar (mg g^{-1} FW)

A significant ($p \leq 0.01$) difference was found among the varieties against reducing sugar content of potato tuber (Appendix-X and Table-5). The highest (0.516 mg g^{-1} FW) reducing sugar content was found in V_1 treatment followed by V_2 while the lowest (0.298 mg g^{-1} FW) reducing content was in V_3. In respects of reducing sugar content of potato tubers also a significant ($p \leq 0.01$) response was noted against different levels of vermicompost applications (Appendix-X and Table-6). The highest reducing sugar (0.456 mg g^{-1} FW) was found from Vm_1 treatment followed by Vm_3 treatment and the lowest (0.326 mg g^{-1} FW) was in Vm_4. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against reducing sugar content of potato tubers (Appendix-X and Table-7). The highest reducing sugar (0.5467 mg g^{-1} FW) of tuber was found from V_1Vm_1 treatment combination which was statistically similar to V_1Vm_2 and V_1Vm_5 while the lowest (0.2367 mg g^{-1} FW) reducing sugar was found in V_4Vm_4 treatment combination which was statistically similar to V_4Vm_5 and V_3Vm_5.

Table 5. Performance of varieties on the processing qualities of potato

Varieties	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
V_1	0.971	17.267 b	4.612 d	16.67 d	0.516 a
V_2	0.983	20.165 a	5.302 c	18.63 c	0.418 b
V_3	1.057	19.358 a	6.202 b	22.719 a	0.298 d
V_4	1.054	19.759 a	6.478 a	21.901 b	0.343 c
CV (%)	11.59	8.21	2.55	2.17	3.48
LSD $_{(0.05)}$	------	1.4037	0.1287	0.3876	0.0123
Significance level	NS	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady rosetta)

Table 6. Effect of vermicompost on the processing qualities of potato

Vermicompost	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
Vm_1	0.958	17.367 b	5.271 b	18.287 b	0.456 a
Vm_2	1.032	17.742 b	5.304 b	18.314 b	0.394 c
Vm_3	1.031	17.786 b	5.524 b	19.074 b	0.430 b
Vm_4	1.062	21.504 a	6.034 a	21.994 a	0.326 e
Vm_5	0.997	21.287 a	6.111 a	22.244 a	0.364 d
CV (%)	13.07	3.81	5.57	4.80	5.70
LSD $_{(0.05)}$	-------	0.6066	0.2616	0.7975	0.0187
Significance level	NS	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicates significant at 1% level of probability
Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}

Table 7. Interaction effect of variety and vermicompost on the processing qualities of potato

Combination	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
V_1Vm_1	0.7247 b	16.120 d	4.1467 h	16.337 d	0.5467 a
V_1Vm_2	1.0227 a	16.833 d	4.2167 h	16.387 d	0.5167 ab
V_1Vm_3	1.0417 a	17.436 bcd	4.5067 h	16.747 d	0.4967 bc
V_1Vm_4	1.0227 a	17.947 bcd	5.0467 g	16.917 d	0.5067 bc
V_1Vm_5	1.0437 a	18.000 bc	5.1467 fg	17.007 d	0.5167 ab
V_2Vm_1	1.0507 a	18.303 bc	5.2867 efg	17.107 d	0.4567 def
V_2Vm_2	1.0547 a	19.180 b	5.3067 d-g	17.277 d	0.4267 f
V_2Vm_3	1.0317 a	18.060 bc	5.7067 b-e	19.317 c	0.4567 def
V_2Vm_4	1.0437 a	22.477 a	5.0067 g	19.247 c	0.3067 hi
V_2Vm_5	0.7353 b	22.803 a	5.2067 efg	20.217 bc	0.4467 ef
V_3Vm_1	1.0287 a	17.309 bcd	5.6467 b-e	20.187 bc	0.3367 gh
V_3Vm_2	1.0267 a	16.950 bcd	5.6067 c-f	20.207 bc	0.3667 g
V_3Vm_3	1.0277 a	17.697 bcd	5.7767 bcd	21.347 b	0.2867 ij
V_3Vm_4	1.0917 a	22.647 a	6.9767 a	26.007 a	0.2567 jk
V_3Vm_5	1.1127 a	22.190 a	7.0067 a	25.847 a	0.2467 k
V_4Vm_1	1.0287 a	17.737 bcd	6.0067 bc	19.517 c	0.4867 bcd
V_4Vm_2	1.0277 a	18.003 bc	6.0867 bc	19.387 c	0.2667 jk
V_4Vm_3	1.0257 a	17.953 bcd	6.1067 b	18.887 c	0.4800 cde
V_4Vm_4	1.0907 a	22.947 a	7.1067 a	25.807 a	0.2367 k
V_4Vm_5	1.0987 a	22.153 a	7.0867 a	25.907 a	0.2467 k
CV (%)	13.07	3.81	5.57	4.80	5.70
LSD $_{(0.05)}$	0.2233	1.7669	0.4848	1.4770	0.0356
Significance level	*	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; * indicates significant at 5% level of probability;
NS=Non-significant
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady rosetta)
Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}

4.16 Correlation co-efficient (r)

A strong negative relation (r=−0.917) was found between number of tuber and average weight of tuber (Figure-4). In Figure-5, a positive relation (r=0.881) was seen between average weight of tuber and weight of tuber per hill. A week but positive relation (r=0.172) was found between specific gravity and dry matter content of potato tuber (Figure-6). A positive relation (r=0.606) was found between dry matter content and Total Soluble Solid (TSS) of potato tuber (Figure-7). In Figure-8, a positive relation (r=0.537) was found between specific gravity and Total Soluble Solid (TSS) of tuber. A strong negative relation (r=−0.849) was found between starch and reducing sugar content of potato tuber (Figure-9).

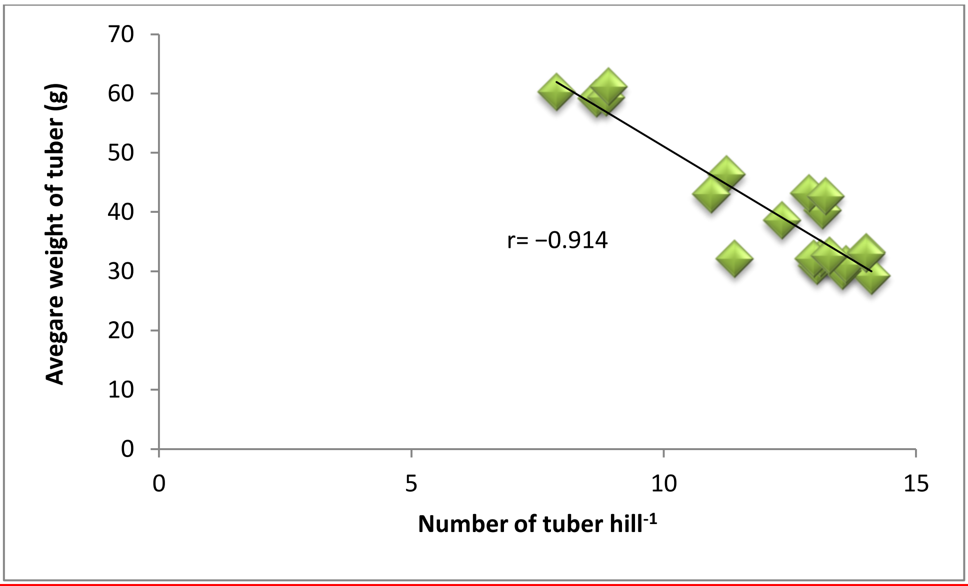

Figure 4. Relationship between number of tuber hill^{-1} and average weight of tuber (g)

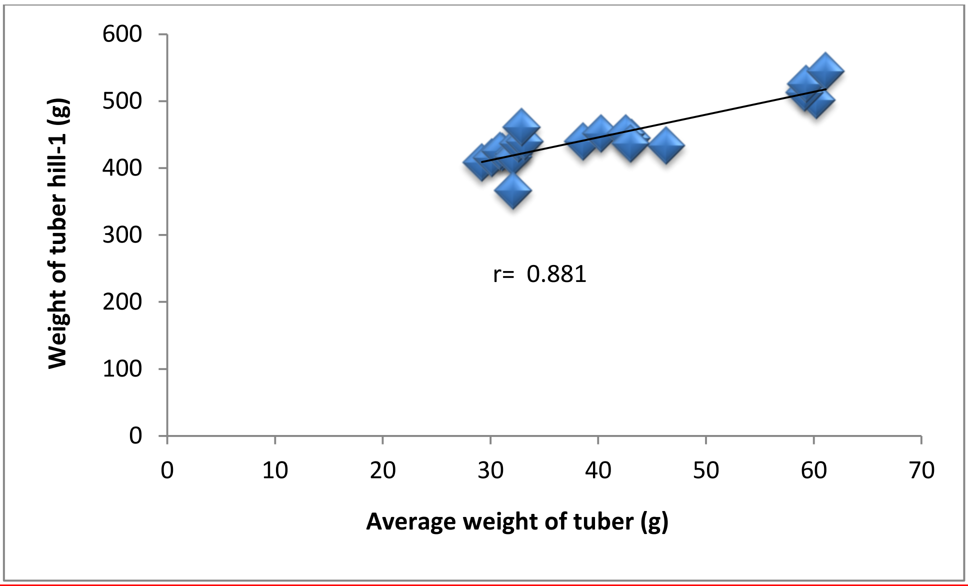

Figure 5. Relationship between average weight of tuber (g) and weight of tuber hill^{-1}

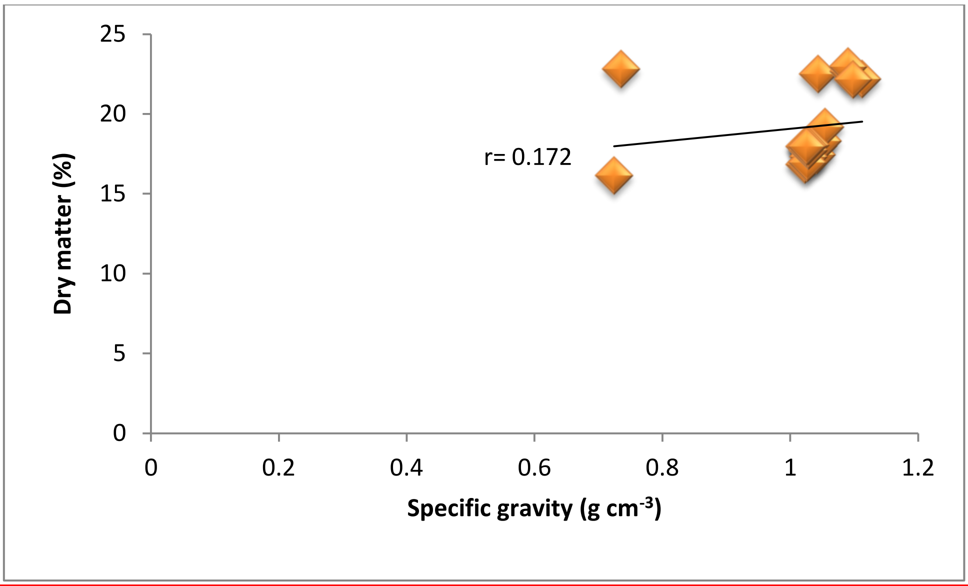

Figure 6. Relationship between specific gravity (g cm^{-3}) and tuber dry matter content (%)

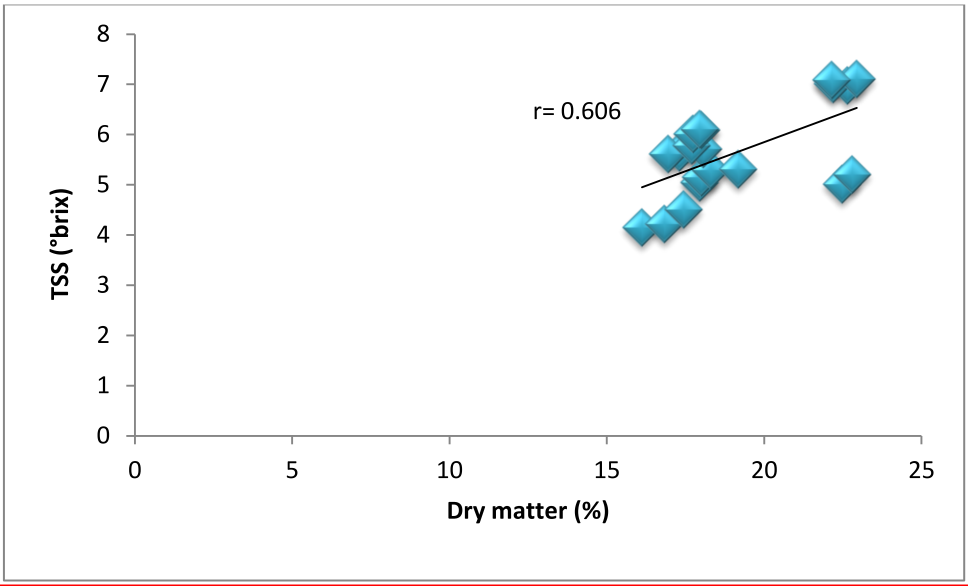

Figure 7. Relationship between tuber dry matter content (%) and TSS (°brix)

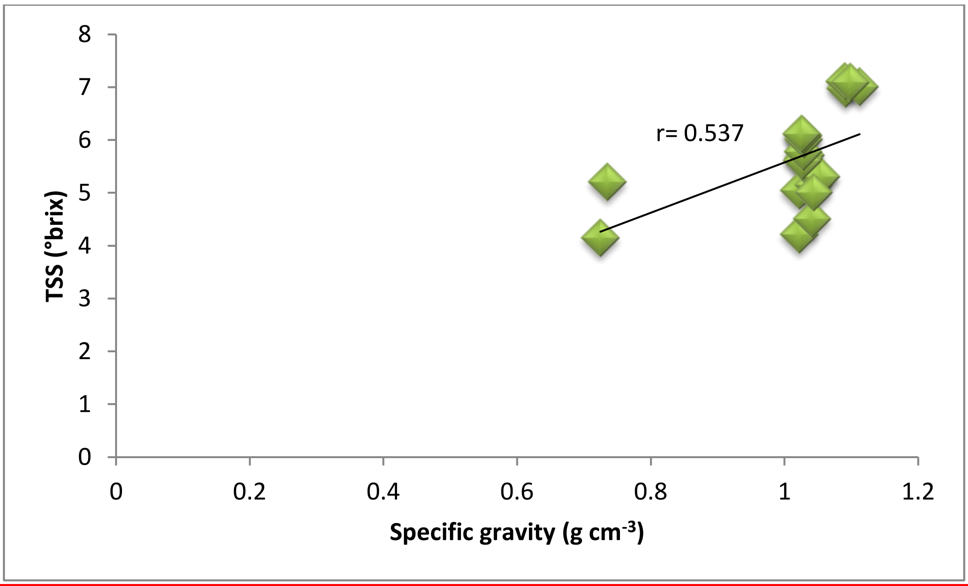

Figure 8. Relationship between specific gravity of tuber (g cm^{-3}) and TSS (°brix)

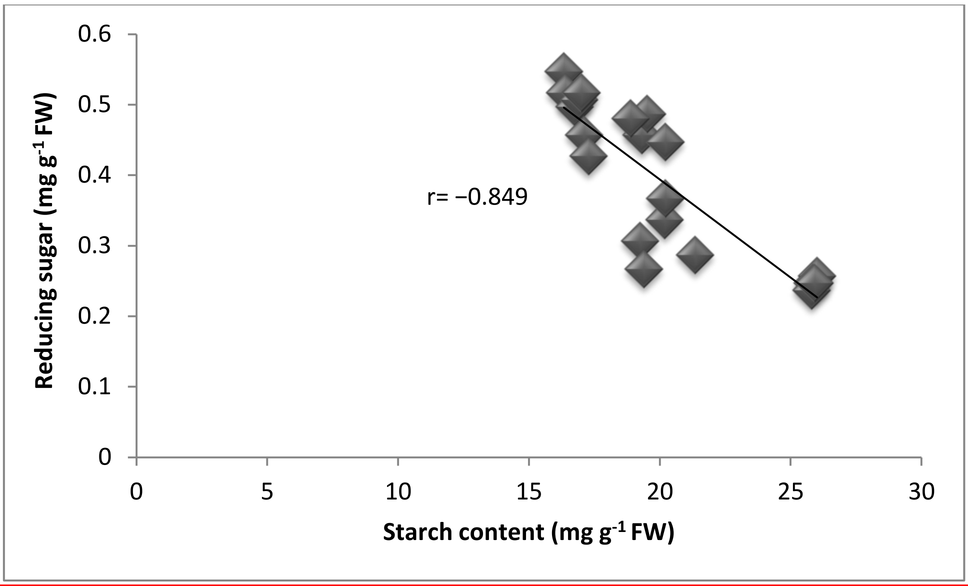

Figure 9. Relationship between starch content (mg g^{-1} FW) and reducing sugar content of potato (mg g^{-1} FW)

4.C Experiment 3

4.17 Tuber yield (t ha^{-1})

Yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XI and Table-8). The highest (28.21 t ha^{-1}) tuber yield was found from V_3 treatment followed by V_5 treatment and the lowest (23.99 t ha^{-1}) was in V_1. In respects of yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XI and Table-9). The highest tuber yield (27.25 t ha^{-1}) was found from Vm_1 treatment and the lowest (25.84 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield under study (Appendix-XI and Table-10). The highest tuber yield (27.40 t ha^{-1}) was found from H_1 treatment and the lowest (25.69 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.05$) variation was found among the treatment against yield of potato tubers (Appendix-XI and Table-11). The highest tuber yield (34.01 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_5Vm_1H_1$ and $V_6Vm_1H_1$ while the lowest (23.22 t ha^{-1}) was in $V_1Vm_1H_1$.

Verma *et al*. (2016) reported that the higher weight of tuber hill^{-1} and higher average weight of tuber might be the main reason for higher tuber yield ha^{-1}. The average tuber weight of potato has been increased with the supply of nutrients from organic source of fertilizers could be due to more luxuriant growth, more foliage and leaf area and higher supply of photosynthesis, which helped in producing bigger tubers, hence resulting in higher yields (Belachew, 2016). Mahmud *et al*. (2009) said that with the rise of temperature in the month of late February or March, potato storage food used in reverse order from tuber to foliage. The tuber weight per hill increased with age, which is obvious up to 80 days under the tropical climatic condition of Bangladesh. Under this climatic conditions, potato crop mature within 85 to 95 days. So, for this reason the tuber yield may have increased under present study.

4.18 Marketable yield (t ha^{-1})

Marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XI and Table-8). The highest (25.95 t ha^{-1}) yield was found from V_3 treatment followed by V_5 treatment and the lowest (21.32 t ha^{-1}) was in V_1. In respects of marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XI and Table-9). The higher yield (24.88 t ha^{-1}) was found from Vm_1 treatment and the lower (23.18 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield under study (Appendix-XI and Table-10). The higher yield (25.02 t ha^{-1}) was found from H_1 treatment and the lower (23.04 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against marketable yield of potato tubers (Appendix-XI and Table-11). The highest yield (32.25 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_5Vm_1H_1$ and $V_6Vm_1H_1$ while the lowest (20.96 t ha^{-1}) was in $V_1Vm_1H_1$ which was statistically similar to $V_1Vm_1H_2$, $V_1Vm_2H_1$ and $V_1Vm_2H_2$.

