INFLUENCE OF BIOSTIMULANTS WITH REDUCED RATE OF CHEMICAL FERTILIZATION AND DEHAULMING SCHEDULE ON POTATO

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MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled, ***"INFLUENCE OF BIOSTIMULANTS WITH REDUCED RATE OF CHEMICAL FERTLIZATION AND DEHAULMING SCHEDULE ON POTATO"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* ***SOUMITRO BISWAS****, Registration No. 18-09233 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.

Dated: December, 2020
Place: Dhaka, Bangladesh

Prof. Dr. Jasim Uddain
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ABSTRACT

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh to find out the effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on potato during the period from November, 2019 to March, 2020. The variety BARI Alu-25 (Asterix) was used in the experiment as the test crop. The experiment consisted of two factors: Factor A: biostimulants with reduced rate of chemical fertilizer viz. M_1 = 6 t ha^{-1} vermicompost, M_2 = Recommended NPK, M_3 = 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4 = 80% NPK+ *Trichoderma* 8 kg ha^{-1}. B: different days of dehaulming I_1 = 65 Days after planting, I_2 = 75 Days after planting, I_3 = 85 Days after planting. There were 12 treatment combinations and experiment was setup in Randomized Complete Block Design (RCBD) with three replications. The result indicated significant variations in number of tubers per hill, weight of tubers per hill, mean tuber weight, yield of tuber per hill, yield of tuber (t ha^{-1}), marketable yield, non-marketable yield (t ha^{-1}), grade of tuber by number, total soluble solids, firmness, starch percentage, dry matter, water percentage, skin color of potato due to biostimulants with reduced rate of chemical fertilization and/or different days of dehaulming. Results also revealed that, the highest yield contributing characters and tuber quality attributes were obtained from 80% NPK+ *Trichoderma* 8 kg ha^{-1} (M_4) treatment. Different days of dehaulming significantly influenced the quality attributes of potato but had non-significant variation on yield contributing characters. The highest tuber yield and quality characters were obtained from dehaulming at 85 days. Among the treatment combination, M_4I_3 (80% NPK+ *Trichoderma* 8 kg ha^{-1} and dehaulming at 85 days) treatment seemed to be more promising for obtaining higher tuber yield (26.63 t ha^{-1}), total soluble solids (6.68), firmness (46.65), starch content (22.38%), dry matter (35.74%) than other treatment combination. Hence, we can summarized that 80% NPK+ *Trichoderma* 8 kg ha^{-1} and dehaulming at 85 days given the maximum output in terms of yield and quality contributing characters compared to other treatments.

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
Cm	Centi-meter
CV	Coefficient of variation
^{o}C	Degree Celsius
d.f.	Degrees of freedom
DAS	Days After Sowing
EC	Electrical Conductivity
et al.	And others
FAO	Food and Agriculture Organization
G	Gram
Ha	Hectare
J.	Journal
Kg	Kilogram
LSD	Least Significant Difference
Mg	Milligram
m^2	Meter Squares
MP	Muriate of Potash
%	Per cent
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resource and Development Institute
TSP	Triple Super Phosphate
Res.	Research
SE	Standard Error
VC	Vermicompost

CHAPTER I

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tuber crop belongs to the family Solanaccae. Potato is the 3rd (just after rice and wheat) most consumed food crop in the world (Champouret, 2010; Verzaux, 2010). Nutritionally, the tuber is rich in carbohydrates.
In Bangladesh, the cultivation of potato was started in the late 19 century but still average yield is very low compared to the leading potato growing countries (Hashem, 1990). Recent reports indicate that 9.65 million tons of potato was produced in this country from 468.375 thousand ha of land in 2018-2019 and the average yield of potato was 20.61 t ha^{-1} in Bangladesh (BBS, 2019). Which is very low in comparison to that of other leading potato growing countries in the world, such as, USA, Denmark and UK. The reasons for low yield of potato in Bangladesh are climate limitation, poor yielding seed tubers and unscientific production practices such as imbalanced fertilizer use and soil moisture regulation.

Potato production can be increased by the adoption of important cultural practices, among them use of fertilizer management practices is important. The continuous use of chemical fertilizer is badly affecting the texture and structure of the soil, decreasing soil organic matter and hampering soil microorganism activity (Brady, 1990). The organic matter of most of the soils of Bangladesh is below 2% as compared to an ideal minimum value 4% (Bhuiya, 1994). Deficiencies of soil organic matter reduced the crop yield which is in important fact for Bangladesh's agriculture. Bangladeshi farmers generally used the inorganic fertilizers judiciously to get high yield and this judicious application of the inorganic fertilizers destroy our agricultural soil.

Now it is important to concern about the soil health. Though single nutrient source may supply the respective required nutrients for plant but integrated use of all sources is required for balanced plant nutrition (Arora, 2008). Vermicompost used as a fertilizer and soil conditioner (Munroe, 2007; Rajesh *et al.* 2003) responsible for the improvement of the physical properties of soil and supply vital plant nutrients. Tuber yield of potato is much more after using organic manures than the recommended dose of inorganic fertilizers only (Boke 2014). Vermicompost improves the physical, chemical and biological properties of soil, increased microbial activity and enzyme production (Kale, 1998). Another existing plan to address the agro-environmental issue is integrated nutrient management, which does not seek to fully eliminate synthetic fertilizers shortly, instead of proposing the use of biostimulants to minimize the amount of fertilizer used.

Biostimulants are biological or biologically derived fertilizer additives and similar products that are used in crop production to enhance plant growth, health and productivity. *Tchichoderma* is a type of biostimulants that can be a good substitute for chemical fertilizers to overcome their adverse effects. Inorganic fertilizer plays a significant role in environmental pollution.Instead, biostimulants, the products containing living cells of different microorganisms, can prevent the depletion of the soil organic matter (Jeyabal and Kuppuswamy, 2001). It has also been reported that application of biostimulants increases yield and reduce environmental pollution (Mia and Shamsuddin, 2010).

It is well documented that the interaction of *Trichoderma* strains with the plant may promote growth, improves crop yield, increase nutrient availability and enhance disease resistance (Harman *et al.*, 2004). In addition, some species of *Trichoderma* are able to colonize root surfaces, interact with the plant, and exchange compounds that can cause substantial changes in plant metabolism (Yedidia *et al*., 2001). Numerous studies on the broad spectrum of horticultural crops have shown that the use of beneficial microorganisms (e.g., the fungus *Trichoderma* sp.) may promote primary or secondary plant metabolism and boosts crop yield (Rouphael *et al.*, 2017). The phyto-stimulatory effect of *Trichoderma* has several direct and indirect impacts on plants, including the release of substances with auxin activity, small peptides, organic acids, which appear to improve root system architecture and assimilation of nutrients, thereby improving plant growth and productivity (Hermosa *et al.,* 2012; Rouphael et al., 2017).

Series of cultivation practices are performed in potato cultivation where dehaulming is considered one of the prime-factors that affect the quality and size of tubers. It is also considered as a key factor in production of healthy potato seed in seed plot technique methods (Struik and Wiersema, 1999). Timing of dehaulming varies according to varieties and in general, the varieties that are not disease resistant are dehaulmed earlier than the disease resistant varieties (Virtanen *et al.,* 2014).

Growth, yield and quality of potato depend on nutrient availability in soil, which is directly related to the judicious application of manures, fertilizers and cultural practices. Considering the above fact, a research was undertaken to find out the effect of biostimulants with reduced rate of chemical fertilization and dehaulming practices on the yield and quality of potato with the following objectives:

i. to investigate the effectiveness of biostimulants with reduced rate of chemical fertilization on yield and quality of potato.

ii. to identify the suitable date of dehaulming schedule for maximum yield and high quality of potato.

iii. to determine the combined effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on the yield and quality of potato.

CHAPTER II
REVIEW OF LITERATURE

Potato is the most important tuber crop in the world as well as in Bangladesh. The yield of potato depends on many factors such as land topography, soil fertility, soil productivity, environment (light, temperature, moisture, humidity and rainfall) and cultural practices. Different types of fertilizers play an important role in its growth, yield and quality. The present study has been taken to investigate the effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on yield and quality of potato. In this chapter an attempt had been made to collect related research findings of the present study. Some literature related to the “Influence of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on yield and quality of potato" are reviewed below-

2.1 Biostimulants with reduced rate of chemical fertilization effect

Shweta and Sharma (2011) conducted an experiment with application of organic manures along with chemical fertilizers had a significant effect on the tuber and haulm yield. Highest tuber (30.46 t ha^{-1}) and haulm yield (9.04 t ha^{-1}) was recorded with application of 100% NPK + 25 t ha^{-1} vermicompost and was significantly higher over sole use of chemical fertilizers. Tuber yield of potato recorded under 100% of recommended dose of NPK without organics (21.39 t ha^{-1}) was at par with 25 t FYM/ha or 12.5 t VC/ha applied along with 75% of recommended dose of NPK thereby, indicating a saving of 25% in NPK.

Alam *et al.* (2007) conducted an experiment to study the effect of vermicompost and NPKS fertilizers on growth and yield of potato (cv. Cardinal) in Level Barind Tract (AEZ-25) soils of Bangladesh. The organic matter of the experimental field soil was very low and in case of N, P, K and S also low.1 The land was medium fertile and PH was 5.4. There were 12 treatments *viz*. control,vermicompost (VC) 2.5 t ha^{-1} , VC 5.0 t ha^{-1}, VC 10.0 t ha^{-1}, VC 2.5 t ha^{-1} + 50% NPKS, VC 5 t ha^{-1} + 50% NPKS, VC 10 t ha^{-1} + 50% NPKS, VC 2.5 t ha^{-1} + 100% NPKS, VC 5 t ha^{-1} + 100% NPKS, 10 11 12 VC 10 t ha^{-1} + 100% NPKS 50% NPKS and 100% NPKS. The experiment was laid out in RCBD with three replications.The doses of N-P-K-S were 90-40-100-18 kg ha^{-1} for potatoes. Application of 10 t ha^{-1} vermicompost and NPKS significantly influenced the growth and yield of potatoes. The treatment produced the highest (25.56 t ha^{-1}) tuber yield of potato. The lowest yield and yield contributing parameters recorded in control. Application of various amounts of vermicompost (2.5, 5, 10 t ha^{-1}) with NPKS fertilizers (50% and 100%) increased the vegetative growth and yield potato. Vermicompost at 2.5, 5 and 10 t ha^{-1} with 50% of NPKS increased tuber yield over control by 78.3, 96.9 and 119.5 t ha^{-1} respectively. And vermicompost at 2.5, 5 and 10 t ha^{-1} with 100% of NPKS increased tuber yield by 146.8, 163.1 and 197.9%, respectively. The results indicated that vermicompost (10 t ha^{-1}) with NPKS (100%) produced the highest growth and yield of potato.