4.19 Non-marketable yield (t ha^{-1})

Non-marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XI and Table-8). The highest (2.82 t ha^{-1}) yield was found from V_2 and the lowest (2.25 t ha^{-1}) was found in V_5 which was statistically similar to V_3 (2.25 t ha^{-1}). In respects of non-marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XI and Table-9). The highest yield (2.66 t ha^{-1}) was found from Vm_2 and the lowest (2.36 t ha^{-1}) was found in Vm_1. Harvesting time significantly ($p \leq 0.01$) influenced the non-marketable yield under study (Appendix-XI and Table-10). The higher yield (2.64 t ha^{-1}) was found from H_2 treatment and the lower (2.37 t ha^{-1}) was in H_1. Combindly, a significant ($p \leq 0.05$) variation was found among the treatment against non-marketable yield of potato tubers (Appendix-XI and Table-11). The highest yield (3.29 t ha^{-1}) was found from $V_2Vm_2H_1$ treatment combination which was statistically similar to $V_6Vm_2H_1$ while the lowest (1.69 t ha^{-1}) was in $V_5Vm_1H_1$ which was statistically similar to $V_3Vm_1H_1$ and $V_6Vm_1H_1$.

Table 8. Performance of varieties on the yield of potato

Varieties	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
V_1	23.99 f	21.32 f	2.65 b
V_2	26.60 d	23.77 e	2.82 a
V_3	28.21 a	25.95 a	2.25 d
V_4	25.58 e	23.15 d	2.44 c
V_5	27.52 b	25.26 b	2.25 d
V_6	27.40 c	24.74 c	2.64 b
CV (%)	0.48	1.16	1.02
LSD $_{(0.05)}$	0.1153	0.1741	0.0933
Significance level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly)

Table 9. Effect of vermicompost on the yield of potato

Vermicompost	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
Vm_1	27.25 a	24.88 a	2.36 b
Vm_2	25.84 b	23.18 b	2.66 a
CV (%)	0.74	1.57	1.26
LSD $_{(0.05)}$	0.1015	0.1330	0.0650
Significance level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 $t\ ha^{-1}$ and Vm_2= 12 $t\ ha^{-1}$

Table 10. Response of harvesting time on the yield of potato

Harvesting time	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
H_1	27.40 a	25.02 a	2.37 b
H_2	25.69 b	23.04 b	2.64 a
CV (%)	9.27	9.54	10.71
LSD $_{(0.05)}$	1.1974	0.7653	0.5237
Significance level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 11. Interaction effect of variety, vermicompost and harvesting time on the yield of potato

Combination	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
$V_1Vm_1H_1$	23.22 d	20.96 efg	2.25 ghi
$V_1Vm_1H_2$	24.56 cd	21.72 g	2.82 bc
$V_1Vm_2H_1$	24.19 cd	21.37 g	2.80 bc
$V_1Vm_2H_2$	23.99 cd	21.24 g	2.74 bcd
$V_2Vm_1H_1$	25.81 bcd	23.23 b-e	2.56 c-g
$V_2Vm_1H_2$	26.02 bcd	23.03 efg	2.97 abc
$V_2Vm_2H_1$	27.82 b	24.52 d-g	3.29 a
$V_2Vm_2H_2$	26.76 bc	24.28 bcd	2.46 d-h
$V_3Vm_1H_1$	34.01 a	32.25 a	1.74 j
$V_3Vm_1H_2$	26.56 bc	24.13 bcd	2.41 d-i
$V_3Vm_2H_1$	25.62 bcd	23.51 b	2.09 i
$V_3Vm_2H_2$	26.66 bc	23.91 b-e	2.74 bcd
$V_4Vm_1H_1$	26.01 bcd	23.72 bcd	2.27 f-i
$V_4Vm_1H_2$	24.95 bcd	22.26 efg	2.67 c-f
$V_4Vm_2H_1$	25.81 bcd	23.23 c-f	2.66 c-f
$V_4Vm_2H_2$	25.55 bcd	23.39 bc	2.14 hi
$V_5Vm_1H_1$	32.05 a	30.34 a	1.69 j
$V_5Vm_1H_2$	25.58 bcd	23.34 bcd	2.23 hi
$V_5Vm_2H_1$	26.11 bcd	23.72 bcd	2.37 e-i
$V_5Vm_2H_2$	26.34 bc	23.63 b-e	2.69 b-e
$V_6Vm_1H_1$	33.15 a	31.38 a	1.75 j
$V_6Vm_1H_2$	25.12 bcd	22.21 fg	2.89 bc
$V_6Vm_2H_1$	25.05 bcd	22.03 g	3.00 ab
$V_6Vm_2H_2$	26.29 bc	23.34 efg	2.93 bc
CV (%)	9.27	9.54	10.71
LSD $_{(0.05)}$	2.9406	1.8965	1.2912
Significance level	*	**	*
V×Vm	**	**	**
V×H	NS	**	**
Vm×H	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; * indicates significant at 5% level of probability; NS= Non-significant
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly)
Vm_1= 9 $t\ ha^{-1}$ and Vm_2= 12 $t\ ha^{-1}$
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.20 Specific gravity (g cm^{-3})

Specific gravity of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XII and Table-12). The highest (1.0619 g cm^{-3}) gravity was found from V_4 treatment followed by V_5 treatment and the lowest (0.9728 g cm^{-3}) was in V_1. In respects of specific gravity of potato tubers a remarkable variation was noted against different levels of vermicompost applications (Appendix-XII and Table-13). The highest gravity (1.0506 g cm^{-3}) was found from Vm_1 treatment and the lowest (1.0203 g cm^{-3}) was in Vm_2. Harvesting time does not (p=NS) influenced the specific gravity under study (Appendix-XII and Table-14). Combindly, a significant ($p \leq 0.05$) variation was found among the treatment against specific gravity of potato tubers (Appendix-XII and Table-15). The highest gravity (1.1020 g cm^{-3}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to maximum treatment combinations followed by $V_2Vm_2H_2$ while the lowest (0.8900 g cm^{-3}) was in $V_1Vm_1H_1$ which was statistically similar to $V_1Vm_2H_1$ and $V_1Vm_2H_2$. Sogut and Ozturk (2011) reported that tuber specific gravity decreased in late harvesting time (120 DAP), which were harvested at warmer part of the season, showing that cooler temperatures during harvesting time is more crucial to the tuber specific gravity under warmer condition.

4.21 Dry matter content (%)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against dry matter content of tuber (Appendix-XII and Table-12). The highest (20.027 %) dry mater content was found from V_5 treatment followed by V_3 treatment and the lowest (16.437 %) was in V_1. In respects of dry mater content of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XII and Table-13). The highest dry matter (19.038 %) was found from Vm_1 treatment and the lowest (17.675 %) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber dry matter content under study (Appendix-XII and Table-14). The higher dry matter (19.025 %) was found from H_1 treatment and the lower (17.688 %) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-XII and Table-15) among the treatment against dry matter content of potato tubers. The highest dry matter (23.307 %) was found from $V_6Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_5Vm_1H_1$ while the lowest (15.947 %) dry matter was in $V_1Vm_2H_2$. Dry matter accumulation in tubers increased rapidly in all the studied varieties from 30 to 80 DAP. Similar findings were reported by Harahagazwe1 *et al*. (2012). They obtained the highest tuber dry matter content at 80 DAP. But Begum *et al.* (2011) obtained the highest dry matter at 90 DAP. According to the findings of Kooman and Rabbinge (1996), the model calculations of the fraction of total dry matter produced allocated to the tuber were on the basis of assumption that the tubers had been the dominant sink in the potato crop.

4.22 Total soluble solid (TSS) (^{o}brix)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against total soluble solid (TSS) content of tuber (Appendix-XII and Table-12). The highest (6.2742°) total soluble solid (TSS) content was found from V_3 treatment followed by V_2 treatment and the lowest (5.4842°) was in V_4. In respects of TSS of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XII and Table-13). The highest TSS (5.9292°) was found from Vm_1 treatment and the lowest (5.7350°) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the TSS content under study (Appendix-XII and Table-14). The higher TSS (5.9908°) was found from H_1 treatment and the lower (5.6733°) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-XII and Table-15) among the treatment against TSS of potato tubers. The highest TSS (6.9067°) was found from $V_5Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_6Vm_1H_1$ while the lowest (4.0067°) TSS was in $V_6Vm_2H_2$.

4.23 Starch content (mg g^{-1} FW)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against starch content of tuber (Appendix-XIII and Table-12). The highest

(19.309 mg g^{-1} FW) starch content was found from V_4 treatment followed by V_5 treatment and the lowest (18.212 mg g^{-1} FW) was in V_1. In respects of starch content of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIII and Table-13). The highest starch (20.827 mg g^{-1} FW) was found from Vm_1 treatment and the lowest (19.877 mg g^{-1} FW) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber starch content under study (Appendix-XIII and Table-14). The higher starch (20.865 mg g^{-1} FW) was found from H_1 treatment and the lower (19.839 mg g^{-1} FW) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against starch content of potato tubers (Appendix-XIII and Table-15). The highest starch (25.347 mg g^{-1} FW) was found from $V_6Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_5Vm_1H_1$ while the lowest (17.507 mg g^{-1} FW) dry matter was in $V_1Vm_1H_1$. Sogut and Ozturk (2011) also reported that starch content also varied significantly with harvesting time. They also indicated a reasonable trend of starch accumulation as harvesting is delayed from 75 to 105 DAP. So, the present result is in agreement with this citation.

4.24 Reducing sugar (mg g^{-1} FW)

Remarkable ($p \leq 0.01$) variation was found among different potato varieties against reducing sugar content of tuber (Appendix-XIII and Table-12). The highest (0.5492 mg g^{-1} FW) reducing sugar content was found from V_1 treatment followed by V_2 treatment and the lowest (0.3642 mg g^{-1} FW) was in V_4. In respects of reducing sugar content of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIII and Table-13). The highest reducing sugar (0.4308 mg g^{-1} FW) was found from Vm_2 treatment and the lowest (0.4075 mg g^{-1} FW) was in Vm_1. Harvesting time significantly ($p \leq 0.01$) influenced the tuber reducing sugar content under study (Appendix-XIII and Table-14). The higher reducing sugar (0.4542 mg g^{-1} FW) was found from H_2 treatment and the lower (0.3842 mg g^{-1} FW) was in H_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against reducing sugar content of potato tubers (Appendix-XIII and Table-15). The highest reducing sugar (0.5667 mg g^{-1} FW) was found from $V_1Vm_1H_1$ treatment combination which was statistically similar to $V_1Vm_1H_2$, $V_1Vm_2H_1$ and $V_2Vm_1H_1$ while the lowest (0.2567 mg g^{-1} FW) dry matter was in $V_6Vm_1H_1$ which was statistically similar to $V_4Vm_1H_1$, $V_5Vm_1H_1$ and $V_3Vm_1H_1$. Due to the higher temperature at the later part of March may increase the internal respiration of potato stored matter as starch due to that, at later crop duration the reducing sugar was greater by breaking the starch into more reducing sugars than that of earlier duration (Mahmud *et al.*, 2009).

Table 12. Performance of varieties on the processing qualities of potato

Varieties	**Specific gravity ($g\ cm^{-3}$)**	**Dry matter content (%)**	**Total soluble solid (^{o}brix)**	**Starch content (mg g^{-1} FW)**	**Reducing sugar (mg g^{-1} FW)**
V_1	0.9728 f	16.437 f	5.5542 e	18.212 f	0.5492 a
V_2	1.0134 e	17.264 e	6.0592 b	20.459 d	0.4817 b
V_3	1.0561 c	19.377 b	6.2742 a	22.192 e	0.3717 d
V_4	1.0619 a	18.172 d	5.4842 f	19.309 a	0.3642 f
V_5	1.0587 b	20.027 a	5.8967 c	21.094 b	0.3692 e
V_6	1.0498 d	18.864 c	5.7242 d	20.847 c	0.3792 c
CV (%)	0.12	0.23	0.93	0.32	0.49
LSD $_{(0.05)}$	0.0289	0.0387	0.0493	0.0584	0.0281
Significance level	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6=BARI Alu-71 (Doly))

Table 13. Effect of vermicompost on the processing qualities of potato

Vermicompost	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
Vm_1	1.0506 a	19.038 a	5.9292 a	20.827 a	0.4075 b
Vm_2	1.0203 b	17.675 b	5.7350 b	19.877 b	0.4308 a
CV (%)	0.39	0.45	0.72	0.41	1.09
LSD $_{(0.05)}$	0.0279	0.0428	0.0215	0.0433	0.0276
Significance level	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

Table 14. Response of harvesting time on the processing qualities of potato

Harvesting time	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
H_1	1.0477	19.025 a	5.9908 a	20.865 a	0.3842 b
H_2	1.0232	17.688 b	5.6733 b	19.839 b	0.4542 a
CV (%)	7.91	6.32	6.51	6.37	6.73
LSD $_{(0.05)}$	--------	0.5646	0.1846	0.6305	0.0137
Significance level	NS	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 15. Interaction effect of variety, vermicompost and harvesting time on the processing qualities of potato

Combination	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
$V_1Vm_1H_1$	0.8900 c	16.247 gh	4.1167 e	17.507 f	0.5667 a
$V_1Vm_1H_2$	1.0510 a	16.547 fgh	6.1067 b	17.687 e	0.5567 ab
$V_1Vm_2H_1$	1.0550 a	17.007 d-h	5.9767 bcd	18.647 def	0.5467 ab
$V_1Vm_2H_2$	0.8950 c	15.947 h	6.0167 bc	19.007 def	0.5267 b
$V_2Vm_1H_1$	1.0450 a	16.247 gh	6.1167 b	20.007 cd	0.5467 ab
$V_2Vm_1H_2$	1.0550 a	17.077 d-h	6.0167 bc	19.577 d	0.4867 c
$V_2Vm_2H_1$	1.0335 ab	18.227 b-e	5.9867 bcd	20.007 cd	0.4167 efg
$V_2Vm_2H_2$	0.9200 bc	17.507 c-g	6.1167 b	22.247 b	0.4767 cd
$V_3Vm_1H_1$	1.1020 a	22.847 a	6.8767a	25.117 a	0.2767 lm
$V_3Vm_1H_2$	1.0350 a	18.007 b-e	6.0967 b	22.577 b	0.4867 c
$V_3Vm_2H_1$	1.0484 a	17.847 b-f	6.1467 b	21.207 bc	0.3467 ij
$V_3Vm_2H_2$	1.0389 a	18.807 bc	5.9767 bcd	19.867 cd	0.3767 hi
$V_4Vm_1H_1$	1.0820 a	19.007 b	5.5467 de	19.237 d	0.2467 m
$V_4Vm_1H_2$	1.0520 a	18.907 b	5.2567 e	18.787 def	0.2967 kl
$V_4Vm_2H_1$	1.0620 a	18.527 bc	5.5467 de	20.107 cd	0.4267 ef
$V_4Vm_2H_2$	1.0515 a	16.247 gh	5.5867 cde	19.107 de	0.4867 c
$V_5Vm_1H_1$	1.0900 a	23.017 a	6.9067 a	24.777 a	0.2667 lm
$V_5Vm_1H_2$	1.0650 a	19.007 b	5.2467 e	20.017 cd	0.4767 cd
$V_5Vm_2H_1$	1.0330 ab	18.977 b	5.8867 bcd	19.447 d	0.3267 jk
$V_5Vm_2H_2$	1.0470 a	19.107 b	5.5467 de	20.137 cd	0.4067 fgh
$V_6Vm_1H_1$	1.0970 a	23.307 a	6.7567 a	25.347 a	0.2567 m
$V_6Vm_1H_2$	1.0430 a	18.247 bcd	6.1067 b	19.287 d	0.4267 ef
$V_6Vm_2H_1$	1.0340 a	17.047 d-h	6.0267 bc	18.977 def	0.3867 gh
$V_6Vm_2H_2$	1.0250 ab	16.857 e-h	4.0067 f	19.777 cd	0.4467 de
CV (%)	7.91	6.32	6.51	6.37	6.73
LSD $_{(0.05)}$	0.0976	1.3855	0.4564	1.5473	0.0339
Significance level	*	**	**	**	**
V×Vm	**	**	**	**	**
V×H	NS	NS	**	**	**
Vm×H	NS	**	NS	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; * indicates significant at 5% level of probability; NS= Non-significant
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}; H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.25 Yield for chips production (t ha^{-1})

Yield of tuber for chips production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIV and Table-16). The highest (17.09 t ha^{-1}) yield was found from V_3 treatment followed by V_5 treatment and the lowest was in V_1 (13.33 t ha^{-1}). In respects of yield of potato tubers for chips a remarkable ($p \leq 0.01$) variation was noted (Appendix-XIV and Table-17) against different levels of vermicompost applications. The highest yield (16.37 t ha^{-1}) was found from Vm_1 treatment while the lowest (15.60 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for chips under study (Appendix-XIV and Table-18). The higher yield (16.36 t ha^{-1}) was found from H_1 treatment and the lower (15.61 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-XIV and Table-19) among the treatment against yield of potato tubers for chips production. The highest yield (20.00 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_6Vm_1H_1$ while the lowest (12.24 t ha^{-1}) was in $V_1Vm_1H_1$. Mean values of harvesting times exhibited that 90 DAP gave higher processable tuber yield than 80 DAP and 100 DAP harvest but the processable tuber yield of 90 and 100 DAP harvest was statistically similar. Results of the processable tuber yield reveals that 90 DAP harvest is better than 80 and 100 DAP harvest for producing potato yield of suitable sizes (Sharkar *et al*., 2019). For chips production, round or oval tubers of 35 to 65 mm sizes having higher dry matter (21-25%) and starch content (16-20%) were emphasized by Lisinska (2006). The present result is in agreement with these citations.

4.26 Yield for french fry production (t ha^{-1})

Yield of tuber for french fry production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIV and Table-16). The highest yield (1.25 t ha^{-1}) was found from V_4 and in V_1, V_2, V_3, V_5 and V_6 no french fry yield was detected. In respects of yield of potato tubers for french fry a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIV and Table-17). The highest yield (0.41 t ha^{-1}) was found from Vm_1 treatment and in Vm_2 no French fry yield was found. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for french fry production under study (Appendix-XIV and Table-18). The highest yield (0.41 t ha^{-1}) was found from H_1 treatment and in H_2 no French fry yield was found. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for french fry production (Appendix-XIV and Table-19). The highest yield (5.00 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination while the no French fry yield was found from the other treatment combinations.

4.27 Yield for flakes production (t ha^{-1})

Yield of tuber for flakes production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIV and Table-16). The highest yield (7.33 t ha^{-1}) was found from V_3 treatment followed by V_5 treatment and the lowest was in V_1 (4.99 t ha^{-1}). In respects of yield of potato tubers for flakes a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIV and Table-17). The highest yield (6.6367 t ha^{-1}) was found from Vm_1 treatment while the lowest (5.90 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for flakes under study (Appendix-XIV and Table-18). The higher (6.74 t ha^{-1}) yield was found from H_1 treatment and the lower (5.79 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for flakes production (Appendix-XIV and Table-19). The highest yield (10.20 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_6Vm_1H_1$ while the lowest (5.03 t ha^{-1}) was in $V_6Vm_2H_2$.

4.28 Yield for canned production (t ha^{-1})

Canned production from potato tuber was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIV and Table-16). The highest yield (5.64 t ha^{-1}) was found from V_1 treatment followed by V_2 treatment and the lowest was in V_4 (2.85 t ha^{-1}). In respects of yield of potato tubers for canned a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIV and Table-17). The highest (4.34 t ha^{-1}) yield was found from Vm_2 treatment while the lowest (3.81 t ha^{-1}) was found in Vm_1. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for canned under study (Appendix-XIV and Table-18). The higher yield (6.74 t ha^{-1}) was found from H_1 treatment and the lower (5.79 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for canned production (Appendix-XIV and Table-19). The highest yield (6.58 t ha^{-1}) was found from $V_1Vm_1H_2$ treatment combination which was statistically similar to $V_1Vm_1H_1$, $V_1Vm_2H_1$ and $V_6Vm_2H_2$ while the lowest (1.45 t ha^{-1}) was in $V_4Vm_1H_1$.

Table 16. Performance of varieties on the yield of potato for different processing purpose

Varieties	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
V_1	13.33 f	0.00 b	4.99 f	5.64 a
V_2	15.41 e	0.00 b	6.21 d	4.95 b
V_3	17.09 a	0.00 b	7.33 a	3.77 c
V_4	16.14 d	1.25 a	5.34 e	2.85 f
V_5	16.93 c	0.00 b	6.99 b	3.57 e
V_6	17.01 b	0.00 b	6.72 c	3.65 d
CV (%)	0.17	21.04	0.60	0.83
LSD $_{(0.05)}$	0.0241	0.0399	0.0340	0.0307
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny)and V_6= BARI Alu-71 (Doly))

Table 17. Effect of vermicompost on the yield of potato for different processing purpose

Vermicompost	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
Vm_1	16.37 a	0.41 a	6.63 a	3.81 b
Vm_2	15.60 b	0.00 b	5.90 b	4.34 a
CV (%)	0.21	21.04	0.55	1.47
LSD $_{(0.05)}$	0.0171	0.0225	0.0178	0.0309
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

Table 18. Response of harvesting time on the yield of potato for different processing purpose

Harvesting time	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
H_1	16.36 a	0.41 a	6.74 a	3.88 b
H_2	15.61 b	0.00 b	5.79 b	4.27 a
CV (%)	3.20	21.04	3.30	8.39
LSD $_{(0.05)}$	0.2486	0.0214	0.1006	0.1664
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 19. Interaction effect of variety, vermicompost and harvesting time on the yield of potato for different processing purpose

Combination	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
$V_1Vm_1H_1$	12.24 g	0.00 b	5.51 h	5.44 ab
$V_1Vm_1H_2$	12.84 fg	0.00 b	5.11 i	6.58 a
$V_1Vm_2H_1$	13.24 f	0.00 b	4.84 jk	6.08 a
$V_1Vm_2H_2$	15.00 d	0.00 b	4.50 k	4.46 bc
$V_2Vm_1H_1$	15.25 d	0.00 b	5.21 i	5.32 b
$V_2Vm_1H_2$	16.20 c	0.00 b	6.11 ef	3.68 cd
$V_2Vm_2H_1$	15.94 c	0.00 b	7.20 c	4.65 bc
$V_2Vm_2H_2$	14.24 e	0.00 b	6.33 e	6.16 ab
$V_3Vm_1H_1$	20.00 a	0.00 b	10.20 a	3.78 cd
$V_3Vm_1H_2$	15.95 c	0.00 b	6.28 e	4.30 bc
$V_3Vm_2H_1$	16.17 c	0.00 b	6.84 d	2.58 d
$V_3Vm_2H_2$	16.24 c	0.00 b	6.00 f	4.40 bc
$V_4Vm_1H_1$	16.28 c	5.00 a	3.24 l	1.45 e
$V_4Vm_1H_2$	15.97 c	0.00 b	6.12 ef	2.83 cd
$V_4Vm_2H_1$	16.10 c	0.00 b	5.97 fg	3.81 cd
$V_4Vm_2H_2$	16.20 c	0.00 b	6.01 f	3.31 cd
$V_5Vm_1H_1$	19.24 b	0.00 b	9.84 b	2.94 de
$V_5Vm_1H_2$	16.50 c	0.00 b	6.10 ef	2.95 de
$V_5Vm_2H_1$	15.98 c	0.00 b	5.88 fg	4.22 bc
$V_5Vm_2H_2$	16.00 c	0.00 b	6.13 ef	4.18 bc
$V_6Vm_1H_1$	19.84 ab	0.00 b	10.10 a	3.18 c
$V_6Vm_1H_2$	16.107 c	0.00 b	5.74 gh	3.25 c
$V_6Vm_2H_1$	15.97 c	0.00 b	6.00 f	3.05 cd
$V_6Vm_2H_2$	16.11 c	0.00 b	5.03 ij	5.12 ab
CV (%)	3.20	21.04	3.30	8.39
LSD $_{(0.05)}$	0.6101	0.0765	0.2507	0.4121
Significance level	**	**	**	**
V×Vm	**	**	**	**
V×H	**	**	**	**
Vm×H	**	**	**	NS

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; * indicates significant at 5% level of probability; NS= Non-significant
V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.29 Correlation co-efficient (r)

A positive relation (r=0.581) was found between specific gravity and dry matter content of potato tuber (Figure-10). In Figure-11, a positive relation (r=0.405) was seen between specific gravity of tuber and total soluble solid (TSS) of tuber. A positive relation (r=0.523) was found between dry matter content of potato tuber and total soluble solid (Figure-12). A positive relation (r=0.606) was found between dry matter content and Total Soluble Solid (TSS) of potato tuber (Figure-7). In Figure-13, a negative relation (r=−0.556) was found between starch and reducing sugar content of potato tuber.

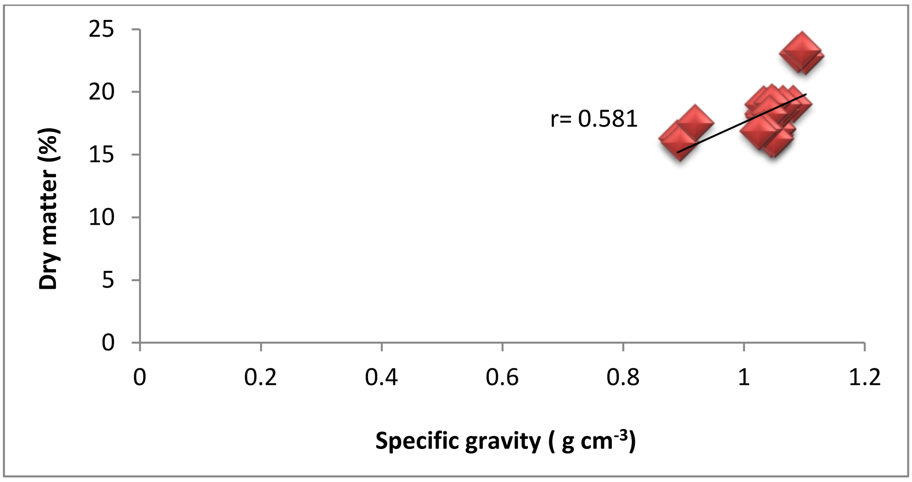

Figure 10. Relationship between specific gravity (g cm^{-3}) and dry matter (%) of potato tuber

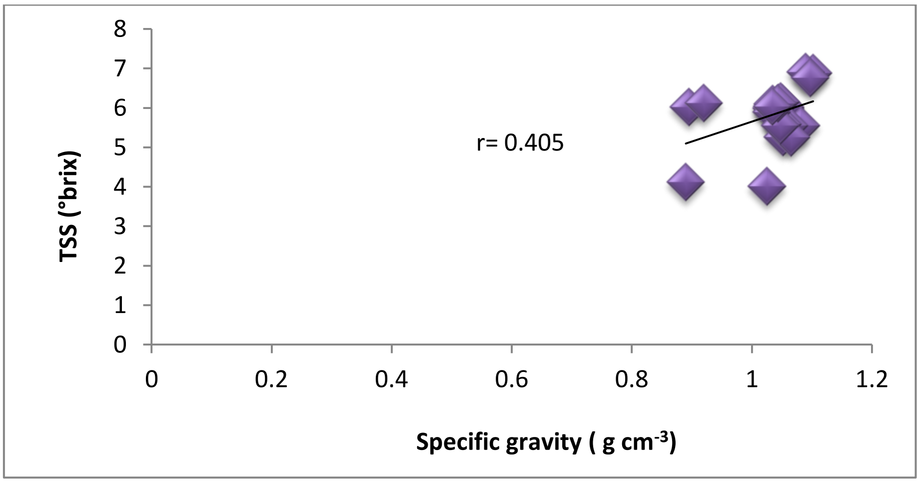

Figure 11. Relationship between specific gravity (g cm^{-3}) and TSS (°brix) of potato tuber

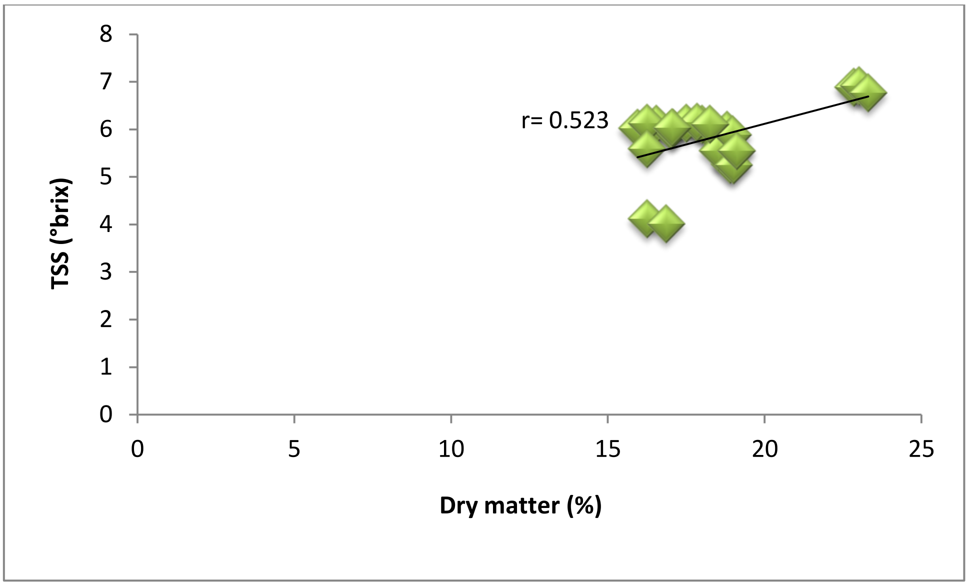

Figure 12. Relationship between dry matter (%) and TSS (°brix) of potato tuber

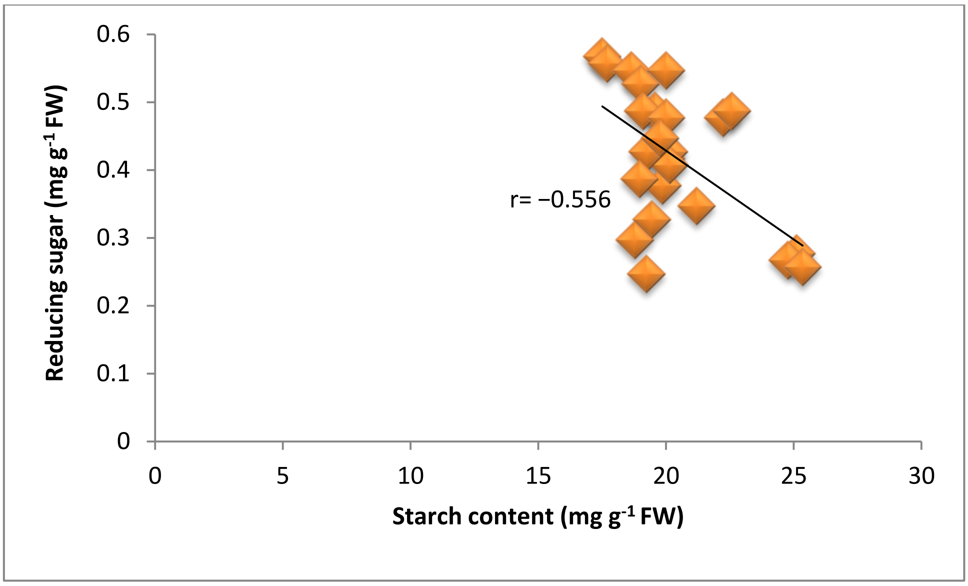

Figure 13. Relationship between starch content (mg g^{-1} FW) and reducing sugar content (mg g^{-1} FW) of potato

4.D Experiment 4

4.30 Tuber yield (t ha^{-1})

Yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XV and Table-20). The highest (30.77 t ha^{-1}) tuber yield was found from V_3 treatment followed by V_4 treatment and the lowest was in V_1 (23.83 t ha^{-1}). In respects of yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted (Appendix-XV and Table-21) against different levels of vermicompost applications. The highest tuber yield (27.85 t ha^{-1}) was found from Vm_1 treatment and the lowest (26.33 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield under study (Appendix-XV and Table-22). The higher tuber yield (27.91 t ha^{-1}) was found from H_1 treatment and the lower (26.28 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers (Appendix-XV and Table-23). The highest tuber yield (33.28 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_2H_1$ and $V_3Vm_1H_2$ while the lowest (23.00 t ha^{-1}) was in $V_1Vm_1H_1$. Shah *et al.* (2007) exposed that in potato genotypes, the difference in tuber yield was primarily due to genetic factors. Verma *et al.* (2016) reported that the higher weight of tuber $hill^{-1}$ and higher average weight of tuber might be the main reason for higher tuber yield ha^{-1}. The average tuber weight of potato has been increased with the supply of nutrients from organic source of fertilizers could be due to more luxuriant growth, more foliage and leaf area and higher supply of photosynthesis, which helped in producing bigger tubers, hence resulting in higher yields (Belachew, 2016).

4.31 Marketable yield (t ha^{-1})

Marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XV and Table-20). The highest (28.74 t ha^{-1}) yield was found from V_3 treatment followed by V_4 treatment and the lowest (21.21 t ha^{-1}) was in V_1. In respects of marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XV and Table-21). The highest yield (25.54 t ha^{-1}) was found from Vm_1 treatment and the lowest (23.72 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield under study (Appendix-XV and Table-22). The higher yield (25.58 t ha^{-1}) was found from H_1 treatment and the lower (23.68 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against marketable yield of potato tubers (Appendix-XV and Table-23). The highest yield (31.53 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_2H_1$ and $V_3Vm_1H_2$ while the lowest (20.80 t ha^{-1}) was in $V_1Vm_1H_1$ which was statistically similar to $V_1Vm_1H_2$, $V_1Vm_2H_1$ and $V_1Vm_2H_2$.

4.32 Non-marketable yield (t ha^{-1})

Non-marketable yield of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XV and Table-20). The highest (2.82 t ha^{-1}) yield was found from V_2 and the lowest (2.02 t ha^{-1}) was found in V_3. In respects of non-marketable yield of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XV and Table-21). The highest yield (2.60 t ha^{-1}) was found from Vm_2 and the lowest (2.31 t ha^{-1}) was found in Vm_1. Harvesting time significantly ($p \leq 0.01$) influenced the non-marketable yield under study (Appendix-XV and Table-22). The higher yield (2.59 t ha^{-1}) was found from H_2 treatment and the lower (2.33 t ha^{-1}) was in H_1. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against non-marketable yield of potato tubers (Appendix-XV and Table-23). The highest yield (3.27 t ha^{-1}) was found from $V_2Vm_2H_1$ treatment combination while the lowest (1.72 t ha^{-1}) was in $V_3Vm_1H_2$ which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_2H_1$ and $V_4Vm_1H_1$.

Table 20. Performance of varieties on the yield of potato

Varieties	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
V_1	23.83 d	21.21 d	2.61 b
V_2	26.57 c	23.74 c	2.82 a
V_3	30.77 a	28.74 a	2.02 d
V_4	27.21 b	24.83 b	2.38 c
CV (%)	0.51	1.02	0.70
LSD $_{(0.05)}$	0.1380	0.1755	0.0689
Significance level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)

Table 21. Effect of vermicompost on yield of potato

Vermicompost	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
Vm_1	27.85 a	25.54 a	2.31 b
Vm_2	26.33 b	23.72 b	2.60 a
CV (%)	0.70	1.38	0.96
LSD $_{(0.05)}$	0.1257	0.1585	0.0631
Significance level	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 $t\ ha^{-1}$ and Vm_2= 12 $t\ ha^{-1}$

Table 22. Response of harvesting time on the yield of potato

Harvesting time	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
H_1	27.91 a	25.58 a	2.33 b
H_2	26.28 b	23.68 b	2.59 a
CV (%)	9.46	8.01	12.23
LSD $_{(0.05)}$	1.5680	0.8458	0.7370
Significance level	*	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
*, ** indicate significant at 5% and 1% level of probability, respectively
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 23. Interaction effect of variety, vermicompost and harvesting time on the yield of potato

Combination	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)
$V_1Vm_1H_1$	23.00 d	20.80 cd	2.20 e
$V_1Vm_1H_2$	24.28 cd	21.51 d	2.76 bc
$V_1Vm_2H_1$	23.98 cd	21.24 d	2.74 bcd
$V_1Vm_2H_2$	24.04 cd	21.30 d	2.74 bcd
$V_2Vm_1H_1$	26.00 bcd	23.37 bc	2.63 bcd
$V_2Vm_1H_2$	25.98 bcd	22.98 cd	3.00 ab
$V_2Vm_2H_1$	27.707 b	24.43 cd	3.27 a
$V_2Vm_2H_2$	26.58 bc	24.19 b	2.39 de
$V_3Vm_1H_1$	32.24 a	30.46 a	1.78 f
$V_3Vm_1H_2$	33.10 a	31.38 a	1.72 f
$V_3Vm_2H_1$	31.94 a	30.17 a	1.77 f
$V_3Vm_2H_2$	25.78 bcd	22.95 cd	2.83 bc
$V_4Vm_1H_1$	33.28 a	31.53 a	1.75 f
$V_4Vm_1H_2$	24.94 bcd	22.25 cd	2.69 bcd
$V_4Vm_2H_1$	25.11 bcd	22.62 c	2.49 cde
$V_4Vm_2H_2$	25.51 bcd	22.91 c	2.60 cd
CV (%)	9.46	8.01	12.23
LSD $_{(0.05)}$	3.1439	1.7151	1.4783
Significance level	**	**	**
V×Vm	**	**	**
V×H	NS	**	*
Vm×H	NS	**	*

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; * indicates significant at 5% level of probability; NS= Non-significant
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)
Vm_1= 9 $t\ ha^{-1}$ and Vm_2= 12 $t\ ha^{-1}$
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.33 Specific gravity (g cm^{-3})

Specific gravity of tubers was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XVI and Table-24). The highest (1.0779 g cm^{-3}) gravity was found from V_3 treatment followed by V_2 treatment and the lowest (0.9614 g cm^{-3}) was in V_1. In respects of specific gravity of potato tubers a remarkable variation was noted against different levels of vermicompost applications (Appendix-XVI and Table-25). The highest (1.0168 g cm^{-3}) specific gravity was found from Vm_1 treatment and the lowest (1.0105 g cm^{-3}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the specific gravity under study (Appendix-XVI and Table-26). The higher gravity (1.0384 g cm^{-3}) was found from H_1 treatment and the lower (0.0988 g cm^{-3}) was in H_2. Combindly, a significant ($p \leq 0.05$) variation was found among the treatment against specific gravity of potato tubers (Appendix-XVI and Table-27). The highest gravity (1.1107 g cm^{-3}) was found from $V_3Vm_1H_2$ treatment combination which was statistically similar to most of the treatment combinations followed by $V_2Vm_1H_2$ while the lowest (0.7487 g cm^{-3}) was in $V_4Vm_2H_2$. Specific gravity is an important factor for maintaining quality tuber and is directly associated with the dry matter content (Pedreschi and Moyano, 2005). They also said that changes in specific gravity between harvesting times is insignificant for all the varieties (interaction effect). Tuber harvested at 90 DAP harvest gave higher specific gravity in case of all varieties. The present result is supported by this citation.