Yelin *et al.* (2020) reported the extensive use of chemical fertilizers poses serious collateral problems such as environmental pollution, pest resistance development and food safety decline. Research focused on applying plant-beneficial microorganisms to partially replace chemical fertilizer use is increasing due to the requirement of sustainable agriculture development. To investigate the possibility of a plant beneficial *Trichoderma* strain and its bio-organic fertilizer product in saving chemical fertilizer application and in improving crop quality, a field trial and continuous pot experiments were carried out with tomatoes. Four treatments were set up: a reduced application of chemical fertilizer (75% of the conventional application) plus *Trichoderma*-enriched bio-organic fertilizer (BF), organic fertilizer (OF) or *Trichoderma* spore suspension (SS), with using the 100% rate of the conventional chemical fertilizer as the control (CF). The results showed that the total soluble sugar, Vitamin C and nitrate accumulations were, respectively, + up to 24%, + up to 57% and + up to 62% in the tomatoes of the BF treatment compared to those of the control (CF). And both of the pot and field trials revealed that reduced rates of chemical fertilizer plus bio-organic fertilizer produced tomato yields equivalent to those obtained using the 100% of the chemical fertilizer.

However, application with the inoculant alone (SS) or combined with the organic fertilizer alone (OF) would lead to a yield decrease of 6–38% and 9–35% over the control. Since the increased abundance of soil microflora and the enhanced soil fertility frequently showed positive linear correlations especially in the BF-treated soils, we conclude that the efficacy of this bioorganic fertilizer for maintaining a stable tomato yield and improving tomato quality may be due to the improved soil microbial activity. Thus, the results suggest that the *Trichoderma* bio-organic fertilizer could be employed in combination with the appropriate rates of chemical fertilizers to get maximum benefits regarding yield, quality and fertilizer savings.

Haque *et al*. (2012) reported biofertilizer plays a significant role in crop cultivation with reduced chemical fertilizer use. Three *Trichoderma*-enriched fertilizers were evaluated in mustard and tomato cultivation at field condition. Sole application of biofertilizers didn't show remarkable contribution but all *Trichoderma* enriched biofertilizers when supplemented with N fertilizer significantly boosted up the growth and yield of mustard and tomato. Application of 50% N fertilizer along with 50% *Trichoderma*-enriched biofertilizers augmented 108 and 203% yields over control both in mustard and tomato, respectively which were 81.90 and 61.82% in mustard and tomato at standard doses of Nitrogen, Phosphorus and Potassium fertilizers. The present results suggest that *Trichoderma*-enriched biofertilizer could save at least 50% N fertilizer uses for mustard and tomato and could reduce excessive uses of NPK for crop cultivation.

Kumar *et al*. (2012) conducted a field experiments with farm yard manure (FYM), poultry manure (PM), vermicompost (VC) and solubilizing bacteria (PSB) and *Azotobacter* + PSB) in subplots. The results showed that 50 % of the recommended dose of NPK through inorganic + 50% recommended dose of nitrogen (RDN) through organic manures (FYM, PM or VC) or 100% recommended dose of NPK through inorganic fertilizers alone favourably influenced the tuber yield, nutrient uptake, soil fertility and paid higher returns compared to other treatments. Seed treatment with *Azotobacter* + PSB proved better in tuber yield, nutrient uptake and recorded higher returns as compared to sole treatment of either *Azotobacter* or PSB. Three years pooled result revealed that integrated application of 50 % of recommended NPK through inorganic and 50 % RDN through PM recorded significantly highest tuber yield (22.73 t ha-1) closely followed by 100 % recommended NPK through inorganic (22.20 t ha-1) which were 228 % and 223 % respectively, higher than control. Integrated application of inorganic and organic fertilizers and seed treatment with *Azotobacter* + PSB biofertilizers improved tuber yield, nutrient uptake, and gave higher return as compared to other treatment combinations. Total organic carbon (TOC), soil microbial biomass carbon (SMBC), available N, P, and K status of the soil after 3 years were maximum when 50 % recommended doses of NPK were applied through inorganic and remaining 50 % RDN through PM.

Kashem *et al.* (2015) conducted a study attempting to compare the effect of cow manure vermicompost and inorganic fertilizers on the vegetative growth and fruits of tomato plants (*Solanum lycopersicum* L.). An air dried sandy loam soil was mixed with five rates of vermicompost equivalent to 0 (control), 5, 10, 15 and 20 t ha^{-1} and three rates of NPK fertilizer equivalent to 50% (N-P-K = 69-16-35 kg t ha^{-1}), 100% (N-P-K = 137-32-70 kg ha^{-1}) and 200% (N-P-K = 274-64-140 kg ha^{-1}).The data revealed that shoot length, number of leaves, dry matter weight of shoots and roots, fruit number and fruit weight were influenced significantly ($P< 0.05$) by the application of vermicompost and NPK fertilizer in the growth media. The highest dose of vermicompost of 20 t/ha increased dry weight of shoot of 52 folds and root of 115 folds, number of fruit(s)/plant of 6 folds and mean fruit weight of 29 folds while the highest rate of NPK fertilizer of 200% increased dry weight of shoot of 35 folds and root of 80 folds, number of fruit (s)/plant of 4 folds and mean fruit weight of 18 folds over the control treatment. The growth performance of tomatoes was better in the vermicompost amended soil pots than the plants grown in the inorganic fertilizer amended soil pots.

Mojtaba *et al.* (2013) conducted an experiment on which experimental factors included nitrogen fertilizer with three levels (50, 100 and 150 kg/ha as urea) and vermicompost with 4 levels 0 (control), 4.5, 9, and 12 t/ha). 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 N.P.K 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.

Sood and Sharma (2001) was doing a field experiments during 2000 at Shimla for assessing the utility of growth promoting bacteria, *Azotobacter* & Vermicompost for potato production indicated 'that *Bacillus cerus* (A) and *Bacillus subtilis* (B) separately increased the tuber yield of potato from 115 to 268 q ha^{-1} par with 100% NPK treatment. Vermicompost @ 5 t ha^{-1} increased the tuber yield by 34 to 65 q ha^{-1}. The increase in yield was more when optimum NPK dose of fertilizer was applied. Inoculation of seed tubers with *Azotobacter* in the absence of N increased the tuber yield by 68 q/ha and the effect of *Azotobacter* decreased gradually as the dose of N was increased.

Meenakumari and Shekhar (2012) conducted an experiment to determine the effect of vermicompost and other fertilizers on growth, yield and fruit quality of tomato in the field condition. The field trials were conducted using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared where was kept as control and five others were treated by different category of fertilizers Chemical fertilizers, Farm Yard Manure (FYM), Vermicompost, and FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively).The treatment plots showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N.P.K treated plots displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Choudhary *et al.* (2010) conducted an experiment with potatoes in an acidic soil fertilized with vermicompost and biofertilizers independently or in combination. It was revealed that graded vermicompost doses @ 20 or 30 t ha^{-1} as well as biofertilizers alone or in combination with vermicompost increased plant height. Enhancements in potato tuber yield as well as gross and net returns were also observed. These results were obtained in the treatment comprising vermicompost @ 30 t/ha + phosphorus solubilizing bacteria (PSB) + Azotobacter followed by vermicompost application @ 30 t/ha + PSB + Azotobacter biofertilizers. Application of varying vermicompost levels alone or in combination with PSB or Azotobacter or their co-inoculation resulted in significant improvement in the available N, DTPA-exchangeable Fe, Mn and Cu in the soil.

The experiment was conducted for the evaluation of the performance of seed potato to organic fertilizers. Two potato varieties *viz*. Asterix (V_1) and Diamant (V_2) were subjected to different inorganic fertilizers *viz*. Control (T_1), Cowdung (T_2), Annapurna organic fertilizer (T_3), 75% Annapurna organic fertilizer + 25 % Vermicompost (T4) and Vermicompost (T_5). Early 80% emergence was found from T_1 (V_1: 26.3 days; V_2: 23.3 days) while early tuberization from T_2 for V_1 (36.0 days) and T_1 for V_2 (29.0 days). Both varieties performed differently to the organic fertilizers used in the experiment. T_4 was the best for V_1 (14.3 kg per plot and 28.8 t.ha-1) while T_3 was best for V_2 (14.1 kg per plot and 28.3 t.ha-1). Asterix yielded more tuber than diamant variety. The performances of both varieties were not varied significantly among the treatments for different graded tuber except for 28–55 mm graded tuber in asterix. From the study it is suggested to use of 75% Annapurna organic fertilizer + 25% Vermicompost for asterix variety with BARI recommended inorganic fertilizers in order to get more yielding seed potato.

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

Goutam *et al.* (2011) was Field trials were conducted using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared where was kept as control and five others were treated by different category of fertilizers Chemical fertilizers, Farm Yard Manure (FYM), Vermicompost, and FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively).The treatment plots showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N.P.K treated plots displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Abdeldaym *et al.* (2019) reported that combined application of biostimulants with other sources of nitrogen fertilizers significantly improved dry matter, starch and protein contents of potato tubers. Similar trends were observed in concentrations of N, P, K and Ca in potato tubers. Furthermore, microbial inoculum not only increased nutrient assimilation by potato plant but also increased soil nutrient contents, such as available N (NH_4-N and NO_3-N), available P and exchangeable content. It can be concluded that combination of nitrogen fixer biostimulants with various sources of nitrogen fertilizers can be a better solution for improving nutritional quality and yield of potato in less fertile soils.

2.2 Dehaulming Schedule effect

Upadhyay and Bashyal (2020) reported potato is one of the most important commercial crops worldwide covering 20 million hectares cropping area. Series of cultivation practices are performed in potato cultivation where dehaulming is considered one of the prime-factors that affect the quality and size of tubers. It is also considered as a key factor in production of healthy potato seed in Seed plot technique methods. Dehaulming practice includes the act of detaching and defoliating the vegetative part lying above the ground of potato plant from the underground tuber. Effect of dehaulming is significantly found in the yield of seed tuber, the post-harvest quality of potato tuber and the disease, pest protection aspect of plants. The weight of tuber was found to be 384.20 g when haulm was cut at 65 days after planting (DAP), then significant increase in weight was found i.e. 533.00 g when the haulm was cut at 80 DAP. And the maximum seed yield was observed when dehaulming was done at 70 DAP i.e. 19.75 t/ha and similar to the non-seed yield. The post-harvest quality of tuber is also significantly improved when dehaulming was performed prior to harvesting.

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

Mahmud *et al.* (2009) conducted an experiment and found five standard potato cultivars (Cardinal, Multa, Ailsa, Heera, and Dheera) in relation to dates of dehaulming (65, 70, and 80 days after planting) in a Seed Potato Production Farm, Debijong, Panchagarh during 1996-97 and 1997-98. Dehaulming at 70 days gave maximum seed size tubers (19.75 t $ha^{-1} \approx 76\%$) but significantly identical to 75 days (19.56 t $ha^{-1} \approx 70\%$) and 80 days (18.69 t $ha^{-1} \approx 63\%$). Considering all the parameters studied, the performance of Heera proved to be best among the cultivars grown. Among the cultivars, the maximum seed tuber yield was recorded from Cardinal at 80 DAP followed by Heera and Cardinal at 70 DAP, Dheera and Ailsa at 75 DAP. In general, most of the cultivars gave the maximum seed tuber yield when the crop was dehaulmed at 70 and 80 DAP and the lowest from 65 DAP.

Sandhu *et al.* (2012) conducted an experiment with cultivars consisting of one Indian *i.e.* Kufri Chipsona-1 and two exotic *viz*. Atlantic and Lady Rosetta along with one popular table variety Kufri Pukhraj were evaluated in relation to different planting times (1st October, 15th October and 25th December) and haulm cuttings (70, 80 and 90 days after planting). Only October plantings produced significantly higher yield with desirable processing attributes. Kufri Pukhraj produced maximum processing grade tubers (13.9 t/ha) but with very poor processing attributes. All the three processing cultivars gave higher tuber dry matter content (>21%), low mean reducing sugars (<50 mg/100g fresh weight), sucrose (231.6 to 248.5 mg/100g fresh weight) and acceptable chip colour score (2.7 to 3.3). (39.2 mg/100g fresh weight) and free amino acids (44.2 mg/100g fresh weight) was recorded in Lady Rosetta and Kufri Pukhraj, respectively.

Alam *et al.* (2017) conducted an field experiment for producing higher processing grade tuber yield and quality by evaluating in relation to different planting times (31 October, 15 and 30 November) and dehaulming dates (80, 90 and 100 days after planting) during 2012-13 potato growing season at Bangladesh Agricultural Research Institute, Gazipur. Results revealed that different growth parameters like plant height, leaves number per hill and foliage coverage were significantly influenced by planting times. Processing and non-processing grade tuber number and yield were significantly affected by all the treatments and their interaction. Significantly higher yield of processing grade tubers were recorded in November 15 planting in combination with all the dehaulming dates, ranging from 20.67 to 21.50 t/ha. Processing quality parameters like specific gravity, dry matter, reducing sugar content were significantly varied by planting times, dehaulming dates and their interaction. Whereas the potato chips colour score were not affected by the planting time and dehaulming but all the processing quality parameters remained in acceptable range. The highest net return (Tk 1, 68,404/ha) with a BCR of 1.93 was obtained on November 15 planting with dehaulming at 90 days after planting.

Mandal and Das (2020) done an experiment to determine the effects of intra row spacing, dates of haulm cutting and fertilizer dose on disease free quality seed grade tuber production of potato. The results revealed that with the decrease in intra row spacing from 20cm to 15cm seed grade size (< 75g) tuber yield and numbers and total tuber numbers were significantly increased but marketable grade (> 75 g) tuber yield and numbers were significantly reduced. Haulm cutting at 65 DAP increased the seed grade size tuber yield and numbers over 75 DAP. With the decrease in fertility levels from 100% RDF of NPK to 50% RDF of NPK the seed grade tuber production and number were significantly increased at 5% level of significance. Disease incidence and intensity of Phoma leaf spot decreased and early blight increased with decreasing doses of fertilizers. No viral disease was observed. Dehaulming at 65 DAP was found safer so far as infestation and chances of viral disease transmission by the sucking pests were concerned. From the present study it may be concluded that, for quality seed tuber production of potato and to get highest net return under New Alluvial Zone of West Bengal, use of 50cm X 15cm spacing along with haulm cutting at 65 DAP, when planting is done on first week of November and grown with 50% RDF of NPK was found best.

CHAPTER III

MATERIALS AND METHODS

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

3.1 Experimental period

The experiment was conducted during the period from November 2019 to March 2020 in Rabi season

3.2 Site description

3.2.1 Geographical location

The experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from November, 2019 to March, 2020. The experimental site was previously used as a vegetable garden and recently developed for research work. The location of the site is 23° 74'N latitude and 90° 35'E longitude with an elevation of 8.2 meter from sea level (Anon., 1989).

3.2.2 Agro-Ecological Region

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

3.2.3 Climate of the experimental site

Experimental site was located in the sub-tropical monsoon climatic zone, set apart by winter during the months from November, 18, 2019 to March, 2020 (Rabi season). Plenty of sunshine and moderately low temperature prevails during the experimental period, which is suitable for potato growing in Bangladesh.

3.3 Details of the Experiment

3.3.1 Experimental treatments

The experiment consisted of two factors such as biostimulants with reduced rate of chemical fertilization and different date of dehaulming. The treatments were as follows:

Factor A: Biostumulants with reduced rate of chemical fertilizer

M_1 = Vermicompost (6 t ha^{-1})

M_2 = Recommended N.P.K.

M_3 = 90% N.P.K. + *Trichoderma* 4 kg ha^{-1}

M_4 = 80 % N.P.K. + *Trichoderma* 8 kg ha^{-1}

Factor B: Different date of dehaulming management practice

I_1 = 65 Days after planting

I_2 = 75 Days after planting

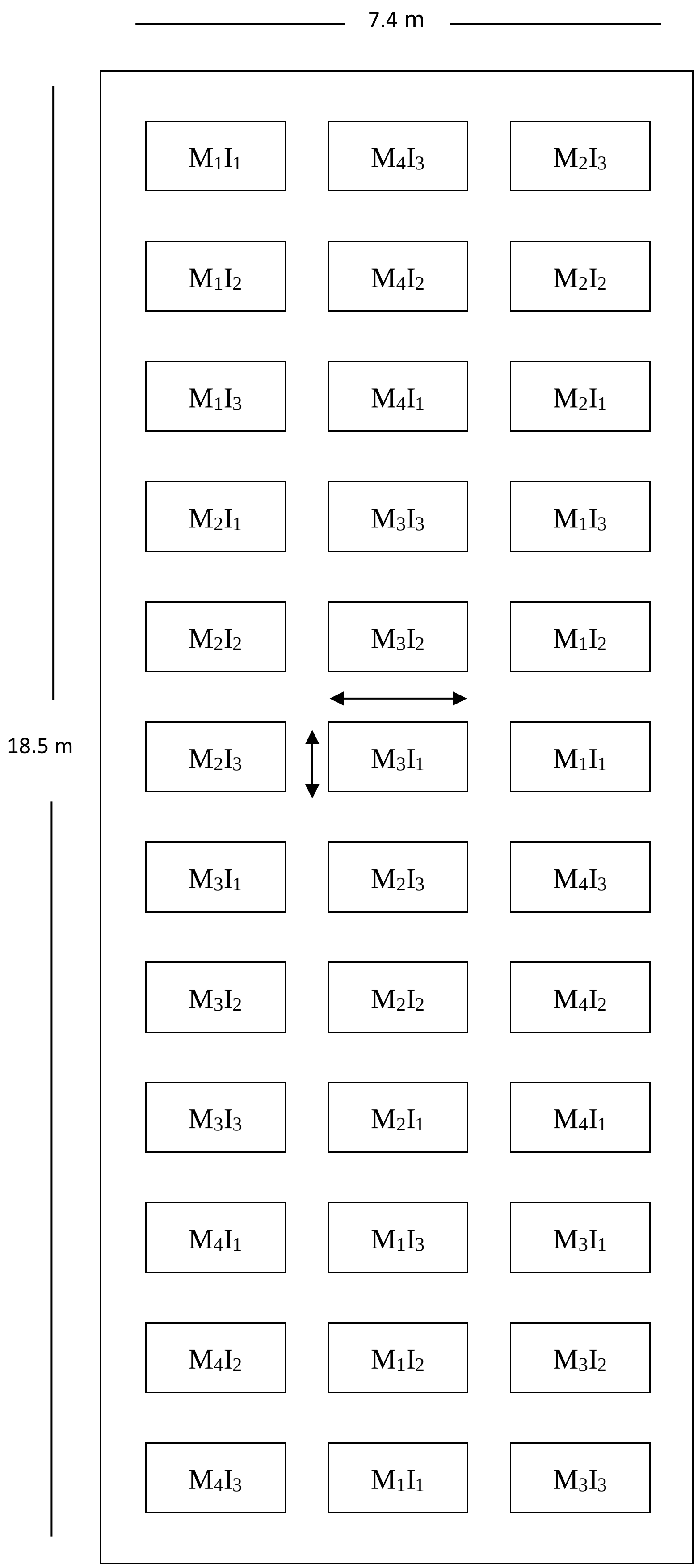
I_3 = 85 Days after planting

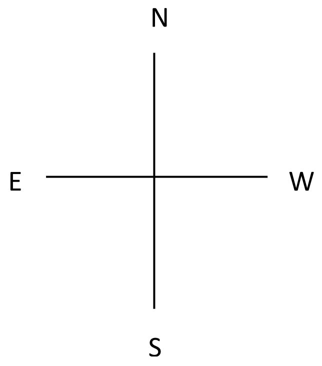
Treatment combinations are as:

M_1I_1 , M_1I_2 , M_1I_2, M_2I_1 , M_2I_2 , M_2I_3 , M_3I_1 , M_3I_2 , M_3I_3 , M_4I_1 , M_4I_2 , M_4I_3

3.3.2 Experimental design

The two-factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. A block consisted of 12 unit plots, each for a combination of biostimulants with reduced rate of fertilizer and dehaulming schedule management practices. The total number of plots was 36. The treatment combinations of the experiment were assigned randomly in each block. The size of the unit plot was 1.8m x 1.0m. The gap between the plots was 50cm and between the blocks was 50cm. The field was laid out on 10th November 2019.





Plot Size: 1.8 m x 1m=1.8 m^2

Block Spacing = 0.5 m

Plot Spacing = 0.5 m

Spacing: 60 cm x 25 cm

Area of total plot= (18.5x7.4) m^2

Plant per plot= 12

Factor A

Biostimulants with reduced rate of chemical fertilization

M = Vermicompost (6 t ha^{-1})

M_2= Recommended N.P.K.

M_3= 90% N.P.K. + *Trichoderma* 4 kg ha^{-1}

M_4= 80 % N.P.K. + *Trichoderma* 8 kg ha^{-1}

Factor B

Different days of dehaulming

I_1= 65 DAP

I_2 = 75 DAP

I_3= 85 DAP

Figure 1. Layout of the experiment

Planting material

The seed tubers of BARI Alu-25 (Asterix) potato variety were collected from Bangladesh Agricultural Development Corporation (BADC) office, Dhaka.

3.5 Crop management

3.5.1 Preparation of seed

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

3.5.2 Soil preparation

Research field was selected at the Horticulture farm of Sher-e-Bangla Agricultural University. The soil was sandy loam. The soil was ploughed 4- 5 times by cross section and level the soil by laddering. Weeds and stubbles were completely removed from soil.

3.5.3 Fertilizer application

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

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

Source: Mondal *et al.,* 2011

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

3.5.4 Planting of seed tuber

The well sprouted healthy and uniform sized potato tubers were planted according to treatment. Seed potatoes were planted in such a way that the potato does not go much under soil or does not remain in shallow soil. On an average, potatoes were planted at 4- 5 cm depth in soil on November 22, 2019.

3.6 Intercultural operations

3.6.1 Weeding

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

3.6.2 Watering

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

3.6.3 Earthing up

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

3.6.4 Plant protection measures

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

3.6.5 Haulm cutting

First Haulm cutting was done on January 27, at 65 DAP. When 40- 50% plants showed senescence and the tops started drying. After fist haulm cutting the second haulm cutting was done on February 7, at 75 DAP. Final haulm cutting was done on 17 February, at 85 DAP. The cut haulm was collected, bagged and tagged separately for further data collection.

3.6.6 Harvesting of potatoes

First harvesting of potatoes started from February 4, 2020 after haulm cutting. The potatoes of each plot were separately harvested, bagged and tagged and brought to the laboratory. The yield of potato plot^{-1} was determined in kg. Harvesting was done manually by hand.

3.7 Collection of data

Six hills from each plot were selected as random and were tagged for the data collection. Data was collected at harvesting stage and the following data was collected during the experimentation.

A. Yield and yield components

1. Number of tuber per hill
2. Weight of tuber per hill (g)
3. Mean tuber weight (g)
4. Yield of tuber per plot (kg)
5. Yield of tuber (t ha^{-1})
6. Marketable tuber yield (t ha^{-1})
7. Non-marketable tuber yield (t ha^{-1})
8. Grade of tuber

B. Quality Characters

1. Total soluble solids (TSS)
2. Firmness
3. Starch content
4. Water percentage
5. Dry matter percentage
6. Skin Colour

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

3.7.1 Number of tubers per hill at harvest

The number of tubers from 6 selected plants was counted and the average number of tubers was calculated.

3.7.2 Weight of tubers per hill at harvest (g)

The weight of tubers from 6 selected hills was recorded and average weight of tubers per hill was calculated.

3.7.3 Average weight of tuber (g)

Average weight of tuber was measured by using the following formula-

Average weight of tuber = $\frac{\text{weight of tuber/plot}}{\text{No of tubers /plot}}$

3.7.4 Yield of tuber per plot (kg)

To obtain yield per hill, weight of tuber was taken from ten harvested sample plants and the tuber yield per unit plot was found out as total tuber weight of all the plants from each unit plot.

3.7.5 Yield of tuber per hectare (t ha^{-1})

The yield of tuber per hectare was calculated from that of per plot yield.

3.7.6 Marketable tuber (t ha^{-1}) and non-marketable tuber Yield (t ha^{-1})

On the basis of weight, the tubers have been graded into marketable tubers (>20 g) and non-marketable tubers (<20 g).

3.7.7 Grade of tubers

Tubers collected from ten plants in each plot the potato was graded by number on the basis of diameter: > 55 mm, 40-55 mm, 28-40 mm and <28 mm.

3.7.8 Total soluble solids (TSS)

TSS of harvested tubers was determined in a drop of potato juice by using Hand Sugar Refractometer and expressed as °BRIX value.

3.7.9 Firmness

Firmness texture measurements were performed at room temperature by a puncture test performed in a texture analyzer equipped with a wedge probe imitating front teeth. Maximum Force (MF) was defined as the force at which the wedge penetrates the outer layer of the surface of the fried potato fries and crisps slices.

3.7.10 Tuber flesh dry matter content (%)

The samples of tuber were collected from each treatment. After peel of the tubers the samples were dried in oven at 72 ^{0}C for 72 hours. From which the weights of tuber flesh dry matter content (%) were recorded.

3.7.11 Skin color

Color was measured with a color spectrophotometer using the L*, a* and b* color scale. The L* value is the lightness parameter indicating degree of lightness of the sample, it varies from 0 = black (dark) to 100 = white (light). The a* which is the chromatic redness parameter, whose value means tending to red color when positive (+) and green color when negative (–). The b* is a yellow chromatic parameter corresponding to yellow color when it is positive (+) and blue color when it is negative (–). Each sample consisted of 10 slices, each of which was measured thrice.

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to find out the significance of variance resulting from the experimental treatments. All mean data were analyzed two way ANOVA by SPSS software version 20. Comparisons of the mean data and standard error (S.E.) were determined by DMRT (Duncan's Multiple Range Test) at $p \leq 0.5$ level significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on potato. The results obtained from the study have been presented, discussed and compared in this chapter through table, figures and appendices. The analysis of variance of data in respect of all the parameters have been shown in Appendix IV- IX. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings

4.1 Yield attributes

4.1.1 Number of tubers per hill

4.1.1.1 Effect of biostimulants with reduced rate of chemical fertilization

Number of tubers per hill was significantly influenced by biostimulants with reduced rate of chemical fertilization (Table 1 and Appendix IV). Results revealed that the highest number of tubers per hill (6.80) was recorded from the M_4 treatment and the lower number (5.36) was found from the M_1 treatment. This variation might be due to change in yield contributing character under biostimulants with different reduced doses of chemical fertilization. Sikder *et al.* (2017) reported similar findings from the different level of fertilizers on the number of tubers per hill.

4.1.1.2 Effect of dehaulming schedule

There was no marked variation was observed on the number of tubers per hill of potato due to different days of dehaulming management practice (Table 2 and Appendix IV). The highest number of tubers per hill (6.21) was recorded from dehaulming at 85 days after planting and the lowest number of tubers per hill (5.96) was recorded from dehaulming at 65 days after planting. However, this parameter is non-significant because tuber formation in potato is almost completed within 50 days (Beukema and Zaag, 1990).

4.1.1.3 Interaction effect of biostimulants with reduced rate of fertilizer and dehaulming schedule

There was marked variation was observed on the number of tubers per hill due to the combined effect of biostimulants with reduced rate of fertilization and dehaulming schedule (Table 3 and Appendix IV) . From the result it was observed that the maximum number of tubers per hill (7.20) was recorded from M_4I_2 combination which was statistically different from all other treatments. On the other hand, the minimum number of tubers per hill (5.19) was recorded from M_1I_1 combination.

4.1.2 Weight of tubers per hill

4.1.2.1 Effect of biostimulants with reduced rate of chemical fertilization

Weight of tubers per hill was significantly affected by the biostimulants with reduced rate of chemical fertilization (Table 1 and Appendix IV). The highest weight (367.88 g) of tubers per hill was recorded from the M_4 treatment. On the other hand, the lowest weight (226.37 g) of tubers per hill was found in M_1 treatment. Chandra (2015) reported similar findings on different levels of vermicompost doses with chemical fertilizer.

4.1.2.2 Effect of dehaulming schedule

There was non-significant variation was observed in the weight of tubers per hill of potato due to different days of dehaulming management practices (Table 2 and Appendix IV). The highest weight of tubers per hill (304.96 g) was recorded from dehaulming at 85 days after planting and the lowest weight of tubers per hill (286.96 g) was recorded from dehaulming at 65 days after planting. The result of 85 DAP was almost statistically similar to 75 DAP.