4.34 Dry matter content (%)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against dry matter content of tuber (Appendix-XVI and Table-24). The highest (21.35 %) dry mater content was found from V_3 treatment followed by V_2 treatment and the lowest (0.9614 %) was in V_1. In respects of dry mater content of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XVI and Table-25). The highest dry matter (19.873 %) was found from Vm_1 treatment and the lowest

(18.395 %) was in Vm_2. Harvesting time does not influenced (p=NS) the tuber dry matter content under study (Appendix-XVI and Table-26). Combindly, a significant ($p \leq 0.05$) variation was found (Appendix-XVI and Table-27) among the treatment against dry matter content of potato tubers. The highest dry matter (24.117 %) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$ while the lowest (16.547 %) dry matter was in $V_1Vm_1H_1$. Varietal means of dry matter content, irrespective of harvesting time, was found significantly higher in BARI Alu-28 (Lady rosetta) as compared to BARI Alu-25 (Asterix) and BARI Alu-29 (Courage) (Sharkar *et al*., 2019). So, present result is in agreement with this citation. The results indicate that variety BARI Alu-28 (Lady rosetta) can be preferred as suitable variety and 90 DAP harvest can be optimum to get higher dry matter (%). Dry matter is an index of better processing quality resulted in better textured products associated with high fat absorption at frying (Araujo *et al*., 2016).

4.35 Total soluble solid (TSS) (^{o}brix)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against total soluble solid (TSS) content of tuber (Appendix-XVI and Table-24). The highest (5.6192°) total soluble solid (TSS) content was found from V_3 treatment followed by V_2 treatment and the lowest (4.4783°) was in V_4. In respects of TSS of potato tubers a remarkable variation was noted against different levels of vermicompost applications (Appendix-XVI and Table-25). The highest TSS (5.4500°) was found from Vm_1 treatment and the lowest (4.6879°) was in Vm_2. Harvesting time does not influenced (p=NS) the TSS content under study (Appendix-XVI and Table-26). Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-XVI and Table-27) among the treatment against TSS of potato tubers. The highest TSS (7.1167°) was found from $V_3Vm_1H_2$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_4Vm_1H_1$ while the lowest (4.0367°) TSS was in $V_4Vm_1H_2$.

4.36 Starch content (mg g^{-1} FW)

Significant ($p \leq 0.01$) variation was noted among different potato varieties against starch content of tuber (Appendix-XVII and Table-24). The highest (22.899 mg g^{-1} FW) starch content was found from V_3 treatment followed by V_2 treatment and the lowest (18.220 mg g^{-1} FW) was in V_1. In respects of starch content of potato tubers a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XVII and Table-25). The highest starch (20.918 mg g^{-1} FW) was found from Vm_1 treatment and the lowest (19.388 mg g^{-1} FW) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber starch content under study (Appendix-XVII and Table-26). The higher starch (20.943 mg g^{-1} FW) was found from H_1 treatment and the lower (19.363 mg g^{-1} FW) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against starch content of potato tubers (Appendix-XVII and Table-27). The highest starch (24.337 mg g^{-1} FW) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_1H_2$ and $V_3Vm_2H_1$ while the lowest (17.117 mg g^{-1} FW) starch was in $V_4Vm_2H_2$. Sharkar *et al*. (2019) reported that the combination of variety and harvesting times on starch content of the potatoes showed an increase up to 90 DAP in all potato varieties they used but this increment was significant in BARI Alu-29 (Courage) , BARI Alu-25 (Asterix) and BARI Alu-28 (Lady rosetta). As we know, higher starch content is desired for quality product because starch comprises the largest part of dry matter, it has direct influence on technological quality, especially with regard to the texture of the processed products.

4.37 Reducing sugar (mg g^{-1} FW)

Remarkable ($p \leq 0.01$) variation was found among different potato varieties against reducing sugar content of tuber (Appendix-XVII and Table-24). The highest (0.5517 mg g^{-1} FW) reducing sugar content was found from V_1 treatment followed by V_2 treatment and the lowest (0.2967 mg g^{-1} FW) was in V_3. In respects of reducing sugar content of potato tubers a remarkable variation was noted against different levels of vermicompost applications (Appendix-XVII and Table-25). The highest reducing sugar (0.4396 mg g^{-1} FW) was found from Vm_2 treatment and the lowest (0.4067 mg g^{-1} FW) was in Vm_1. Harvesting time does not (p=NS) influenced the tuber reducing sugar content under study (Appendix-XVII and Table-26). Combindly, a significant ($p \leq 0.05$) variation was found among the treatment against reducing sugar content of potato tubers (Appendix-XVII and Table-27). The highest reducing sugar (0.5667 mg g^{-1} FW) was found from $V_1Vm_1H_1$ treatment combination which was statistically similar to $V_1Vm_1H_2$, $V_1Vm_2H_1$, $V_1Vm_2H_2$ and $V_2Vm_1H_1$ while the lowest (0.2567 mg g^{-1} FW) was in $V_4Vm_1H_1$ which was statistically similar to $V_4Vm_1H_2$, $V_2Vm_2H_1$, $V_1Vm_1H_1$ and $V_3Vm_1H_2$. Higher specific gravity is an indication of higher dry matter content and lower reducing sugar content in potato tubers (Solaiman *et al.*, 2015).

Table 24. Performance of varieties on the processing qualities of potato

Varieties	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
V_1	0.9614 d	17.654 d	4.4783 d	18.220 d	0.5517 a
V_2	1.0307 b	18.929 b	5.3767 b	19.922 b	0.4867 b
V_3	1.0779 a	21.357 a	5.6192 a	22.899 a	0.2967 d
V_4	0.9847 c	18.597 c	4.8017 c	19.572 c	0.3575 c
CV (%)	0.42	0.49	0.89	0.45	1.49
LSD $_{(0.05)}$	0.0257	0.0929	0.0450	0.0903	0.0237
Significance level	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)

Table 25. Effect of vermicompost on processing qualities of potato

Vermicompost	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
Vm_1	1.0168 a	19.873 a	5.4500 a	20.918 a	0.4067 b
Vm_2	1.0105 b	18.395 b	4.6879 b	19.388 b	0.4396 a
CV (%)	0.35	0.46	0.93	0.39	1.08
LSD $_{(0.05)}$	0.0276	0.0586	0.0314	0.0521	0.0269
Significance level	**	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

Table 26. Response of harvesting time on the processing qualities of potato

Harvesting time	Specific gravity (g cm^{-3})	Dry matter content (%)	Total soluble solid (^{o}brix)	Starch content (mg g^{-1} FW)	Reducing sugar (mg g^{-1} FW)
H_1	1.0384 a	19.374	5.1375	20.943 a	0.4154
H_2	0.9889 b	18.894	5.0004	19.363 b	0.4308
CV (%)	7.09	7.93	8.01	6.53	6.40
LSD $_{(0.05)}$	0.0440	--------	--------	0.8052	---------
Significance level	*	NS	NS	**	NS

Values with common letter (s) within a column do not differ significantly at 5% level of probability
*, ** indicate significant at 5% and 1% level of probability, respectively; NS= Non-significant
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 27. Interaction effect of variety, vermicompost and harvesting time on the processing qualities of potato

Combination	Specific gravity ($g\ cm^{-3}$)	Dry matter content (%)	Total soluble solid (^{0}brix)	Starch content ($mg\ g^{-1}$ FW)	Reducing sugar ($mg\ g^{-1}$ FW)
$V_1Vm_1H_1$	0.8747 c	16.547 f	4.4333 d	17.509 fg	0.5567 a
$V_1Vm_1H_2$	0.8977 c	17.747 b-f	4.2467 d	17.697 fg	0.5667 a
$V_1Vm_2H_1$	1.0227 ab	18.007 b-f	4.1867 d	18.627 b-g	0.5367 a
$V_1Vm_2H_2$	1.0507 ab	18.317 b-f	5.0467 c	19.047 b-f	0.5467 a
$V_2Vm_1H_1$	1.0587 ab	18.527 b-e	5.1167 c	19.987 bc	0.5567 a
$V_2Vm_1H_2$	0.9447 bc	19.007 bcd	5.0867 c	19.567 b-e	0.4967 b
$V_2Vm_2H_1$	1.0577 ab	19.207 bc	5.2467 c	19.897 bcd	0.4267 c
$V_2Vm_2H_2$	1.0617 a	18.977 bcd	6.0567 b	20.237 b	0.4667 bc
$V_3Vm_1H_1$	1.1087 a	24.117 a	6.6867 a	25.117 a	0.2667 e
$V_3Vm_1H_2$	1.1107 a	23.247 a	7.1167 a	24.587 a	0.2767 e
$V_3Vm_2H_1$	1.0437 ab	18.557 b-e	4.4467 d	23.787 a	0.2767 e
$V_3Vm_2H_2$	1.0487 ab	19.507 b	4.2267 d	18.107 efg	0.3667 d
$V_4Vm_1H_1$	1.0907 a	22.787 a	6.8767 a	24.337 a	0.2567 e
$V_4Vm_1H_2$	1.0487 ab	17.007 ef	4.0367 d	18.547 c-g	0.2767 e
$V_4Vm_2H_1$	1.0507 ab	17.247 def	4.1067 d	18.287 d-g	0.4467 c
$V_4Vm_2H_2$	0.7487 d	17.347 c-f	4.1867 d	17.117 g	0.4500 c
CV (%)	7.09	7.93	8.01	6.53	6.40
LSD $_{(0.05)}$	0.0882	1.8621	0.5006	1.6145	0.0340
Significance level	*	*	**	**	*
V×Vm	**	**	**	**	**
V×H	**	*	**	**	NS
Vm×H	NS	NS	**	NS	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability; NS= Non-significant

*, ** indicate significant at 5% and 1% level of probability, respectively; NS= Non-significant

V_1= Destiny, V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)

Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.38 Texture of chips (N)

Significant ($p \le 0.01$) variation was noted among different potato varieties against texture of potato chips (Appendix-XVIII and Table-28). The heavy (9.0567 N) texture of potato chips was found from V_3 treatment followed by V_4 treatment and the weak (5.8617 N) was in V_1. In respects of texture of potato chips a remarkable ($p \le 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XVIII and Table-29). The heavy texture of potato chips (7.8479 N) was found from Vm_1 treatment and the weak (6.5367 N) was in Vm_2. Harvesting time significantly ($p \le 0.01$) influenced the texture of potato chips under study (Appendix-XVIII and Table-30). The heavy texture of potato chips (7.6017 N) was found from H_1 treatment and the weak (6.7829 N) was in H_2. Combindly, a significant ($p \le 0.01$) variation was found among the treatment against texture of potato chips (Appendix-XVIII and Table-31). The heavy texture of potato chips (11.107 N) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_3Vm_1H_2$ while the weak (5.447 N) texture of potato chips was in $V_4Vm_2H_2$. Moyano *et al.* (2007) stated that the texture of potato chips was found to be directly related to specific gravity, total solids and starch content. Chips obtained from potatoes rich in dry matter can exhibit hard textures; whereas chips made of tubers with low dry matter content are characterized by greasy and sticky textures.

4.39 Bitterness (1= not bitter and 2 = less bitter)

Bitterness of potato chips showed significant ($p \le 0.01$) response against different potato varieties (Appendix-XVIII and Table-28). The highest bitterness (1.4972) of potato chips was found from V_2 treatment followed by V_3 treatment and the lowest (1.4667) was in V_4. In respects of bitterness of potato chips a remarkable ($p \le 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XVIII and Table-29). The highest bitterness of potato chips (1.5267) was found from Vm_2 treatment and the lowest bitterness (1.4354 N) was in Vm_1. Harvesting time significantly ($p \le 0.01$) influenced the bitterness of potato chips under study (Appendix-XVIII and Table-30). The higher bitterness of potato chips (1.5204) was found from

H_2 treatment and the lower bitterness (1.4417) was in H_1. Combindly, a non-significant (p=NS) effect was found (Appendix-XVIII and Table-31) among the treatment against bitterness of potato chips. Asmamaw *et al.* (2010) showed that the reduced bitterness of the chips could be due to the minimal internal glykoalkaloids level of tubers at harvest. They also showed that the loss in taste of chips prepared from tubers harvested at extended period may due to the increase in the concentration of glykoalkaloids level of tubers.

4.40 Sweetness (1=not sweet and 5 = very sweet)

Sweetness of potato chips showed significant ($p \leq 0.01$) response against different potato varieties (Appendix-XVIII and Table-28). The highest sweetness (3.9342) of potato chips was found from V_1 treatment followed by V_2 treatment and the lowest (2.8542) was in V_3. In respects of sweetness of potato chips a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XVIII and Table-29). The highest sweetness of potato chips (3.6054) was found from Vm_2 treatment and the lowest sweetness (2.9129) was in Vm_1. Harvesting time significantly ($p \leq 0.01$) influenced the sweetness of potato chips under study (Appendix-XVIII and Table-30). The higher sweetness of potato chips (3.4004) was found from H_2 treatment and the lower sweetness (3.1179) was in H_1. Combindly, a significant ($p \leq 0.01$) variation was found (Appendix-XVIII and Table-31) among the treatment against sweetness of potato chips. The highest sweetness of potato chips (4.3467) was found from $V_4Vm_2H_2$ treatment combination while the lowest sweetness (1.8567) of potato chips was in $V_3Vm_1H_1$ which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$. The tuber contains high amount of reducing sugar resulted in high sweetness of chips during taste. The late harvested tuber have high amount of reducing sugar resulted from high breakdown of starch.

4.41 Sourness (1= not sour and 2 = less sour)

Sourness of potato chips showed significant ($p \leq 0.01$) response against different potato varieties (Appendix-XVIII and Table-28). The highest sourness (1.5867) of potato chips was found from V_3 treatment followed by V_4 treatment and the lowest (1.0667) was in V_1. In respects of sourness of potato chips a remarkable ($p \le 0.01$) variation was noted (Appendix-XVIII and Table-29) against different levels of vermicompost applications. The highest sourness of potato chips (1.3917) was found from $V1_2$ treatment and the lowest sourness (1.2642) was in Vm_2. Harvesting time significantly ($p \le 0.05$) influenced the sourness of potato chips under study (Appendix-XVIII and Table-30). The higher sourness of potato chips (1.3654) was found from H_1 treatment and the lower sourness (1.2904) was in H_2. Combindly, a significant ($p \le 0.01$) variation was found among the treatment against sourness of potato chips (Appendix-XVIII and Table-31). The highest sourness of potato chips (1.8467) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$ while the lowest (1.0167) sourness was found in $V_1Vm_1H_1$. The tuber contains low amount of reducing sugar resulted in moderate sourness of chips during taste. The early harvested tuber have high amount of starch resulted in sourness since at harvest starch molecules are staying intact in nature.

Table 28. Performance of varieties on the sensory traits of potato chips

Varieties	Texture of chips (N)	Bitterness (1= not bitter and 2 = less bitter)	Sweetness (1=not sweet and 5 = very sweet)	Sourness (1=not sour and 2 = less sour)
V_1	5.8617 d	1.4792 c	3.9342 a	1.0667 d
V_2	6.5042 c	1.4942 a	3.3617 b	1.2592 c
V_3	9.0567 a	1.4842 b	2.8542 d	1.5867 a
V_4	7.3467 b	1.4667 d	2.8867 c	1.3992 b
CV (%)	0.98	0.17	0.87	0.65
LSD $_{(0.05)}$	0.0704	0.0275	0.0284	0.0213
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly), V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)

Table 29. Effect of vermicompost on the sensory traits of potato chips

Vermicompost	Texture of chips (N)	Bitterness (1= not bitter and 2 = less bitter)	Sweetness (1=not sweet and 5 = very sweet)	Sourness (1=not sour and 2 = less sour)
Vm_1	7.8479 a	1.4354 b	2.9129 b	1.3917 a
Vm_2	6.5367 b	1.5267 a	3.6054 a	1.2642 b
CV (%)	0.56	0.29	0.54	0.46
LSD $_{(0.05)}$	0.0270	0.0271	0.0118	0.0259
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

Table 30. Response of harvesting time on the sensory traits of potato chips

Harvesting time	Texture of chips (N)	Bitterness (1= not bitter and 2 = less bitter)	Sweetness (1=not sweet and 5 = very sweet)	Sourness (1=not sour and 2 = less sour)
H_1	7.6017 a	1.4417 b	3.1179 b	1.3654 a
H_2	6.7829 b	1.5204 a	3.4004 a	1.2904 b
CV (%)	6.49	6.40	7.10	7.84
LSD $_{(0.05)}$	0.2858	0.0580	0.1415	0.0637
Significance level	**	**	**	*

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability, * indicates significant at 5% level of probability
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 31. Interaction effect of variety, vermicompost and harvesting time on the sensory traits of potato chips

Combination	Texture of chips (N)	Bitterness (1= not bitter and 2 = less bitter)	Sweetness (1=not sweet and 5 = very sweet)	Sourness (1=not sour and 2 = less sour)
$V_1Vm_1H_1$	5.557 de	1.4867	4.0067 bc	1.0167 g
$V_1Vm_1H_2$	5.777 cde	1.5667	4.0467 b	1.0567 fg
$V_1Vm_2H_1$	6.007 cde	1.4167	3.9467 bc	1.1067 efg
$V_1Vm_2H_2$	6.107 cd	1.4467	3.7367 c	1.0867 fg
$V_2Vm_1H_1$	6.147 c	1.3767	3.3467 d	1.1667 def
$V_2Vm_1H_2$	5.977 cde	1.5167	3.3767 d	1.2467 cd
$V_2Vm_2H_1$	6.887 b	1.5067	3.3367 d	1.3367 bc
$V_2Vm_2H_2$	7.007 b	1.5767	3.3867 d	1.2867 bcd
$V_3Vm_1H_1$	11.247 a	1.3367	1.8567 f	1.8467 a
$V_3Vm_1H_2$	10.887 a	1.3467	2.0067 f	1.7667 a
$V_3Vm_2H_1$	7.117 b	1.6067	3.8067 bc	1.3467 bc
$V_3Vm_2H_2$	6.977 b	1.6467	3.7467 c	1.3867 b
$V_4Vm_1H_1$	11.107 a	1.3167	2.1067 f	1.8067 a
$V_4Vm_1H_2$	6.087 cd	1.5367	2.5567 e	1.2267 cde
$V_4Vm_2H_1$	6.747 b	1.4867	2.5367 e	1.2967 bc
$V_4Vm_2H_2$	5.447 e	1.5267	4.3467 a	1.2667 bcd
CV (%)	6.49	6.40	7.10	7.84
LSD $_{(0.05)}$	0.5771	-------	0.2849	0.1279
Significance level	**	NS	**	**
V×Vm	**	**	**	**
V×H	**	NS	**	**
Vm×H	**	NS	NS	NS

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; NS= Non-significant
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.42 Yield for chips production (t ha^{-1})

Yield of tuber for chips production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIX and Table-32). The highest (18.34 t ha^{-1}) yield was found from V_3 treatment followed by V_2 treatment and the lowest (13.26 t ha^{-1}) was in V_1. In respects of yield of potato tubers for chips a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIX and Table-33). The highest yield (15.97 t ha^{-1}) was found from Vm_2 treatment while the lowest (15.21 t ha^{-1}) was in Vm_1. Harvesting time does not influenced (p=NS) the tuber yield for chips under study (Appendix-XIX and Table-34). Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for chips production (Appendix-XIX and Table-35). The highest (19.11 t ha^{-1}) yield was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_2Vm_1H_1$ and $V_2Vm_1H_2$ while the lowest (11.01 t ha^{-1}) was in $V_2Vm_2H_1$.