4.1.2.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was significant variation was observed in the weight of tubers per hill due to the combined effect of biostimulants with reduced rate of fertilization and different days of dehaulming schedule (Table 3 and Appendix IV). From the result it was observed that the highest weight of tuber per hill (400.10 g) was recorded from M_4I_2 combination which was statistically different from all other treatments. On the other hand, the lowest weight of tubers per hill (219.46 g) was recorded from M_1I_1 combination.

Table 1. Effect of biostimulants with reduced rate of chemical fertilization on number of tubers per hill and weight of tubers per hill

Treatments	No of tubers per hill	Weight of tubers per hill (g)
M_1	5.36±0.07^d	226.37±3.39^d
M_2	5.85±0.07^c	270.97±7.56^c
M_3	6.32±0.44^b	312.51±2.80^b
M_4	6.80±0.11^a	367.88±9.50^a
Level of Significance	***	***

(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and *** Indicates significant at <1% level of probability)

Table 2. Effect of dehaulming schedule on number of tubers per hill and weight of tubers per hill

Treatments	Number of tuber per hill	Weight of tuber per hill (g)
I_1	5.96±0.16	286.96±15.38
I_2	6.21±0.20	304.19±19.56
I_3	6.07±0.14	292.15±14.17
Level of Significance	NS	NS

(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and NS indicates non-significant)

Table 3. Interaction effect of biostimulants with reduced rate of fertilizer and dehaulming schedule on number of tubers per hill and weight of tubers per hill

Treatment	Number of tubers per hill	Weight of tubers per hill (g)
M_1I_1	5.19 ± 0.02^{g}	219.46±0.10^{f}
M_1I_2	5.51 ± 0.18^{fg}	235.44±8.34^{f}
M_1I_3	5.37± 0.01^{g}	224.20±1.08^{f}
M_2I_1	5.74 ± 0.07^{ef}	264.87±6.17^{e}
M_2I_2	5.83 ± 0.19^{ef}	265.48±23.27^{e}
M_2I_3	5.98 ± 0.06^{de}	282.57±2.53^{de}
M_3I_1	6.26± 0.02^{cd}	306.83±0.80^{cd}
M_3I_2	6.32 ± 0.05^{c}	315.76±4.35^{c}
M_3I_3	6.39 ± 0.12^{bc}	314.95±7.12^{c}
M_4I_1	6.66 ± 0.02^{b}	356.69±4.24^{b}
M_4I_2	7.20± 0.02^{a}	400.10±3.93^{a}
M_4I_3	6.54 ± 0.18^{bc}	346.87±15.74^{b}
Level of Significance	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

4.1.3 Mean tuber weight

4.1.3.1 Effect of biostimulants with reduced rate of chemical fertilization

Mean tuber weight was significantly affected by the biostimulants with reduced rate of chemical fertilization (Table 4 and Appendix IV). The highest mean tuber weight (54 g) was found in was recorded from the M_4 treatment. On the other hand, the lowest mean tuber weight (42.21 g) was found in 6 t ha^{-1} vermicompost treatment. Similar result was found in the experiment done by Ahmed *et al.* (2019).

4.1.3.2 Effect of dehaulming schedule

There was no significant variation observed on mean tuber weight of potato due to different days of dehaulming management practices (Table 5 and Appendix IV). The highest mean tuber weight (48.38 g) was recorded from dehaulming at 75 days after planting and the lowest mean tuber weight (47.72 g) was recorded from dehaulming at 65 days after planting. The result of 85 DAP was almost statistically similar to 75 DAP for the mean tuber weight. This corroborates the result of Mahmud *et al.* (2009).

4.1.3.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was significant variation was observed on mean tuber weight due to the combined effect of biostimulants with reduced rate of fertilizer and dehaulming schedule (Table 6 and Appendix IV). From the result it was observed that the highest mean tuber (55.56 g) was recorded from M_4I_2 combination which was statistically different from all other treatments. On the other hand, the minimum number of tubers per hill (42.25 g) was recorded from M_1I_1 combination.

4.1.4 Yield of tuber per plot

4.1.4.1 Effect of biostimulants with reduced rate of chemical fertilization

There was marked variation was observed on yield of tuber per plot influenced by biostimulants with reduced rate of chemical fertilization (Table 4 and Appendix V). Results showed that highest yield of tuber (4.18 kg) per plot was obtained from M_4 which was statistically different from all other treatments and the lowest (2.71 kg) yield of tuber per plot was recorded in M_1 treatment. Similar result was found in the experiment done by Rahman (2009).

4.1.4.2 Effect of dehaulming schedule

Different days of dehaulming practices have no significant effect on yield of tuber per plot (Table 5 and Appendix V). The highest yield of tuber per plot (3.50 kg) was recorded from dehaulming at 75 days after planting and the lowest yield of tuber per plot (3.44 kg) was recorded from dehaulming at 65 days after planting. The result of 75 DAP was almost statistically similar to 85 DAP for the yield of tuber per plot.

4.1.3.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was marked variation was observed on yield of tuber per plot due to combined effect of biostimulants with reduced rate of fertilizer and dehaulming schedule (Table 6 and Appendix V). From the result it was observed that the highest yield of tuber per plot (4.28 kg) was recorded from M_4I_1 combination which was statistically different from all other treatments. On the other hand, the minimum number of tubers per hill (2.63 kg) was recorded from M_1I_1 combination.

Table 4. Effect of biostimulants with reduced rate of chemical fertilization on mean tuber weight (g) and yield of tuber per plot (kg)

Treatments	Mean tuber weight (g)	Yield of tuber per plot (kg)
M_1	42.21 ± 0.16^{d}	2.71 ± 0.03^{d}
M_2	46.24 ± 0.81^{c}	3.27 ± 0.60^{c}
M_3	49.39 ± 0.21^{b}	3.74 ± 0.03^{b}
M_4	54.00 ± 0.50^{a}	4.18 ± 0.21^{a}
Level of Significance	***	***

(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and *** Indicates significant at <1% level of probability)

Table 5. Effect of dehaulming schedule on mean tuber weight and yield of tuber per plot (kg)

Treatments	Mean tuber weight (g)	Yield of tuber per plot (Kg)
I_1	47.72±1.24	3.44±0.18
I_2	48.38±1.57	3.50±0.21
I_3	47.78±1.24	3.50±0.16
Level of Significance	NS	NS

(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and NS indicates non-significant)

Table 6. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on mean tuber weight and yield of tubers per plot (kg)

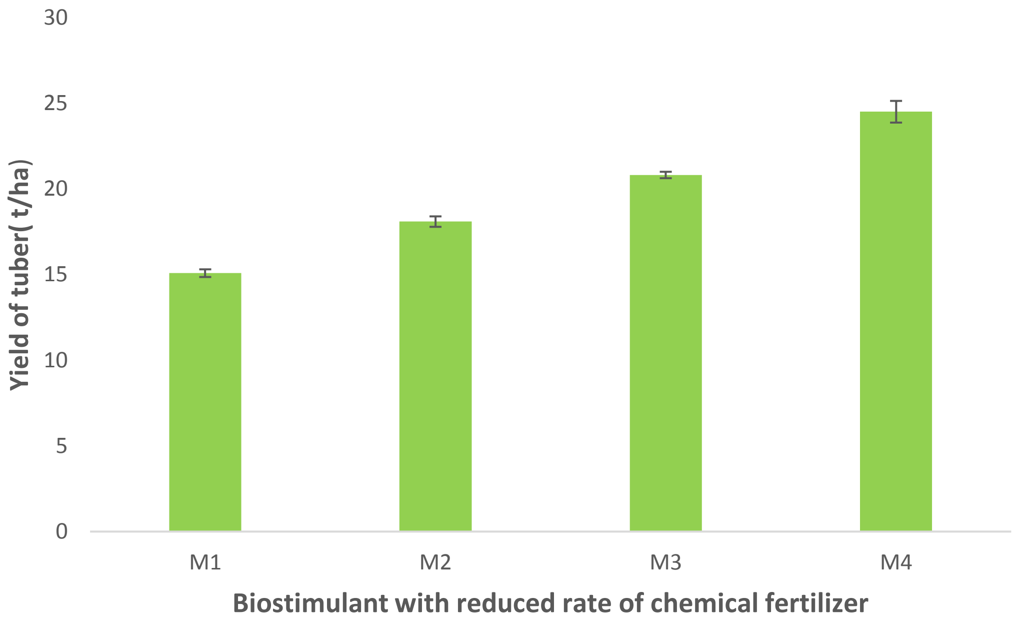
Treatments	Mean tuber weight (g)	Yield of tuber per plot (kg)
M_1I_1	42.25±0.14^{e}	2.63±0.03^{d}
M_1I_2	42.70±0.23^{e}	2.82±0.09^{cd}
M_1I_3	41.70±0.10^{e}	2.68±0.01^{cd}
M_2I_1	46.13±0.51^{d}	3.17±0.07^{bcd}
M_2I_2	45.34±2.60^{d}	3.26±0.16^{bcd}
M_2I_3	47.26±0.06^{cd}	3.39±0.03^{bc}
M_3I_1	49.01±0.28^{c}	3.68±0.01^{ab}
M_3I_2	49.93±0.37^{c}	3.78±0.05^{ab}
M_3I_3	49.23±0.33^{c}	3.77±0.08^{ab}
M_4I_1	53.50±0.40^{ab}	4.28±±0.05^{a}
M_4I_2	55.56±0.32^{a}	4.12±0.70^{a}
M_4I_3	52.93±0.92^{b}	4.15±0.19^{a}
Level of Significance	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

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

4.1.5.1 Effect of biostimulants with reduced rate of chemical fertilization

There was marked variation was observed on yield of tuber per hectare influenced by biostimulants with reduced rate of chemical fertilization (Figure 2 and Appendix V). Results showed that highest yield of tuber (24.50 t ha^{-1}) per plot was obtained from M_4 treatment (80% NPK + *Trichoderma* 8 kg ha^{-1}) treatment which was statistically different from all other treatments and the lowest (15.08 t ha^{-1}) yield of tuber per hectare was recorded in M_1 treatment. This corroborates the result of Hossain *et al.* (2003).