4.43 Yield for french fry production (t ha^{-1})

Yield of tuber for french fry production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIX and Table-32). The highest (1.721 t ha^{-1}) yield was found from V_4 and in V_1, V_2 and V_3 no french fry yield was detected. In respects of yield of potato tubers for french fry a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIX and Table-33). The highest yield (0.86 t ha^{-1}) was found from Vm_1 treatment and in Vm_2 no french fry yield was found. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for french fry production under study (Appendix-XIX and Table-34). The higher yield (0.86 t ha^{-1}) was found from H_1 treatment and in H_2 no French fry yield was found. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for french fry production (Appendix-XIX and Table-35). The highest yield (6.88 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination while the no french fry yield was found from the other treatment combinations.

4.44 Yield for flakes production (t ha^{-1})

Yield of tuber for flakes production was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIX and Table-32). The highest yield (8.15 t ha^{-1}) was found from V_4 treatment followed by V_5 treatment and the lowest (5.00 t ha^{-1}) was in V_1. In respects of yield of potato tubers for flakes a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIX and Table-33). The highest yield (7.15 t ha^{-1}) was found from Vm_1 treatment while the lowest (6.19 t ha^{-1}) was in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for flakes under study (Appendix-XIX and Table-34). The higher (6.89 t ha^{-1}) yield was found from H_1 treatment and the lower (6.46 t ha^{-1}) was in H_2. Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for flakes production (Appendix-XIX and Table-35). The highest yield (9.81 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_4Vm_1H_1$ and $V_3Vm_1H_2$ while the lowest (4.97 t ha^{-1}) was in $V_1Vm_1H_1$.

4.45 Yield for canned production (t ha^{-1})

Canned production from potato tuber was found significant ($p \leq 0.01$) against different potato varieties (Appendix-XIX and Table-32). The highest yield (5.55 t ha^{-1}) was found from V_1 treatment followed by V_2 treatment and the lowest was in V_4 (3.49 t ha^{-1}). In respects of yield of potato tubers for canned a remarkable ($p \leq 0.01$) variation was noted against different levels of vermicompost applications (Appendix-XIX and Table-33). The highest (4.61 t ha^{-1}) yield was found from Vm_1 treatment while the lowest (4.16 t ha^{-1}) was found in Vm_2. Harvesting time significantly ($p \leq 0.01$) influenced the tuber yield for canned under study (Appendix-XIX and Table-34). The higher yield (4.84 t ha^{-1}) was found from H_1 treatment and the lower (3.93 t ha^{-1}) was in H_2.

Combindly, a significant ($p \leq 0.01$) variation was found among the treatment against yield of potato tubers for canned production (Appendix-XIX and Table-35). The highest yield (7.03 t ha^{-1}) was found from $V_1Vm_1H_2$ treatment combination while the lowest (2.44 t ha^{-1}) was found in $V_4Vm_1H_2$ which was statistically similar to $V_4Vm_2H_2$ and $V_3Vm_1H_1$.

Table 32. Performance of varieties on the yield of potato for different processing purpose

Varieties	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
V_1	13.26 d	0.00 b	5.00 d	5.55 a
V_2	15.85 b	0.00 b	6.47 c	4.23 b
V_3	18.34 a	0.00 b	8.15 a	4.26 b
V_4	14.92 c	1.72 a	7.06 b	3.49 c
CV (%)	0.74	21.78	0.52	1.06
LSD $_{(0.05)}$	0.1149	0.0937	0.0345	0.0463
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)

Table 33. Effect of vermicompost on the yield of potato for different processing purpose

Vermicompost	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
Vm_1	15.2 b	0.86 a	7.15 a	4.61 a
Vm_2	15.9 a	0.00 b	6.19 b	4.16 b
CV (%)	0.55	21.78	0.72	2.31
LSD $_{(0.05)}$	0.0571	0.0624	0.0318	0.0676
Significance level	**	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}

Table 34. Response of harvesting time on the yield of potato for different processing purpose

Harvesting time	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
H_1	15.31	0.86 a	6.89 a	4.84 a
H_2	15.88	0.00 b	6.46 b	3.93 b
CV (%)	8.21	21.78	8.08	9.00
LSD $_{(0.05)}$	--------	0.0574	0.3303	0.2417
Significance level	NS	**	**	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; NS= Non-significant
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

Table 35. Interaction effect of variety, vermicompost and harvesting time on the yield of potato for different processing purpose

Combination	Yield of potato for chips production (t ha^{-1}) (45-75 mm)	Yield of potato for french fry production (t ha^{-1}) (>75 mm)	Yield of potato for flakes production (t ha^{-1}) (30-45 mm)	Yield of potato for canned production (t ha^{-1}) (<30 mm)
$V_1Vm_1H_1$	11.74 cd	0.00 b	4.97 e	6.27 bc
$V_1Vm_1H_2$	13.18 c	0.00 b	5.23 d	7.03 a
$V_1Vm_2H_1$	15.88 b	0.00 b	5.00 d	5.78 c
$V_1Vm_2H_2$	16.30 b	0.00 b	4.80 de	3.12 gh
$V_2Vm_1H_1$	19.76 a	0.00 b	5.88 d	4.22 de
$V_2Vm_1H_2$	18.50 a	0.00 b	6.24 cd	3.72 ef
$V_2Vm_2H_1$	11.01 d	0.00 b	6.97 bc	4.41 d
$V_2Vm_2H_2$	16.07 b	0.00 b	6.80 bc	4.56 d
$V_3Vm_1H_1$	12.00 cd	0.00 b	9.81 a	2.65 hi
$V_3Vm_1H_2$	16.10 b	0.00 b	9.57 a	4.40 d
$V_3Vm_2H_1$	16.00 b	0.00 b	7.00 b	6.42 b
$V_3Vm_2H_2$	15.20 b	0.00 b	6.20 cd	3.58 fg
$V_4Vm_1H_1$	19.11 a	6.88 a	9.24 a	6.12 bc
$V_4Vm_1H_2$	15.98 b	0.00 b	6.28 c	2.44 i
$V_4Vm_2H_1$	16.20 b	0.00 b	6.20 cd	2.82 hi
$V_4Vm_2H_2$	16.40 b	0.00 b	6.51 bc	2.58 i
CV (%)	8.21	21.78	8.08	9.00
LSD $_{(0.05)}$	1.5729	0.1721	0.6629	0.4949
Significance level	**	**	**	**
V×Vm	**	**	**	**
V×H	**	**	**	**
Vm×H	NS	**	NS	**

Values with common letter (s) within a column do not differ significantly at 5% level of probability
** indicate significant at 1% level of probability; NS= Non-significant
V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.46 Correlation co-efficient (r)

A positive relation (r=0.577) was found between specific gravity and dry matter content of potato tuber (Figure-14). In Figure-15, a strong negative relation (r=−0.720) was found between starch and reducing sugar content of potato tuber. A strong positive relation (r=0.954) was found between dry matter content of potato tuber and texture of potato chips (Figure-16). A strong negative relation (r=−0.698) was found between starch content of potato tuber and sweetness of potato chips (Figure-17). In Figure-18, a positive relation (r=0.687) was found between reducing sugar content of potato tuber and sweetness of potato chips. A strong negative relation (r=−0.803) was found between sweetness and sourness of potato chips (Figure-19).

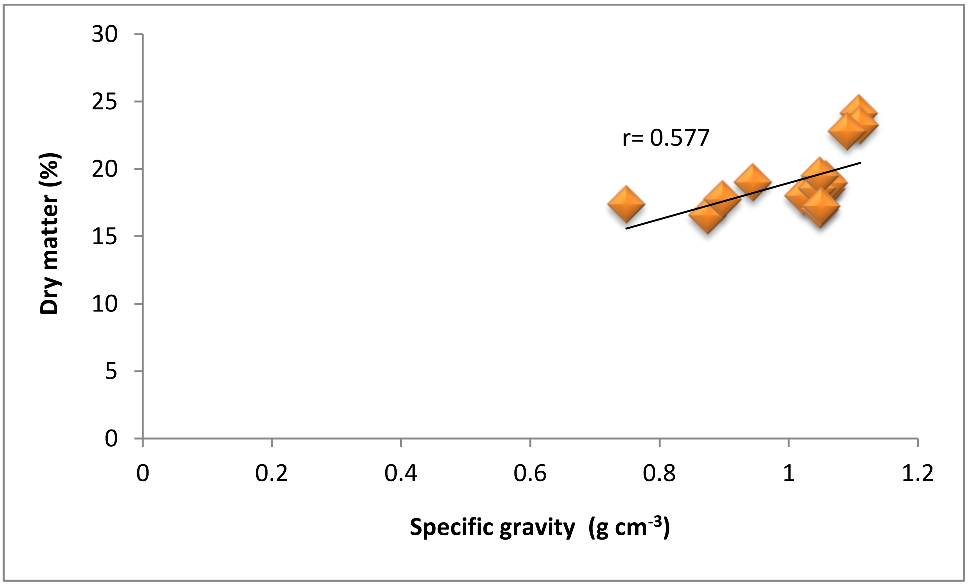

Figure 14. Relationship between specific gravity (g cm^{-3}) and dry matter (%) of potato tuber

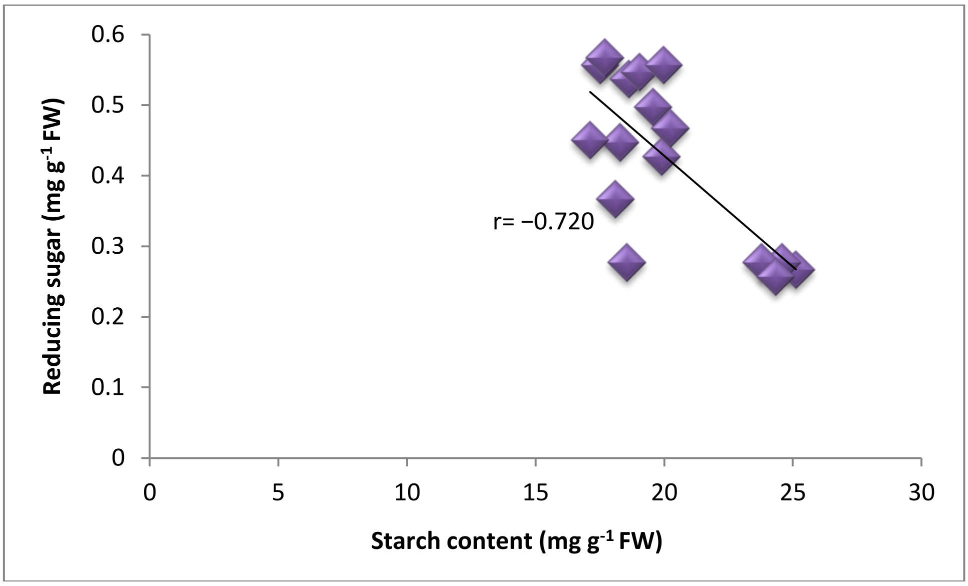

Figure 15. Relationship between starch content (mg g^{-1} FW) and reducing sugar content (mg g^{-1} FW) of potato tuber

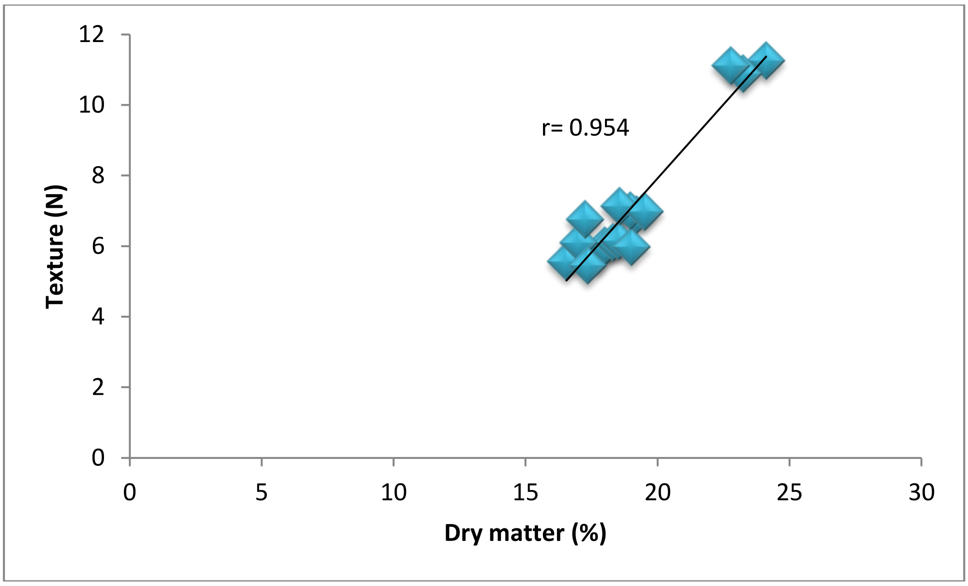

Figure 16. Relationship between dry matter (%) and texture (N) of potato chips

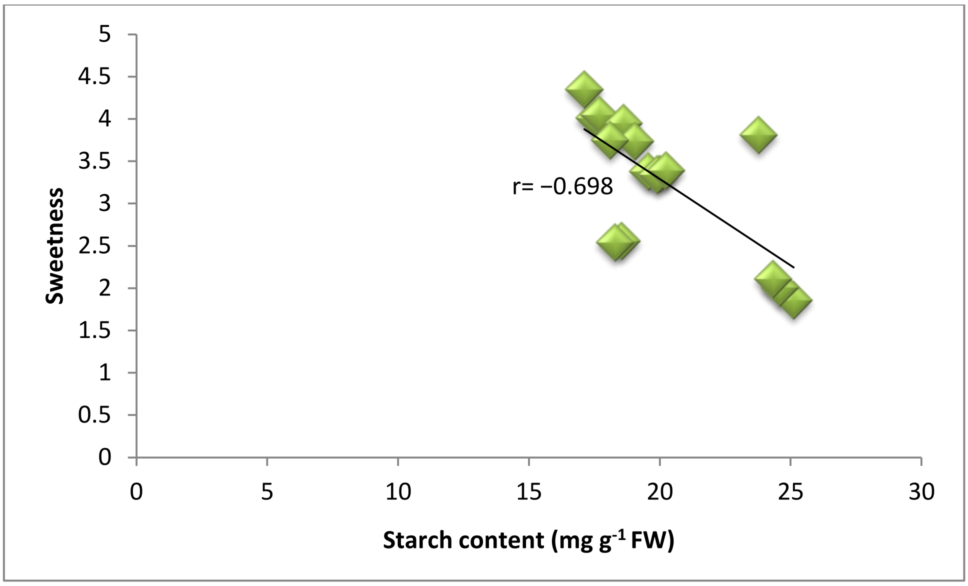

Figure 17. Relationship between starch content (mg g^{-1} FW) and sweetness of potato chips

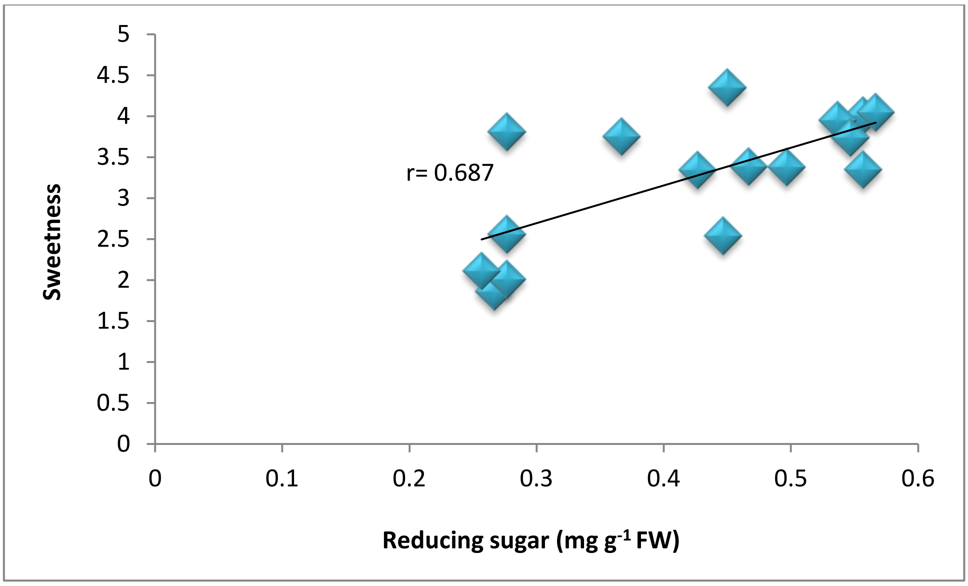

Figure 18. Relationship between reducing sugar content (mg g^{-1} FW) and sweetness of potato chips

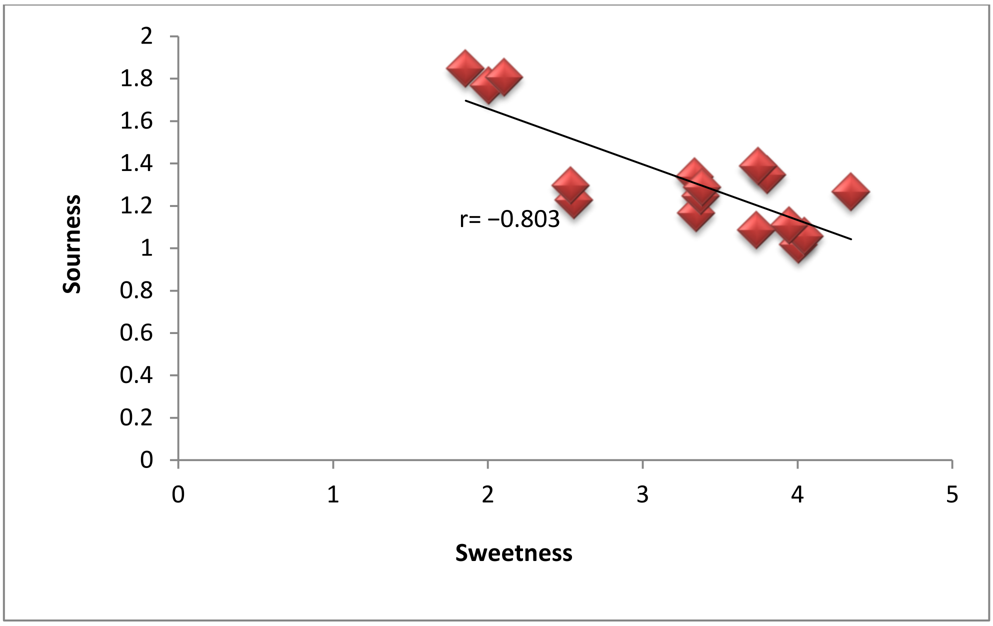

Figure 19. Relationship between sweetness and sourness of potato chips

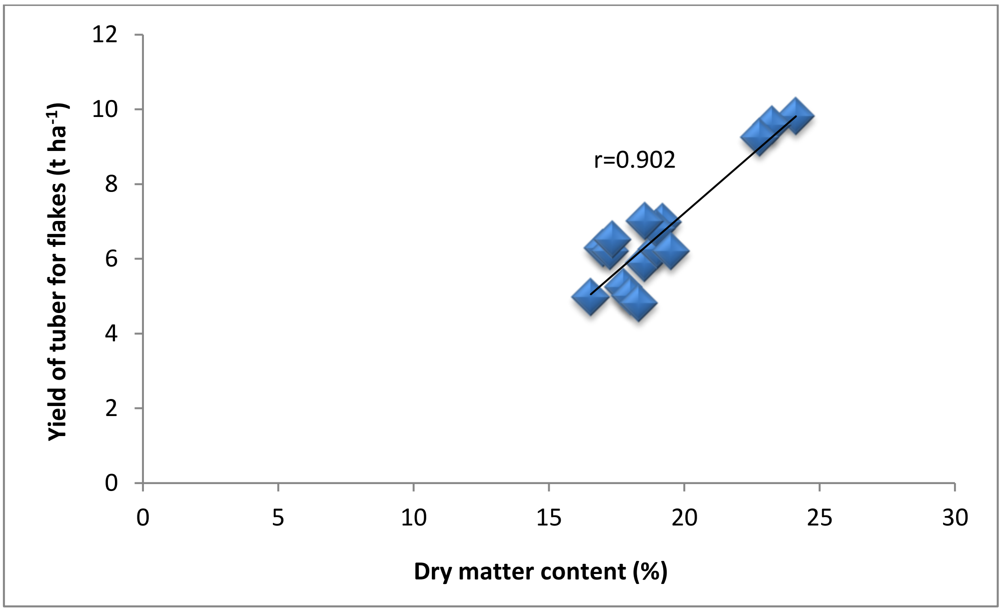

Figure 20. Relationship between dry matter content (%) and yield of tuber for flakes production (t ha^{-1})