(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 2. Effect of biostimulants with reduced rate of chemical fertilization on yield of tuber (t ha^{-1})

4.1.5.2 Effect of dehaulming schedule

Different days of dehaulming practices have no significant effect on yield of tuber per hectare (Table 7 and Appendix V). The highest yield of tuber per plot (20.29 t ha^{-1}) was recorded from dehaulming at 75 days after planting and the lowest yield of tuber per plot (19.12 t ha^{-1}) was recorded from dehaulming at 65 days after planting. The result of 85 DAP was almost statistically similar to 65 DAP for the yield of tuber. This corroborates the result of Mahmud *et al.* (2009).

Table 7. Effect of dehaulming at different days on yield of tuber (t ha^{-1})

Treatments	Yield of tuber (t ha^{-1})
I_1	19.12±1.02
I_2	20.29±1.26
I_3	19.45±0.94
Level of significance	NS

(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and NS indicates non-significant)

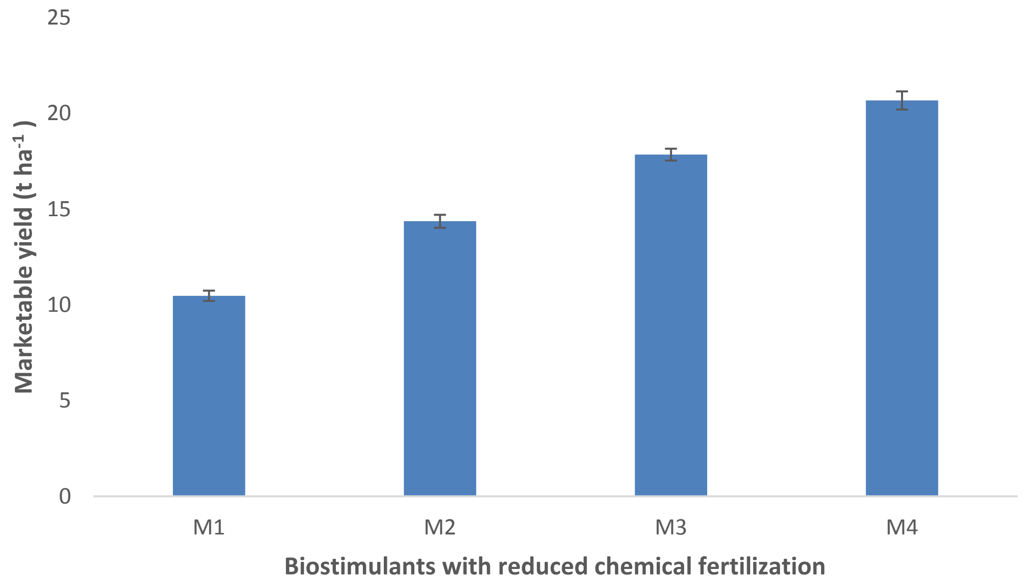
4.1.5.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was marked variation was found on yield of tuber per plot due to combined effect of biostimulants with reduced rate of fertilizer and dehaulming schedule (Table 7 and Appendix V). From the result it was observed that the highest yield of tuber (26.63 t ha^{-1}) was recorded from the M_4I_2 combination which was statistically different from all other treatments. On the other hand, the minimum number of tubers (14.63 t ha^{-1}) was recorded from the M_1I_1 combination.

4.1.6 Marketable yield of tuber (t ha^{-1})

4.1.6.1 Effect of biostimulants with reduced rate of chemical fertilization

There was marked variation was observed on marketable yield of tuber per hectare influenced by biostimulants with reduced rate of chemical fertilization (Figure 3 and Appendix V). Results showed that highest yield of marketable tuber (20.67 t ha^{-1}) was obtained from M_4 treatment (80% NPK + *Trichoderma* 8 kg ha^{-1}) which was statistically different from all other treatments and the lowest (10.47 tha^{-1}) yield of tuber per hectare was recorded in M_1 treatment. Pulok (2014) reported similar findings using different chemical fertilizer on marketable yield of potato.

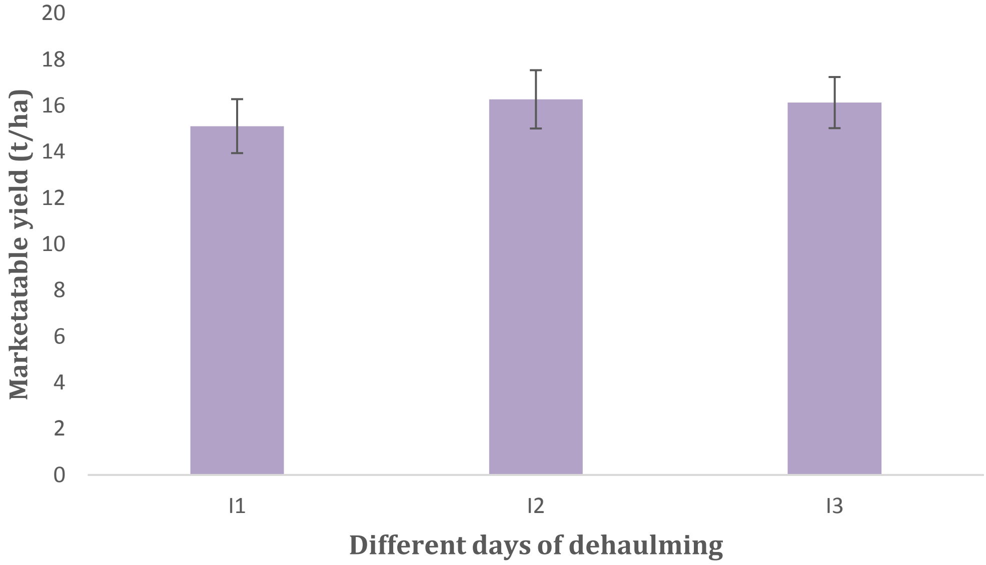


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 3. Effect of biostimulants with reduced rate of chemical fertilization on marketable yield of potato

4.1.6.2 Effect of dehaulming schedule

Different days of dehaulming practices have no significance effect on marketable yield of tuber per hectare (Figure 4 and Appendix V). The highest marketable yield of tuber (16.27 t/ha) was recorded from dehaulming at 75 days after planting and the lowest marketable yield of tuber (15.11 t/ha) was recorded from dehaulming at 65 days after planting.



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 4. Effect of dehaulming at different days on marketable yield of potato

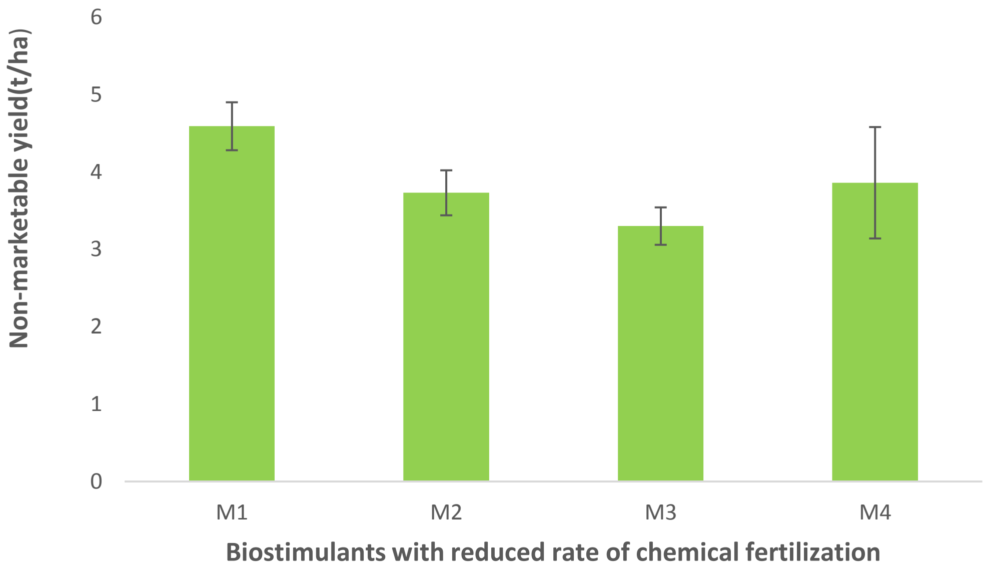
4.1.6.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was marked variation was observed on yield of tuber per plot due to combined effect of biostimulants with reduced rate of fertilizer and dehaulming schedule (Table 7 and Appendix V). From the result it was observed that the highest marketable yield of tuber (22.09 t/ha) was recorded from M_4I_2 combination which was statistically different from all other treatments. On the other hand, the lowest marketable yield of tuber (9.67 t ha^{-1}) was recorded from the M_1I_1 combination.

4.1.7 Non-marketable yield of tuber (t ha^{-1})

4.1.7.1 Effect of biostimulants with reduced rate of chemical fertilization

There was marked variation was observed on non-marketable yield of tuber per hectare influenced by biostimulants with reduced rate of chemical fertilization (Figure 5 and Appendix V). Results showed that highest yield of marketable tuber (4.59 t ha^{-1}) per plot was obtained from M_1 treatment (6 t ha^{-1} vermicompost) which was statistically different from all other treatments and the lowest (3.73 tha^{-1}) non-marketable yield of tuber per hectare was recorded in M_3 treatment. This corroborates the result of Hossain (2000).