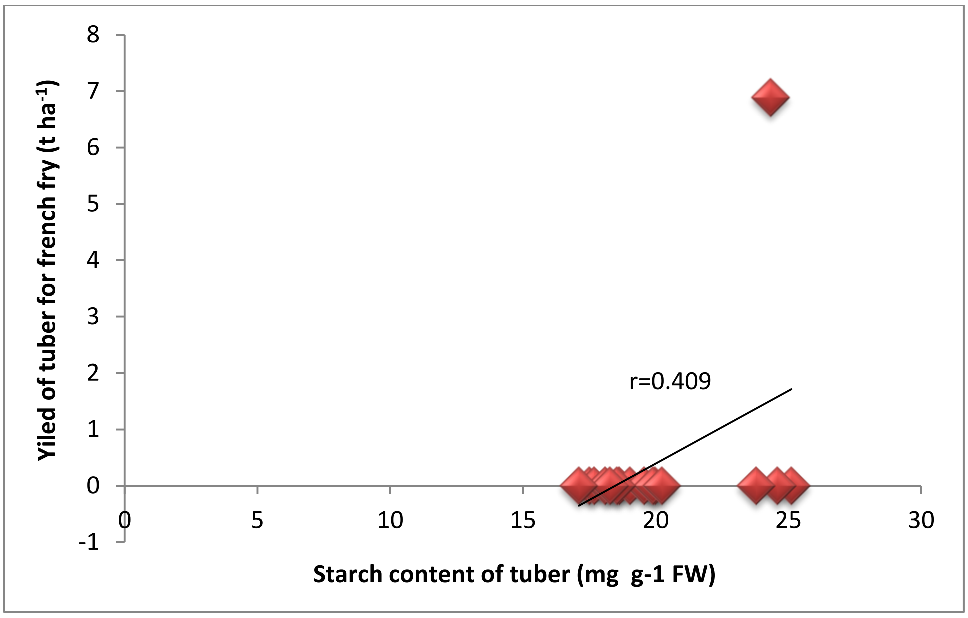

Figure 21. Relationship between starch content of tuber (mg g^{-1} FW) and yield of tuber for french fry production (t ha^{-1})

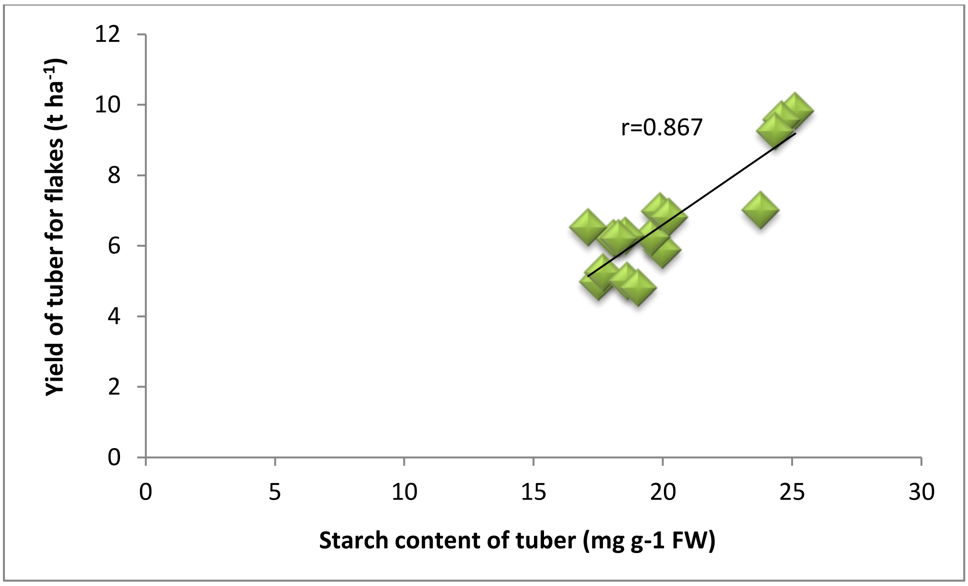

Figure 22. Relationship between starch content of tuber (mg g-1 FW) and yield of tuber for flakes

4.47 Tuber yield merit (%)

A much variation was found after the calculation of tuber yield merit under the study. Apparently, $V_4Vm_1H_1$ exhibited the maximum tuber yield merit (30.88%) and which was very near to $V_3Vm_1H_2$ (30.50%), $V_3Vm_1H_1$ (28.65%) and $V_3Vm_2H_1$ (27.98%) over $V_1Vm_1H_1$.

Treatment combination	Tuber yield merit (%)
$V_1Vm_1H_1$	-----
$V_1Vm_1H_2$	5.27
$V_1Vm_2H_1$	4.08
$V_1Vm_2H_2$	4.32
$V_2Vm_1H_1$	11.53
$V_2Vm_1H_2$	11.46
$V_2Vm_2H_1$	16.96
$V_2Vm_2H_2$	13.46
$V_3Vm_1H_1$	**28.65**
$V_3Vm_1H_2$	**30.50**
$V_3Vm_2H_1$	**27.98**
$V_3Vm_2H_2$	10.78
$V_4Vm_1H_1$	**30.88**
$V_4Vm_1H_2$	7.77
$V_4Vm_2H_1$	8.40
$V_4Vm_2H_2$	9.83

V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)

4.48 Monetary Advantage (Tk./ha)

From the study it was found that, the uses of vermicompost and harvesting time has shown much economic benefits on potato. Numerically, $V_4Vm_1H_1$ gave the maximum monetary return (945,960 Tk) and which was very near to $V_3Vm_1H_2$ (941,520 Tk), $V_3Vm_1H_1$ (913,920 Tk) and $V_3Vm_2H_1$ (905,220 Tk) over $V_1Vm_1H_1$ (624,210 Tk).

Treatment combination	Monetary Advantage (Tk./ha)
$V_1Vm_1H_1$	624,210
$V_1Vm_1H_2$	645,570
$V_1Vm_2H_1$	637,260
$V_1Vm_2H_2$	639,210
$V_2Vm_1H_1$	701,310
$V_2Vm_1H_2$	689,610
$V_2Vm_2H_1$	732,960
$V_2Vm_2H_2$	725,760
$V_3Vm_1H_1$	**913,920**
$V_3Vm_1H_2$	**941,520**
$V_3Vm_2H_1$	**905,220**
$V_3Vm_2H_2$	688,560
$V_4Vm_1H_1$	**945,960**
$V_4Vm_1H_2$	667,710
$V_4Vm_2H_1$	678,660
$V_4Vm_2H_2$	687,510

V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and, V_4= BARI Alu-25 (Asterix)
Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1}
H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP)
Price of Potato tuber: 30 Tk/kg.

CHAPTER V
SUMMARY AND CONCLUSION

All the experiments were carried out in the research field of Sher-e-Bangla Agricultural University (SAU), Dhaka-1207. The expt. 1 was conducted during the period from November, 2015 to March, 2016; expt. 2 and expt. 3 were conducted during the period from November, 2016 to April, 2017; expt. 4 was conducted during the period from November, 2017 to April, 2018. The experimental area was belonged to $23^o7'$N latitude and 93^oE' longitude at an altitude of 8.6 meter above the sea level and research area was also belonged to agro-ecological zone of “Madhupur Tract”, AEZ-28. The experimental site most probably characterized by winter with a significant monsoon climate with sub-tropical cropping zone during the months from November, 2015 to April, 2018 (*Rabi* season). The soil above the sub-surface soil are termed as “Surface soil” which was characterized by silty clay with slight sandy loam in texture, olive-slight grayish white with common fine to medium distinct dark whitish brownish-light brown mottles was seen on the top soil.

Potato (*Solanum tuberosum* L.) was used as test crop under present study. Different varieties and local cultivars were collected from Tuber Crops Research Centre (TCRC) of Bangladesh Agricultural Research Institute (BARI), Gazipur; Bangladesh Agricultural Development Corporation (BADC), Domar farm, Nilphamari and BARI, Debigonj farm, Panchagarh. As a whole, in view of assessing the processing quality in released and local potatoes to standardize a sustainable production package through vermicompost application adjusted with harvesting time and for improving the income status of potato farmers in Bangladesh these varieties and cultivars were selected.

Thirty six (36) potato varieties and cultivars' were used as treatment under **experiment 1** namely: BARI Alu-25 (Asterix), Cardinal, Rojato, BARI Alu-70 (Destiny), Festa Pakri, Tel Pakri, Bot Pakri, Stick, Dora, Granolla, BARI Alu-68 (Atlantic), Raja, Binella, Dheera, Sagita, Patrones, BARI Alu-29 (Courage), Provento, Felsina, Multa, BARI Alu-28 (Lady rosetta), Meridian, Forza, Saikat, Laura, Ailsa, Cumbica, Omera, Rumba, Jerla, Elgar, BARI Alu-71 (Doly) , Agila, Quincy, Almerah and Steffi.

The **experiment 2** comprised of two (2) factors namely, factor A: Variety (4): V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-25 (Asterix) and V_4= BARI Alu-28 (Lady rosetta) and factor B: Vermicompost (5): Vm_1= 0 t ha^{-1}, Vm_2= 3 t ha^{-1}, Vm_3= 6 t ha^{-1}, Vm_4= 9 t ha^{-1} and Vm_5= 12 t ha^{-1}.

The **experiment 3** comprised of three (3) factors namely, factor A: Variety (6): V_1= BARI Alu-68 (Atlantic), V_2= BARI Alu-29 (Courage) , V_3= BARI Alu-28 (Lady rosetta), V_4= BARI Alu-25 (Asterix) , V_5= BARI Alu-70 (Destiny) and V_6= BARI Alu-71 (Doly) ; factor B: Vermicompost (2): Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1} and factor C: Harvesting period (2): H_1= 90 days after planting (DAP) and H_2= 100 days after planting (DAP).

The **experiment 4** comprised of three (3) factors namely, factor A: Variety (4): V_1= BARI Alu-70 (Destiny), V_2= BARI Alu-71 (Doly) , V_3= BARI Alu-28 (Lady rosetta) and V_4= BARI Alu-25 (Asterix) ; factor B: Vermicompost (2): Vm_1= 9 t ha^{-1} and Vm_2= 12 t ha^{-1} and factor C: Harvesting period (2): H_1= 90 (DAP) and H_2= 100 (DAP). The design used in the experiment 1, 2, 3 and 4 were RCBD, Split-plot, Split-split-plot and Split-split-plot design, respectively with three replications. The unit plot size was 2.0 m × 1.5 m for all experiment.

The crop was fertilized by using recommended dose of fertilizers at the rate of 350-220-250-120-10 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively. Vermicompost was used as per treatment as manure. Zinc sulphate and vermicompost was applied during last ploughing time of experimental land. Half urea along with full TSP, MoP and gypsum was applied in furrow during planting of tuber. The rest amount of Urea was applied at 35 DAP as top dressing. Different intercultural operations and control measures against insects and diseases were done as per when necessary under all experiments. For each experiment, haulm cutting was done at second week of March when 60-70% plants showed senescence and these potatoes were harvested after 7 days of haulm cutting for skin hardening. Then the tuber was collected, bagged and tagged separately for taking quality data further in laboratory.

Under the four year experimentation, the number of tubers hill^{-1}, average weight of tuber hill^{-1}, weight of tuber hill^{-1}, tuber yield, marketable yield, non-marketable yield, specific gravity, dry matter content, total soluble solid, starch content, reducing sugar content, texture of chips, bitterness of chips, sweetness of chips and sourness of chips were considered for taking data for statistical analysis. Person's correlation co-efficient (r) done by using Excel spread sheet, tuber yield merit and monetary advantages was calculated for final experiment. Collected data on different parameters were analyzed statistically using the analysis of variance (ANOVA) technique with the help of WASP (Web Agri Stat Package: version-1) computer program and mean were adjusted by using LSD (Least Significant Difference) at 5 % level of probability. Raw data management and graphical representation were done by using Microsoft excel spread sheet.

From the four (4) year study, it was found that, some varieties have good performances under different yield and processing parameters of potato. The application of vermicompost has significantly influenced most of the parameters studied under all experiments. The thinking on harvesting time has shown a better dimension and added a new thing under the experiment 2 and experiment 3 in combination of variety and vermicompost. From the correlation studies, it was also found that, different yield and processing qualities of potato were strongly related either positive or negative.

The highest tuber yield (34.570 t ha^{-1}) was produced by BARI Alu-28 (Lady rosetta) which was statistically similar with BARI Alu-25 (Asterix) (32.543 t ha^{-1}) followed by BARI Alu-29 (Courage) (31.520 t ha^{-1}), BARI Alu-71 (Doly) (31.477 t ha^{-1}), BARI Alu-70 (Destiny) (28.550 t ha^{-1}) and BARI Alu-68 (Atlantic) (26.250 t ha^{-1}). The lowest tuber yield (19.567 t ha^{-1}) was found from Stick which was statistically similar to Granolla, Binella, Dora, Dheera, Sagita, Provento, Felsina, Multa, Meridian, Forza, Saikat, Laura, Ailsa, Cumbica, Omera, Rumba, Agila, Quincy, Almerah, Festa Pakri, Tel Pakri and Bot Pakri. The maximum (1.1033 g cm^{-3}) specific gravity was exhibited by BARI Alu-28 (Lady rosetta) which was statistically similar to the BARI Alu-25 (Asterix) (1.0833 g cm^{-3}) and BARI Alu-29 (Courage) (1.0933 g cm^{-3}) followed by Cardinal, BARI Alu-71 (Doly) , BARI Alu-70 (Destiny)and BARI Alu-68 (Atlantic). The minimum (1.0087 g cm^{-3}) specific gravity was found from Malta which wa statically similar to Rojato, Dora, Granolla, Raja, Binella, Dheera, Sagita, Patrones, Provento, Felsina, Meridian, Forza, Saikat, Laura, Ailsa, Cumbika, Quincy, Almerah, Steffi. The highest dry matter content (22.090 %) was partitioned by BARI Alu-28 (Lady rosetta) which was statistically similar to the BARI Alu-29 (Courage) (21.623 %) and BARI Alu-25 (Asterix) (20.527 %) and followed by BARI Alu-71 (Doly) , BARI Alu-70 (Destiny), and BARI Alu-68 (Atlantic). The lowest dry matter (15.220 %) was partitioned in Dora which was statistically similar to Raja, Binella, Dheera, Granolla, Stick, Provento, Felsina, Multa, Meridian, Forza, Cumbica, Omera, Rumba, Jerla, Elgar, Almerah, respectively.

Combinedly, the maximum number (14.113) was found in V_1Vm_1 which was statistically similar to maximum treatment combinations while the minimum number (7.877) was found in V_3Vm_4 which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5. Combindly, a significant variation was found among the treatment against average weight of potato tubers. The highest average weight

(60.247 g) of tuber was found from V_3Vm_4 treatment combination which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5. The lowest average (29.207 g) was in V_1Vm_1 treatment combination which was statistically similar to rest of the treatment combinations. Combindly, a significant variation was found among the treatment against weight of potato tubers. The highest weight (544.49 g) of tuber was found from V_4Vm_5 treatment combination which was statistically similar to V_4Vm_4, V_3Vm_4 and V_3Vm_5. The lowest (408.12 g) was in V_1Vm_1 treatment combination. Combindly, a significant variation was found among the treatment against yield of potato tubers. The highest tuber yield (33.563 t ha^{-1}) was found from V_2Vm_4 treatment combination which was statistically similar to V_3Vm_4, V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (24.380 t ha^{-1}) was in V_1Vm_2. Combindly, a significant variation was found among the treatment against specific gravity of potato tubers. The maximum gravity (1.1127 g cm^{-3}) of tuber was found from V_3Vm_5 treatment combination which was statistically similar to rest all treatment combinations while the lowest (0.7247 g cm^{-3}) specific gravity was found in V_1Vm_1 treatment combination. Combindly, a significant variation was found among the treatment against dry matter content of potato tubers. The highest dry matter (22.803 %) of tuber was found from V_2Vm_5 treatment combination which was statistically similar to V_2Vm_4, V_3Vm_4, V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (16.120 %) dry matter was found in V_1Vm_1 treatment combination. Combindly, a significant variation was found among the treatment against TSS of potato tubers. The highest TSS (7.1067°) of tuber was found from V_4Vm_5 treatment combination which was statistically similar to V_4Vm_4, V_3Vm_4 and V_3Vm_5 while the lowest (4.146°) TSS was found in V_1Vm_1 treatment combination.

Combindly, a significant variation was found among the treatment against starch content of potato tubers. The highest starch (26.007 mg g^{-1} FW) of tuber was found from V_3Vm_4 treatment combination which was statistically similar to V_3Vm_5, V_4Vm_4 and V_4Vm_5 while the lowest (16.337 mg g^{-1} FW) starch was found in V_1Vm_1 treatment combination. Combindly, a significant variation was found among the treatment against reducing sugar content of potato tubers. The highest reducing sugar (0.5467 mg g^{-1} FW) of tuber was found from V_1Vm_1 treatment combination which was statistically similar to V_1Vm_2 and V_1Vm_5 while the lowest (0.2367 mg g^{-1} FW) reducing sugar was found in V_4Vm_5 treatment combination which was statistically similar to V_4Vm_4 and V_3Vm_5. Combindly, a significant variation was found among the treatment against yield of potato tubers. The highest tuber yield (34.010 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_5Vm_1H_1$ and $V_6Vm_1H_1$ while the lowest (23.220 t ha^{-1}) was in $V_1Vm_1H_1$. Combindly, a significant variation was found among the treatment against specific gravity of potato tubers. The highest specific gravity (1.1020 g cm^{-3}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to maximum treatment combinations followed by $V_2Vm_2H_2$ while the lowest (0.8900 g cm^{-3}) was in $V_1Vm_1H_1$ which was statistically similar to $V_1Vm_2H_1$ and $V_1Vm_2H_2$. Combindly, a significant variation was found among the treatment against dry matter content of potato tubers. The highest dry matter (23.307 %) was found from $V_6Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_5Vm_1H_1$ while the lowest (15.947 %) dry matter was in $V_1Vm_2H_2$.

Combindly, a significant variation was found among the treatment against TSS of potato tubers. The highest TSS (6.9067°) was found from $V_5Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_6Vm_1H_1$ while the lowest (4.0067°) TSS was in $V_6Vm_2H_2$. Combindly, a significant variation was found among the treatment against starch content of potato tubers. The highest starch (25.347 mg g^{-1} FW) was found from $V_6Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_5Vm_1H_1$ while the lowest (17.507 mg g^{-1} FW) dry matter was in $V_1Vm_1H_1$. Combindly, a significant variation was found among the treatment against reducing sugar content of potato tubers. The highest reducing sugar

(0.5667 mg g^{-1} FW) was found from $V_1Vm_1H_1$ treatment combination which was statistically similar to $V_1Vm_1H_2$, $V_1Vm_2H_1$ and $V_2Vm_1H_1$ while the lowest (0.2567 mg g^{-1} FW) dry matter was in $V_6Vm_1H_1$ which was statistically similar to $V_4Vm_1H_1$, $V_5Vm_1H_1$ and $V_3Vm_1H_1$. Combindly, a significant variation was found among the treatment against yield of potato tubers. The highest tuber yield (33.287 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_2H_1$ and $V_3Vm_1H_2$ while the lowest (23.007 t ha^{-1}) was in $V_1Vm_1H_{1.}$ Combindly, a significant variation was found among the treatment against specific gravity of potato tubers. The highest gravity (1.1107 g cm^{-3}) was found from $V_3Vm_1H_2$ treatment combination which was statistically similar to most of the treatment combinations followed by $V_2Vm_1H_2$ while the lowest (0.7487 g cm^{-3}) was in $V_4Vm_2H_2$. Combindly, a significant variation was found among the treatment against dry matter content of potato tubers. The highest dry matter (24.117 %) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$ while the lowest (16.547 %) dry matter was in $V_1Vm_1H_1$.

Combindly, a significant variation was found among the treatment against TSS of potato tubers. The highest TSS (7.1167°) was found from $V_3Vm_1H_2$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_4Vm_1H_1$ while the lowest (4.0367°) TSS was in $V_4Vm_1H_2$. Combindly, a significant variation was found among the treatment against starch content of potato tubers. The highest starch (24.337 mg g^{-1} FW) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$, $V_3Vm_1H_2$ and $V_3Vm_2H_1$ while the lowest (17.117 mg g^{-1} FW) starch was in $V_4Vm_2H_2$. Combindly, a significant variation was found among the treatment against texture of potato chips. The heavy texture of potato chips (11.107 N) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_1$ and $V_3Vm_1H_2$ while the weak (5.447 N) texture of potato chips was in $V_4Vm_2H_2$. Combindly, a non-significant effect was found (Table-27) among the treatment against bitterness of potato chips. Combindly, a significant variation was found among the treatment against sweetness of potato chips. The highest sweetness of potato chips (4.3467) was found from $V_4Vm_2H_2$ treatment combination while the lowest sweetness (1.8567) of potato chips was in $V_3Vm_1H_1$ which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$. Combindly, a significant variation was found among the treatment against sourness of potato chips. The highest sourness of potato chips (1.8467) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_3Vm_1H_2$ and $V_4Vm_1H_1$ while the lowest (1.0167) sourness was found in $V_1Vm_1H_1$. Combindly, a significant variation was found among the treatment against yield of potato tubers for chips production. The highest yield (19.117 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination which was statistically similar to $V_2Vm_1H_1$ and $V_2Vm_1H_2$ while the lowest (11.017 t ha^{-1}) was in $V_2Vm_2H_1$. Combindly, a significant variation was found among the treatment against yield of potato tubers for french fry production. The highest yield (6.8867 t ha^{-1}) was found from $V_4Vm_1H_1$ treatment combination while the no french fry yield was found from the other treatment combinations. Combindly, a significant variation was found among the treatment against yield of potato tubers for flakes production. The highest yield (9.8167 t ha^{-1}) was found from $V_3Vm_1H_1$ treatment combination which was statistically similar to $V_4Vm_1H_1$ and $V_3Vm_1H_2$ while the lowest (4.9767 t ha^{-1}) was in $V_1Vm_1H_1$.

Combindly, a significant variation was found among the treatment against yield of potato tubers for canned production. The highest yield (7.0367 t ha^{-1}) was found from $V_1Vm_1H_2$ treatment combination while the lowest (2.4467 t ha^{-1}) was found in $V_4Vm_1H_2$ which was statistically similar to $V_4Vm_2H_2$ and $V_3Vm_1H_1$. A much variation was found after the calculation of tuber yield merit under the study. Apparently, $V_4Vm_1H_1$ exhibited the maximum tuber yield merit (30.88%) and which was very near to $V_3Vm_1H_2$ (30.50%), $V_3Vm_1H_1$ (28.65%) and $V_3Vm_2H_1$ (27.98%) over $V_1Vm_1H_1$. From the study it was found that, the uses of vermicompost and harvesting time has shown much economic benefits on potato. Numerically, $V_4Vm_1H_1$ gave the maximum monetary return (945,960 Tk/ha) and which was very near to $V_3Vm_1H_2$ (941,520 Tk/ha), $V_3Vm_1H_1$ (913,920 Tk/ha) and $V_3Vm_2H_1$ (905,220 Tk/ha) over $V_1Vm_1H_1$ (624,210 Tk/ha).

Conclusions

1. From the **experiment 1**, it may be reported that among the thirty six (36) potato varieties, BARI Alu-28 (Lady rosetta), BARI Alu-25 (Asterix) , BARI Alu-29 (Courage) , BARI Alu-7 (Destiny), BARI Alu-71 (Doly) and BARI Alu-68 (Atlantic) exhibited the better results for tuber yield, specific gravity and dry matter content.

2. From the **experiment 2**, it may be mentioned that BARI Alu-28 (Lady rosetta) and BARI Alu-25 (Asterix) performed the better for most of the yield and other processing qualities of potato. Vermicompost application at the rate of 9 t ha^{-1} and 12 t ha^{-1} exhibited the best two doses for yield and processing qualities of potato. Combindly, BARI Alu-28 (Lady rosetta) showed good performance with 9 t ha^{-1} and 12 t ha^{-1} vermicompost which was statistically similar to BARI Alu-25 (Asterix) with 9 t ha^{-1} and 12 t for most parameters studied.

3. From the **experiment 3**, it may be said that BARI Alu-28 (Lady rosetta), BARI Alu-25 (Asterix), BARI Alu-70 (Destiny) and BARI Alu-71 (Doly) showed the better four variety for yield and other processing qualities of potato. Vermicompost application at the rate of 9 t ha^{-1} exhibited the best one dose for yield and processing qualities of potato. Under this study, the potato harvested at 90 DAP exhibited the best performance for most of the parameters studied. Combindly, BARI Alu-28 (Lady rosetta) showed good performance along with 9 t ha^{-1} vermicompost harvested at 90 DAP which was statistically similar to BARI Alu-70 (Destiny) with 9 t ha^{-1} vermicompost harvested at 90 DAP and BARI Alu-71 (Doly) with 9 t ha^{-1} vermicompost harvested at 90 DAP for most parameters studied in this experiment.

4. From the **experiment 4**, it may be concluded that BARI Alu-28 (Lady rosetta) and BARI Alu-25 (Asterix) showed the better two variety for yield, processing qualities and sensory traits of potato chips. Vermicompost application at the rate of 9 t ha^{-1} exhibited the best one dose for yield, processing qualities and sensory traits of potato chips. Under this study, the potato harvested at 90 DAP (days after Planting) exhibited the best performance for most of the parameters studied. Combindly, BARI Alu-28 (Lady rosetta) showed good performance with 9 t ha^{-1} vermicompost harvested at 90 DAP which was statistically similar to BARI Alu-25 (Asterix) with 9 t ha^{-1} vermicompost harvested at 90 DAP.

Recommendations

1. The potato growers may use the variety, BARI Alu-28 (Lady rosetta) and BARI Alu-25 (Asterix) for better yield and processing qualities under the prevailing climatic condition of Bangladesh with the combination of vermicompost at the rate of 9 t ha^{-1} and the tuber should be harvested at 90 DAP for maintaining quality of tubers.

2. In order to confirm these findings, more research programs should be conducted to assess the combined effect of the organic sources of nutrient and inorganic fertilizers in different major potato growing areas of Bangladesh. So, the further researchers should be drawn attention to impart a better combination of nutritional management with reasonable cost for commercial potato growing under prevailing climatic condition of Bangladesh in combination of better storage of potato tubers. The extension and other technology dissemination personnel’s should be involved in further attempt to give the message in front of commercial potato growers.

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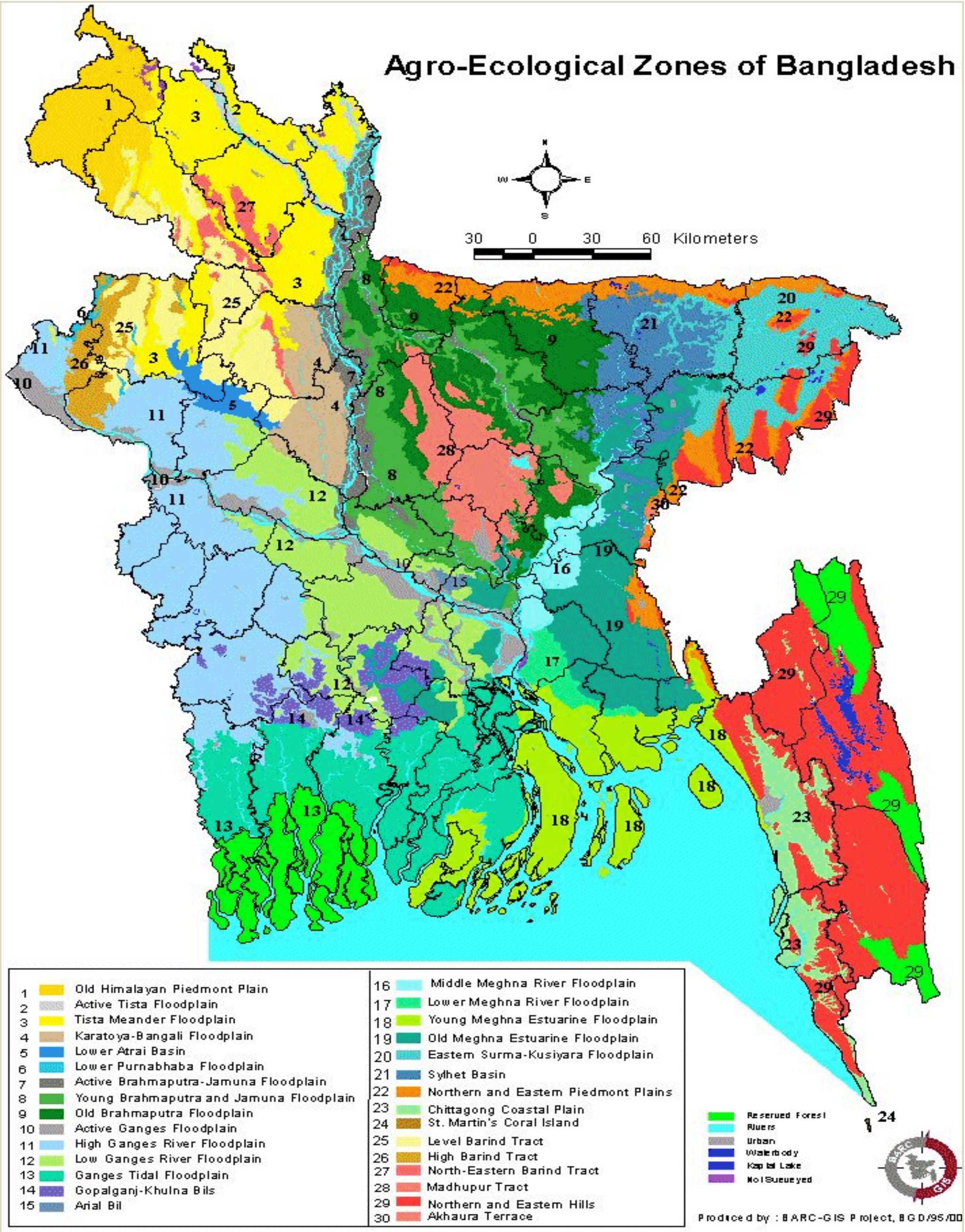
APPENDICES

Appendix I. Map showing the site used for present study



Appendix II. Monthly meteorological information during the period from November, 2015 to March, 2018

Year	Month	Air temperature (^{0}C)		Relative Humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2015-2016	November	25.22	9.66	56.52	55
	December	25.03	8.76	66.98	1.29
	January	23.87	9.02	70.49	Trace
	February	25.88	11.88	75.21	Trace
	March	27.51	14.96	65.76	64
2016-2017	November	24.78	8.88	55.28	34.25
	December	23.84	7.89	61.05	2.25
	January	22.12	9.52	68.55	Trace
	February	23.64	10.29	72.12	Trace
	March	28.35	13.97	73.45	45.01
2017-2018	November	24.91	9.09	55.12	49.02
	December	26.01	8.91	59.09	0.54
	January	24.55	11.11	63.33	1.01
	February	26.11	12.05	68.25	1.05
	March	28.88	13.98	72.25	39.25

Source: Metrological Centre (Climate Division), Agargaon, Dhaka

Appendix III: Analysis of pre-planting and post-harvesting soil of experiment 2, 3 and 4 (2016-2018)

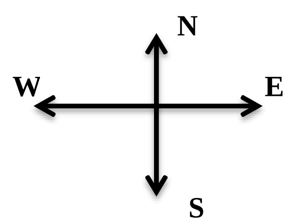
Constituents of soil	Pre-planting	After harvesting
Expt. 2 (2016-2017)		
pH	5.67	5.73
Organic Matter (%)	1.09	2.17
Total Nitrogen (%)	0.14	0.28
K (meq/100g soil)	0.16	0.20
P (mg/g soil)	7.34	8.11
S (mg/g soil)	28.75	30.12
B (mg/g soil)	0.57	0.59
Zn (mg/g soil)	4.62	4.98
Expt. 3 (2016-2017)		
pH	5.71	5.73
Organic Matter (%)	1.27	1.89
Total Nitrogen (%)	0.12	0.25
K (meq/100g soil)	0.13	0.17
P (mg/g soil)	7.89	8.62
S (mg/g soil)	27.45	29.39
B (mg/g soil)	0.44	0.53
Zn (mg/g soil)	3.59	4.28
Expt. 4 (2017-2018)		
pH	5.67	5.73
Organic Matter (%)	1.09	2.17
Total Nitrogen (%)	0.14	0.28
K (meq/100g soil)	0.16	0.20
P (mg/g soil)	7.34	8.11
S (mg/g soil)	28.75	30.12
B (mg/g soil)	0.57	0.59
Zn (mg/g soil)	4.62	4.98

Source: Soil Resources Development Institute (SRDI), Krishi Khamar Sorok, Dhaka.

Appendix IVa. Layout of Experiment 1

Aesterix	Felsina		Stick	Agila		Felsina	Sagita
Cardinal	Multa		Dora	Quincy		Multa	Patrones
Rojato	LadyRosetta		Granolla	Almerah		LadyRosetta	Courage
Destiny	Meridian		Rojato	Steffi		Meridian	Provento
Festa Pakri	Forza		Destiny	Felsina		Forza	BA-68
Tel Pakri	Saikat		FestaPakri	Multa		Saikat	Raja
Bot Pakri	Laura		Tel Pakri	LadyRosetta		Laura	Binella
Stick	Ailsa		Aesterix	Meridian		Ailsa	Dheera
Dora	Cumbica	Replication	Cardinal	Forza	Replication	Cumbica	Bot Pakri
Granolla	Omera		Sagita	Saikat		Omera	Stick
BA-68	Rumba		Patrones	Laura		Rumba	Dora
Raja	Jerla		Courage	Ailsa		Jerla	Granolla
Binella	Elgar		Provento	Cumbica		Elgar	Rojato
Dheera	Doly		BA-68	Omera		Doly	Destiny
Sagita	Agila		Raja	Rumba		Agila	FestaPakri
Patrones	Quincy		Binella	Jerla		Quincy	Tel Pakri
Courage	Almerah		Dheera	Elgar		Almerah	Aesterix
Provento	Steffi		Bot Pakri	Doly		Steffi	Cardinal
R_1			R_2			R_3	

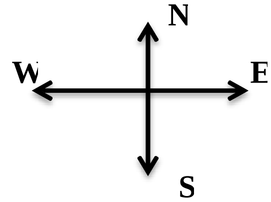
Length of plot: 2.5 m, **Width of plot:** 2.5 m, **Replication to replication distance**: 1.0 m, **Unit plot size**: 2.5 m × 2.5 m (6.25 m^2)



Appendix IVb. Layout of Experiment 2

V_1VM_1	V_4VM_1		V_2VM_2	V_3VM_1		V_4VM_1	V_1VM_5
V_1VM_2	V_4VM_2		V_2VM_5	V_3VM_3		V_4VM_5	V_1VM_3
V_1VM_3	V_4VM_3		V_2VM_4	V_3VM_2		V_4VM_3	V_1VM_2
V_1VM_4	V_4VM_4		V_2VM_3	V_3VM_5		V_4VM_2	V_1VM_1
V_1VM_5	V_4VM_5	Replication	V_2VM_1	V_3VM_4	Replication	V_4VM_4	V_1VM_4
V_2VM_1	V_3VM_1		V_1VM_5	V_4VM_1		V_3VM_1	V_2VM_2
V_2VM_2	V_3VM_2		V_1VM_3	V_4VM_5		V_3VM_3	V_2VM_5
V_2VM_3	V_3VM_3		V_1VM_2	V_4VM_3		V_3VM_2	V_2VM_4
V_2VM_4	V_3VM_4		V_1VM_1	V_4VM_2		V_3VM_5	V_2VM_3
V_2VM_5	V_3VM_5		V_1VM_4	V_4VM_4		V_3VM_4	V_2VM_1
R_1			R_2			R_3	

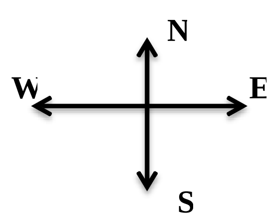
Length of plot: 2.5 m
Width of plot: 2.5 m
Replication to replication distance: 1.0 m
Unit plot size: 2.5 m × 2.5 m (6.25 m^2)



Appendix IVc. Layout of Experiment 3

$V_1VM_1H_1$	$V_4VM_1H_1$		$V_4VM_1H_1$	$V_1VM_1H_1$		$V_5VM_1H_1$	$V_4VM_1H_1$
$V_1VM_1H_2$	$V_4VM_1H_2$		$V_4VM_1H_2$	$V_1VM_1H_2$		$V_5VM_1H_2$	$V_4VM_1H_2$
$V_1VM_2H_1$	$V_4VM_2H_1$		$V_4VM_2H_1$	$V_1VM_2H_1$		$V_5VM_2H_1$	$V_4VM_2H_1$
$V_1VM_2H_2$	$V_4VM_2H_2$		$V_4VM_2H_2$	$V_1VM_2H_2$		$V_5VM_2H_2$	$V_4VM_2H_2$
$V_2VM_1H_1$	$V_5VM_1H_1$		$V_6VM_1H_1$	$V_2VM_1H_1$		$V_6VM_1H_1$	$V_3VM_1H_1$
$V_2VM_1H_2$	$V_5VM_1H_2$	Replication	$V_6VM_1H_2$	$V_2VM_1H_2$	Replication	$V_6VM_1H_2$	$V_3VM_1H_2$
$V_2VM_2H_1$	$V_5VM_2H_1$		$V_6VM_2H_1$	$V_2VM_2H_1$		$V_6VM_2H_1$	$V_3VM_2H_1$
$V_2VM_2H_2$	$V_5VM_2H_2$		$V_6VM_2H_2$	$V_2VM_2H_2$		$V_6VM_2H_2$	$V_3VM_2H_2$
$V_3VM_1H_1$	$V_6VM_1H_1$		$V_3VM_1H_1$	$V_5VM_1H_1$		$V_1VM_1H_1$	$V_2VM_1H_1$
$V_3VM_1H_2$	$V_6VM_1H_2$		$V_3VM_1H_2$	$V_5VM_1H_2$		$V_1VM_1H_2$	$V_2VM_1H_2$
$V_3VM_2H_1$	$V_6VM_2H_1$		$V_3VM_2H_1$	$V_5VM_2H_1$		$V_1VM_2H_1$	$V_2VM_2H_1$
$V_3VM_2H_2$	$V_6VM_2H_2$		$V_3VM_2H_2$	$V_5VM_2H_2$		$V_1VM_2H_2$	$V_2VM_2H_2$
R_1			R_2			R_3	