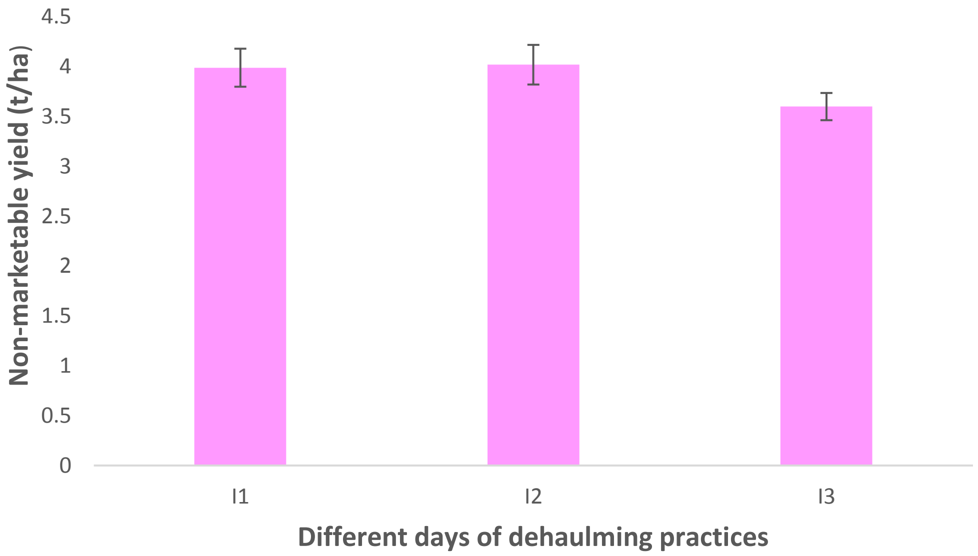


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 5. Effect of biostimulants with reduced rate of chemical fertilization on non-marketable yield

4.1.7.2 Effect of dehaulming schedule

Different days of dehaulming practices have no significance effect on non-marketable yield of tuber per hectare (Figure 6 and Appendix V). The highest non-marketable yield of tuber (4.02 t/ha) was recorded from dehaulming at 75 days after planting and the lowest non-marketable yield of tuber (3.60 t ha^{-1}) was recorded from dehaulming at 85 days after planting. The result of 65 DAP was almost statistically similar to 75 DAP for the yield of tuber.



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 6. Effect of dehaulming at different days on non-marketable yield of potato

4.1.7.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

There was marked variation was observed on yield of tuber per plot due to combined effect of biostimulants with reduced rate of fertilizer and dehaulming schedule (Table 8 Appendix V). From the result it was observed that the highest non-marketable yield of tuber (4.89 t ha^{-1}) was recorded from M_1I_1 combination which was statistically different from all other treatments. On the other hand, the lowest marketable yield of tuber (3.22 t ha^{-1}) was recorded from M_3I_2 combination.

Table 8. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on tuber yield (t ha^{-1}), marketable and non-marketable yield (t ha^{-1}) of potato

Treatments	Yield of tuber(t ha^{-1})	Marketable Yield of tuber (t ha^{-1})	Non-marketable yield of tuber (t ha^{-1})
M_1I_1	14.63±0.01^{e}	9.67±0.01^{f}	4.89±0.09^{a}
M_1I_2	15.68±0.55^{e}	11.03±0.60^{f}	4.65±0.05^{ab}
M_1I_3	14.94±0.07^{e}	10.71±0.06^{f}	4.22±0.04^{acd}
M_2I_1	17.65±0.40^{d}	13.63±0.45^{e}	4.02±0.06^{cde}
M_2I_2	17.81±0.71^{d}	14.13±0.60^{de}	3.68±0.13^{defg}
M_2I_3	18.83±0.17^{d}	15.34±0.16^{d}	3.48±0.13^{efg}
M_3I_1	20.44±0.05^{c}	17.20±0.03^{c}	3.23±0.06^{fg}
M_3I_2	21.04±0.28^{c}	17.82±0.35^{c}	3.22±0.15^{g}
M_3I_3	20.96±0.48^{c}	18.51±0.77^{bc}	3.45±0.17^{efg}
M_4I_1	23.77±0.28^{b}	19.95±0.04^{b}	3.82±0.27^{def}
M_4I_2	26.63±0.25^{a}	22.09±0.18^{a}	4.53±0.34^{abc}
M_4I_3	23.09±1.06^{b}	19.97±1.07^{b}	3.25±0.28^{fg}
Level of Significance	***	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

4.1.8 Grade of tuber by number

4.1.8.1 Effect of biostimulants with reduced rate of chemical fertilization

Biostimulants with reduced rates of chemical fertilization showed significant variation in the production of extra-large tubers (>55 mm) by number (Table 9 and Appendix VI). The highest percentage of extra-large tuber by number was found in M_4 treatment and the lowest percentage was found in M_1 treatment.

There was significant variation on the production of 40-55 mm size influenced by biostimulants with reduced rate of chemical fertilization (Table 9 and Appendix VI).

The highest percentage (31.30%) of large tubers by number was produced by M_4 treatment and the lowest (25.46%) were in M_1 treatment.

Biostimulants with reduced rates of chemical fertilization have significant effect on the production of 28-40 mm size (Table 9 and Appendix VI). The highest percentage (32.55%) of large tubers by number was produced by M_1 treatment and the lowest (18.33%) were in M_4 treatment.

Biostimulants with reduced rates of chemical fertilization have a significant effect on the production of <28 mm size (Table 9 and Appendix VI). The highest percentage (25.22%) of large tubers by number was produced by M_1 treatment and the lowest (17.17%) were in M_4 treatment. This corroborates the result of Pulok *et al.* (2014).

Table 9. Effect of biostimulants with reduced rate of chemical fertilization on grade of potato (%)

Treatments	>55 mm	40-55 mm	28-40 mm	<28 mm
M_1	16.74±0.13^c	25.46±0.23^d	32.5556±0.27^a	25.2289±0.23^a
M_2	22.03±0.29^b	28.56±0.32^b	26.6589±0.37^b	22.6811±0.37^b
M_3	24.76±3.10^b	26.98±0.33^c	23.6133±0.37^c	21.5267±0.29^c
M_4	33.15±0.30^a	31.30±0.25^a	18.3378±0.29^d	17.1733±0.17^d
Level of Significance	***	***	***	***

(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1}, *** Indicates significant at <1% level of probability)

4.1.8.2 Effect of dehaulming schedule

Different days of dehaulming practices have no significant variation on the production of extra-large tubers (>55mm) by number (Table 10 and Appendix VI). The highest percentage (25.36%) of large tubers by number was produced by I_3 treatment and the lowest (22.60%) were in I_1 treatment.

Different days of dehaulming practices have no significant variation on the production of 40-55mm size by number (Table 10 and Appendix VI). The highest percentage (28.35%) of large tubers by number was produced by I_3 treatment and the lowest (25.05%) were in I_1 treatment.

Different days of dehaulming practices have no significant variation on the production of 28-40 mm size by number (Table 10 and Appendix VI). The highest percentage (25.45%) of large tubers by number was produced by I_1 treatment and the lowest (25.06%) were in I_3 treatment.

Different days of dehaulming practices have no significant variation on the production of <28 mm size by number (Table 10 and Appendix VI). The highest percentage (21.92%) of large tubers by number was produced by I_1 treatment and the lowest (21.19%) were in I_3 treatment.

Table 10. Effect of dehaulming at different days on grade of tuber (%)

Treatments	>55 mm	40-55 mm	28-40 mm	<28 mm
I_1	22.60±2.71	25.05±2.36	25.45±1.45	21.92±0.90
I_2	24.55±1.81	28.24±0.71	25.35±1.61	21.84±0.87
I_3	25.36±1.98	28.35±0.65	25.06±1.64	21.19±0.93
Level of significance	NS	NS	NS	NS

(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and NS indicates non-significant)

4.1.8.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

The interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule management practices has significant effect on the grade of extra-large tuber >55 mm, 40-55 mm, 28-40 mm, 28 mm (Table 11 and Appendix VI). The highest percentage (34.13%) of tuber by number was produced by M_4I_3 and the lowest (16.80%) were in M_1I_1 treatment in case of extra-large tuber >55mm. In case of grade 40-55 mm the highest percentage (31.40%) of by number was produced by M_4I_3 and the lowest (24.93%) were in M_1I_1 treatment. The highest percentage (32.62%) of tuber by number was produced by M_1I_2 and the lowest (17.51%) were in M_4I_3 treatment of grade 28-40 mm and in case of <28 mm tuber grade the highest percentage (25.15%) of tuber by number was produced by M_1I_3 and the lowest were (16.85%) in M_4I_3 treatment.

Table 11. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on grade of tuber (%)

Treatments	>55 mm	40-55 mm	28-40 mm	<28 mm
M_1I_1	16.80±0.14^{c}	24.93±0.29^{f}	32.50±0.68^{a}	25.76±0.27^{a}
M_1I_2	16.91±0.23^{c}	25.69±0.32^{ef}	32.62±0.56^{a}	24.76±0.36^{a}
M_1I_3	16.51±0.31^{c}	25.78±0.47^{ef}	32.54±0.36^{a}	25.15±0.42^{a}
M_2I_1	22.47±0.42^{bc}	28.81±0.86^{b}	25.63±0.38^{cd}	22.88±0.39^{b}
M_2I_2	21.07±0.36^{bc}	28.15±0.26^{bc}	27.75±0.22^{b}	23.02±0.40^{b}
M_2I_3	22.55±0.16^{bc}	28.72±0.58^{bc}	26.59±0.57^{bc}	22.13±1.06^{bc}
M_3I_1	18.34±9.18^{c}	26.23±0.39^{def}	24.59±0.59^{de}	21.48±0.23^{cd}
M_3I_2	27.68±0.03^{ab}	27.20±0.63^{cde}	22.65±0.34^{f}	22.46±0.33^{bc}
M_3I_3	28.26±0.73^{ab}	27.50±0.56^{bcd}	23.60±0.55^{ef}	20.63±0.24^{d}
M_4I_1	32.79±0.23^{a}	30.57±10.12^{a}	19.09±0.59^{g}	17.54±0.17^{e}
M_4I_2	32.54±0.53^{a}	31.93±0.21^{a}	18.40±0.15^{gh}	17.12±0.20^{e}
M_4I_3	34.13±0.29^{a}	31.40±0.37^{a}	17.51±0.51^{h}	16.85±0.40^{e}
Level of Significance	***	***	***	***