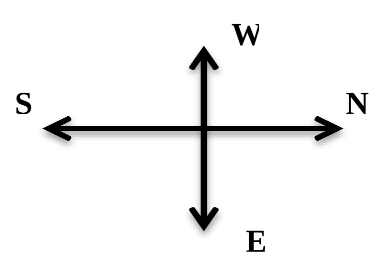
Length of plot: 2.5 m
Width of plot: 2.5 m
Replication to replication distance: 1.0m
Unit plot size: 2.5 m × 2.5 m (6.25 m^2)

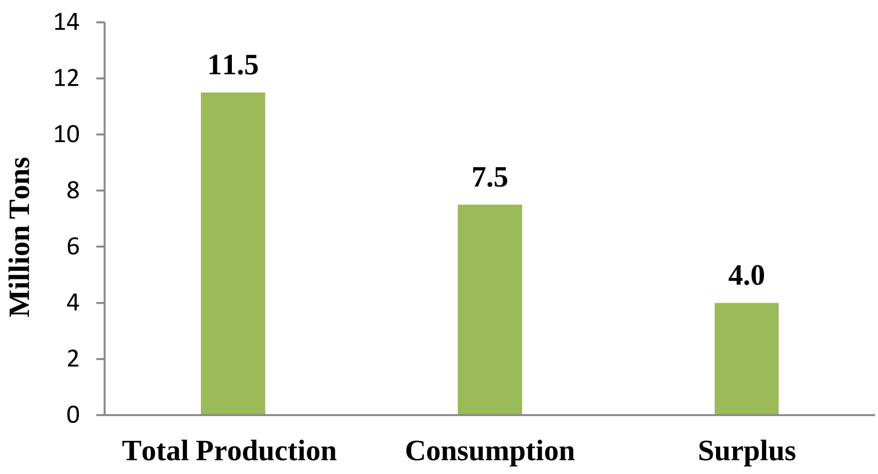


Appendix IVd. Layout of Experiment 4

V_1		V_2		V_2		V_4		
VM_1H_1	VM_2H_2	VM_2H_1	VM_1H_2	VM_1H_1	VM_2H_2	VM_1H_1	VM_2H_2	R_1
$VM_1 H_2$	$VM_2 H_1$	VM_2H_2	$VM_1 H_1$	VM_1H_2	VM_2H_1	VM_1H_2	VM_2H_1	
Replication								
VM_2H_1	VM_1H_2	VM_1H_2	VM_2H_1	VM_2H_1	VM_1H_1	VM_2H_2	VM_1H_1	R_3
VM_2H_2	VM_1H_1	VM_1H_1	VM_2H_2	VM_2H_2	VM_1H_2	VM_2H_1	VM_1H_2	
Replication								
VM_2H_2	VM_1H_1	VM_1H_2	VM_2H_1	VM_1H_2	VM_2H_1	VM_2H_2	VM_1H_1	R_2
VM_2H_1	VM_1H_2	VM_1H_1	VM_2H_2	VM_1H_1	VM_2H_2	VM_2H_1	VM_1H_2	

Length of plot: 2.5 m
Width of plot: 2.5 m
Replication to replication distance: 1.0m
Unit plot size: 2.5 m × 2.5 m (6.25 m^2)





Appendix V. Showing the production of consumption capacity of potato in Bangladesh (FAOSTAT, 2017)

Appendix for Experiment No. 1

Appendix VI. Mean sum square values for tuber yield, specific gravity and dry matter content of potato tuber

Source of variation	df	Tuber Yield	Specific Gravity	Dry Matter Content
Varieties	35	41.536**	0.028**	7.013**
Error	72	2.905	0.038	1.336
Total	107			

** indicates significant at 1% level of probability

Appendices for Experiment No. 2

Appendix VII. Mean sum square values for yield contributing traits of potato tuber

Source of variation	df	Number of tuber per hill	Average tuber weight	Weight of tuber per hill
Replication (A)	2	0.0056	0.01	14.61
Variety (V)	3	38.2320**	1377.03**	8495.60**
Error (A×V**)**	6	0.2007	1.56	167.36
Vermicompost (Vm)	4	14.9087**	411.90**	9976.53**
V×Vm	12	4.3861**	111.19**	3361.99**
Error (A× V×Vm**)**	32	0.7737	9.34	875.03
Total	59			

*, ** indicate significant at 1% level of probability

Appendix VIII. Mean sum square values for yield contributing traits of potato tuber

Source of variation	df	Tuber yield	Marketable yield	Non-marketable yield
Replication (A)	2	4.987	0.001	4.9714
Variety (V)	3	62.151**	173.032**	42.3393**
Error (A×V**)**	6	5.485	0.226	5.5276
Vermicompost (Vm)	4	102.300**	239.406**	29.2682**
V×Vm	12	11.965**	26.464**	6.4086NS
Error (A× V×Vm**)**	32	2.491	1.732	3.4369
Total	59			

*, ** indicate significant at 1% level of probability, NS, Non-significant

Appendix IX. Mean sum square values for processing quality of potato tuber

Source of variation	df	Specific gravity	Dry matter content	TSS
Replication (A)	2	0.01614	6.8256	0.0006
Variety (V)	3	0.03139NS	24.9387**	10.9441**
Error (A×V**)**	6	0.01389	2.4680	0.0208
Vermicompost (Vm)	4	0.01904NS	51.3830**	1.9179**
V×Vm	12	0.03509*	3.2782**	0.4830**
Error (A× V×Vm**)**	32	0.01764	0.5321	0.0989
Total	59			

*, ** indicate significant at 1% level of probability, NS, Non-significant

Appendix X. Mean sum square values for processing quality of potato tuber

Source of variation	df	Starch content	Reducing sugar content
Replication (A)	2	0.03708	0.00018
Variety (V)	3	119.517**	0.13655**
Error (A×V**)**	6	0.18820	0.00019
Vermicompost (Vm)	4	46.9386**	0.03194**
V×Vm	12	8.22480**	0.01290**
Error (A× V×Vm**)**	32	0.91982	0.00051
Total	59		

*, ** indicate significant at 1% level of probability, NS, Non-significant

Appendices for Experiment No. 3

Appendix XI. Mean sum square values for yield contributing traits of potato tuber

Source of variation	df	Tuber yield	Marketable yield	Non-marketable yield
Replication (A)	2	0.0602	0.207	0.0394
Variety (V)	5	28.6291**	55.747**	10.7258**
Error (A×V**)**	10	0.0161	0.037	0.0105
Vermicompost (Vm)	1	35.4903**	122.618**	26.5356**
V×Vm	5	15.6215**	30.721**	3.5773**
Error (A× V×Vm**)**	12	0.0390	0.067	0.0160
Harvesting date (H)	1	52.3776**	139.612**	20.6403**
V×H	5	9.0086NS	25.171**	5.5614**
Vm×H	1	63.0003**	193.454**	36.0825**
V×Vm×H	5	18.5291*	15.892**	3.1060*
Error (A× V×Vm×H**)**	24	6.0591	2.475	1.1591
Total	71			

*, ** indicate significant at 5 and 1% level of probability, NS, Non-significant

Appendix XII. Mean sum square values for processing quality of potato

Source of variation	df	Specific gravity	Dry matter content	TSS
Replication (A)	2	0.05000	0.0206	0.00443
Variety (V)	5	0.01510	21.6025**	1.10665**
Error (A×V**)**	10	0.05866	0.0018	0.00293
Vermicompost (Vm)	1	0.01653	33.4562**	0.67861**
V×Vm	5	0.02782	9.4157**	1.73815**
Error (A× V×Vm**)**	12	0.04833	0.0070	0.00175
Harvesting date (H)	1	0.01076NS	32.1602**	1.81451**
V×H	5	0.02988NS	3.1568NS	2.06945**
Vm×H	1	0.01004NS	11.8098**	0.08611NS
V×Vm×H	5	0.01682*	10.1632**	1.17613**
Error (A× V×Vm×H**)**	24	0.02933	1.3470	0.14402
Total	71			

*, ** indicate significant at 5 and 1% level of probability, NS, Non-significant

Appendix XIII. Mean sum square values for processing quality of potato tuber

Source of variation	df	Starch content	Reducing sugar
Replication (A)	2	0.0133	0.03696
Variety (V)	5	23.6637**	0.07245**
Error (A×V**)**	10	0.0041	0.05584
Vermicompost (Vm)	1	16.2165**	0.0202**
V×Vm	5	14.7776**	0.02552**
Error (A× V×Vm**)**	12	0.0071	0.04791
Harvesting date (H)	1	18.9420**	0.08820**
V×H	5	5.9552**	0.01350**
Vm×H	1	31.2445**	0.01125**
V×Vm×H	5	6.6010**	0.02085**
Error (A× V×Vm×H**)**	24	1.6799	0.03204
Total	71		

Appendix XIV. Mean sum square values for yield grading for processing of potato tuber

Source of variation	df	Yield for chips	Yield for French fry	Yield for flakes	Yield for canned
Replication (A)	2	0.0017	0.00193	0.0028	0.0033
Variety (V)	5	25.3445**	3.13334**	10.4501**	12.5977**
Error (A×V**)**	10	0.0007	0.00193	0.0014	0.0011
Vermicompost (Vm)	1	10.6260**	3.13334**	9.7461**	4.9928**
V×Vm	5	5.8503**	3.13334**	7.8334	2.6119**
Error (A× V×Vm**)**	12	0.0011	0.00193	0.0012	0.0036
Harvesting date (H)	1	9.9013**	3.13334**	16.1596**	2.7848**
V×H	5	4.3760**	3.13334**	7.6163**	1.1047**
Vm×H	1	11.7128**	3.13334**	4.3660**	0.3872NS
V×Vm×H	5	4.8848**	3.13334**	6.3419**	3.9376**
Error (A× V×Vm×H**)**	24	0.2611	0.00193	0.0428	0.1170
Total	71				

** indicate significant at 1% level of probability, NS, Non-significant

Appendices for Experiment No. 4

Appendix XV. Mean sum square values for yield contributing traits of potato

Source of variation	df	Tuber yield	Marketable yield	Non-marketable yield
Replication (A)	2	0.0496	0.089	0.0056
Variety (V)	3	97.8235**	193.353**	22.3220**
Error (A×V**)**	6	0.0191	0.031	0.0048
Vermicompost (Vm)	1	27.8161**	86.028**	16.0083**
V×Vm	3	21.1435**	35.101**	2.2936**
Error (A× V×Vm**)**	8	0.0356	0.057	0.0090
Harvesting date (H)	1	31.8828*	86.028**	13.1671**
V×H	3	12.9296NS	30.005**	6.2634*
Vm×H	1	0.0675NS	5.713NS	7.0227*
V×Vm×H	3	32.0691**	71.665**	13.0157**
Error (A× V×Vm×H**)**	16	6.5647	1.910	1.4505
Total	47			

*, ** indicate significant at 5 and 1% level of probability, NS, Non-significant

Appendix XVI. Mean sum square values for processing quality of potato tuber

Source of variation	df	Specific gravity	Dry matter content	TSS
Replication (A)	2	0.00002	0.0034	0.00041
Variety (V)	3	0.03195**	29.8434**	3.27079**
Error (A×V**)**	6	0.00002	0.0087	0.00203
Vermicompost (Vm)	1	0.00047**	26.1961**	6.96925**
V×Vm	3	0.05879**	20.7863**	6.35129**
Error (A× V×Vm**)**	8	0.00001	0.0077	0.00223
Harvesting date (H)	1	0.02940*	2.7648NS	0.22550NS
V×H	3	0.02347*	7.7313*	2.10570**
Vm×H	1	0.00337NS	6.9769NS	3.23960**
V×Vm×H	3	0.01927*	7.4701*	1.60764**
Error (A× V×Vm×H**)**	16	0.00517	2.3045	0.16465
Total	47			

*, ** indicate significant at 5 and 1% level of probability, NS, Non-significant

Appendix XVII. Mean sum square values for processing quality of potato tuber

Source of variation	df	Starch content	Reducing sugar
Replication (A)	2	0.0209	0.00023
Variety (V)	3	46.6827**	0.16344**
Error (A×V**)**	6	0.0082	0.00004
Vermicompost (Vm)	1	28.1000**	0.01300**
V×Vm	3	21.4768**	0.03797**
Error (A× V×Vm**)**	8	0.0061	0.00002
Harvesting date (H)	1	29.9663**	0.00285NS
V×H	3	11.8567**	0.00189NS
Vm×H	1	0.0400NS	0.00500**
V×Vm×H	3	12.1112**	0.00250*
Error (A× V×Vm×H**)**	16	1.7311	0.00073
Total	47		

Appendix XVIII. Mean sum square values for sensory traits of potato tuber

Source of variation	df	Texture	Bitterness	Sweetness	Sourness
Replication (A)	2	0.0050	0.00019	0.00076	0.00036
Variety (V)	3	22.9752**	0.00157**	3.07565**	0.58003**
Error (A×V**)**	6	0.0050	0.00001	0.00081	0.00007
Vermicompost (Vm)	1	20.6325**	0.09992**	5.75467**	0.19507**
V×Vm	3	16.4682**	0.07237**	2.75213**	0.19843**
Error (A× V×Vm**)**	8	0.0017	0.00002	0.00031	0.00004
Harvesting date (H)	1	8.0442**	0.07442**	0.95768**	0.06750*
V×H	3	7.3929**	0.00677NS	0.96852**	0.07125**
Vm×H	1	3.1673**	0.01367NS	0.15870NS	0.04320NS
V×Vm×H	3	2.4406**	0.00562NS	0.43625**	0.06995**
Error (A× V×Vm×H**)**	16	0.2181	0.00898	0.05349	0.01085
Total	47				

*, ** indicate significant at 5 and 1% level of probability, NS, Non-significant

Appendix XIX. Mean sum square values for the yield of potato for different processing purpose

Source of variation	df	Yield for chips	Yield for French fry	Yield for flakes	Yield for canned
Replication (A)	2	0.0047	0.00879	0.0024	0.0122
Variety (V)	3	54.0596**	8.89241**	20.6147**	8.7922**
Error (A×V**)**	6	0.0132	0.00879	0.0012	0.0021
Vermicompost (Vm)	1	6.8177**	8.89241**	11.2327**	2.4031**
V×Vm	3	17.1714**	8.89241**	8.4985**	8.9762**
Error (A× V×Vm**)**	8	0.0074	0.00879	0.0023	0.0103
Harvesting date (H)	1	3.8817NS	8.89241**	2.2188**	9.8827**
V×H	3	11.6041**	8.89241**	1.2964**	1.7775**
Vm×H	1	5.2470NS	8.89241**	0.5547NS	2.8812**
V×Vm×H	3	7.1711**	8.89241**	2.6898**	10.2947**
Error (A× V×Vm×H**)**	16	1.6385	0.00879	0.2912	0.1560
Total	47				

** indicate significant at 1% level of probability, NS, Non-significant

<u>**Plates for Experiment 1**</u>

Plate 1. Experimental signboard

Plate 2. Good potato varieties

Plates for Experiment 2

Plate 3. Experimental signboard with growing crops

Plate 4. Refractometer for TSS determination

<u>**Plates for Experiment 3**</u>

Plate 5. Experimental signboard with growing crops

Plate 6. Tuber harvesting from field

Plate 7. Bagging and carrying of tubers to store house

Plates for Experiment 4

Plate 8. Experimental layout

Plate 9. Experimental signboard with growing crops

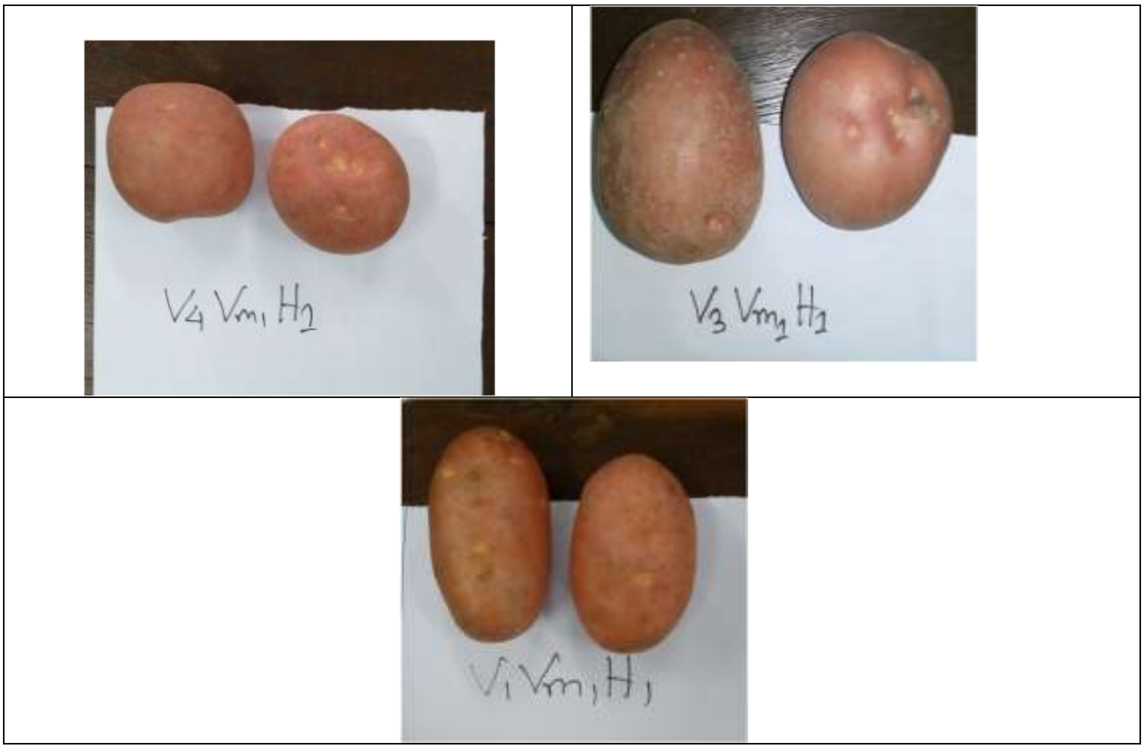


Plate 10. Potatoes from different combinations

Plate 11. Starch determination

Plate 12. Reducing sugar determination

Plate 13. TSS determination

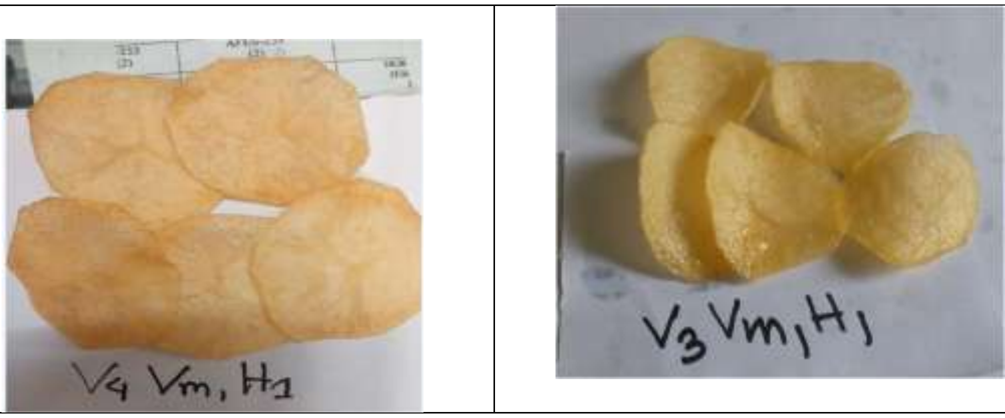


Plate 14. Chips from two combinations

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