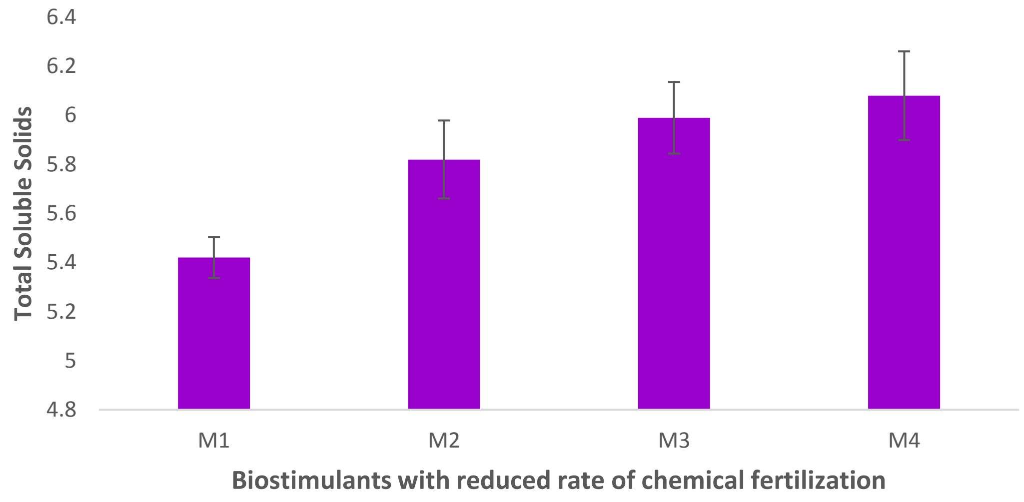
(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

4.2 Quality Characters

4.2.1 Total soluble solids (TSS)

4.2.1.1 Effect of biostimulants with reduced rate of chemical fertilization

Total soluble solids (TSS) has significantly been influenced by biostimulants with reduced rate of chemical fertilization (Figure 7 and Appendix VII). The highest TSS value (6.08) was recorded from the M_4 treatment (80% NPK + *Trichoderma* 8 kg ha^{-1}) and the minimum (5.42) was found from the M_1 (Vermicompost 6 t ha^{-1}) treatment. This corroborates the result of Ferdous *et al.* (2019).

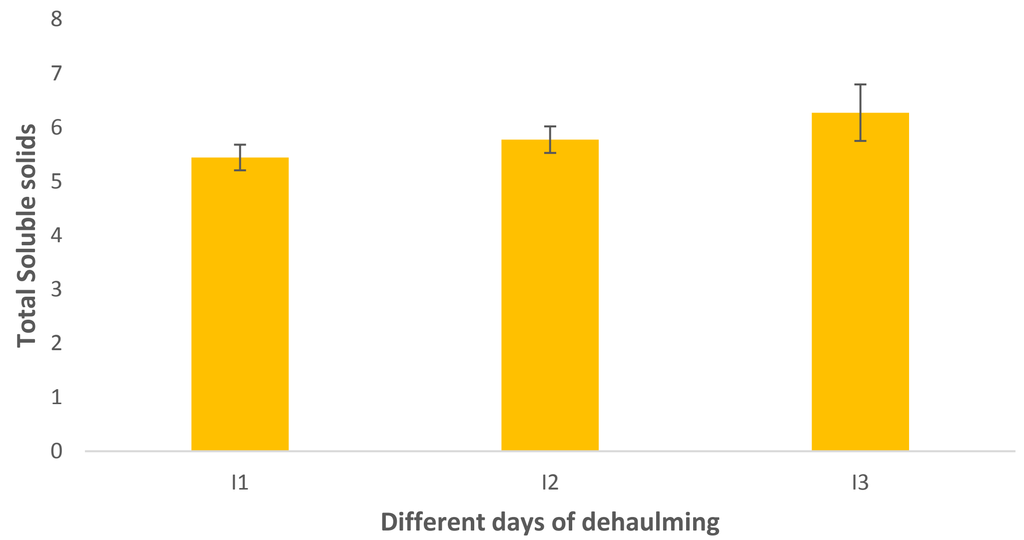


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 7. Effect of biostimulants with reduced rate of chemical fertilization on total soluble solids

4.2.1.2 Effect of dehaulming schedule

Significant influence was observed on total soluble solids to the variation different days of dehaulming practices the highest (Figure 8 and AZppendix VII). TSS value (6.27) was recorded from the I_3 treatment and the minimum (5.44) was found from the I_1 treatment. This findings is more or less similar with the result of Marwaha *et al.* (2015).



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 8. Effect of dehaulming at different days on total soluble solids

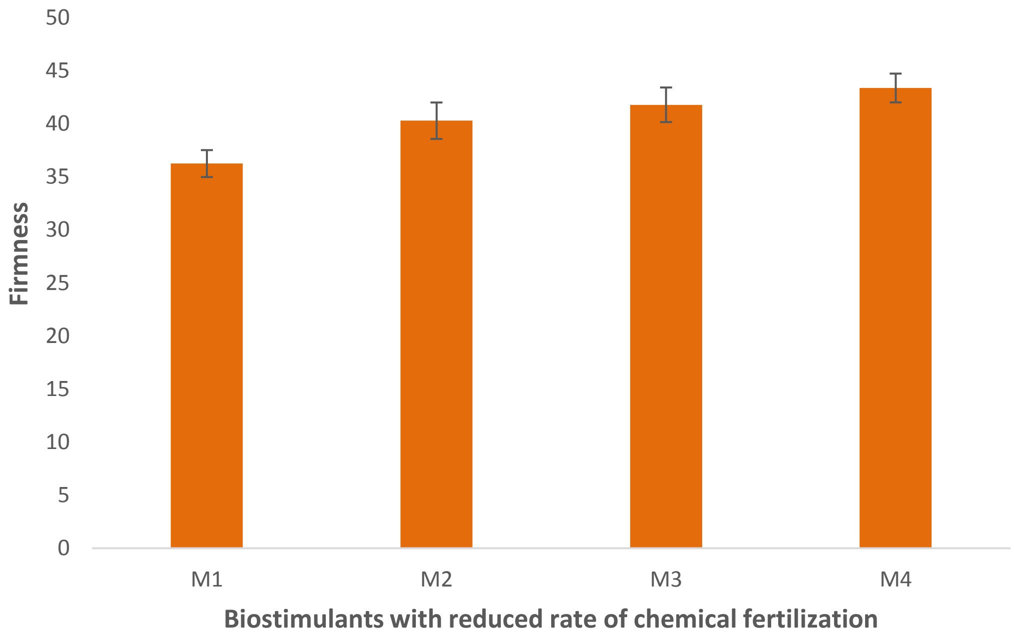
4.2.1.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect of total soluble solid (TSS) of potato (Table 12 and Appendix VII). The highest TSS (6.68) was recorded in M_4I_3 and the lowest TSS value potato (5.15) was observed in M_1I_1.

4.2.2 Firmness of potato

4.2.2.1 Effect of biostimulants with reduced rate of chemical fertilization

Firmness value has been significantly influenced by biostimulants with different rates of chemical fertilization (Figure 9 and Appendix VII). The highest firmness value (43.36) was recorded from the M_4 treatment and the minimum (36.24) was found from the M_1 treatment. This corroborates the result of Haque (2014).

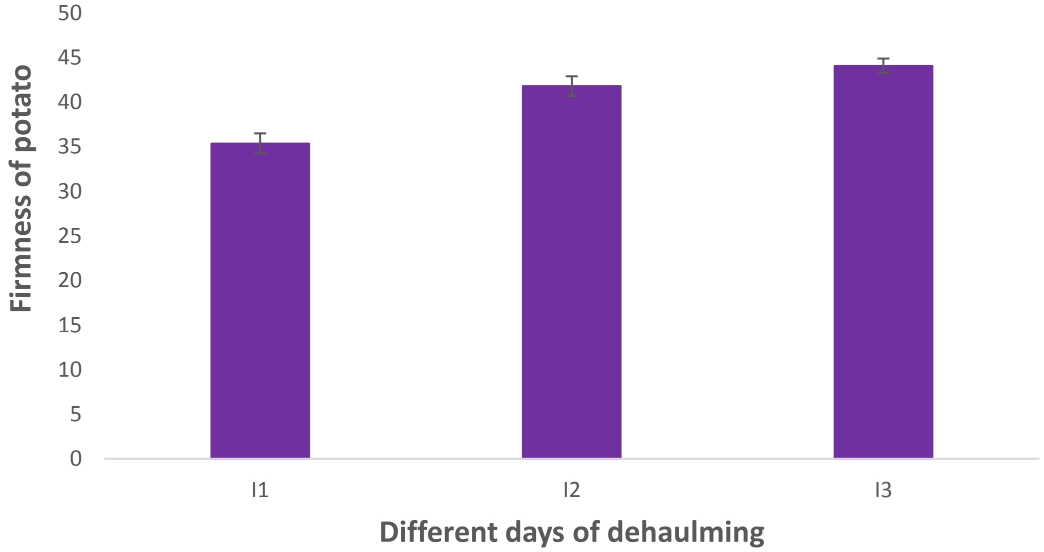


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 9. Effect of biostimulants with reduced rate of chemical fertilization on firmness of potato

4.2.2.2 Effect of dehaulming schedule

There was marked variation was observed on the firmness of potato due to the different date of dehaulming practices (Figure 10 and Appendix VII). The highest firmness value (43.36) was recorded from the I_3 treatment and the minimum (36.24) was found from the I_1. This corroborates the result of Alam *et al.* (2017).



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 10. Effect of dehaulming at different days on firmness of potato

4.2.2.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect on firmness of potato (Table 12 and Appendix VII). The highest firmness (46.85) was recorded in M_4I_3 and the lowest firmness value of potato (33) was observed in M_1I_1 treatment.

Table 12. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on Total Soluble Solids and Firmness of potato

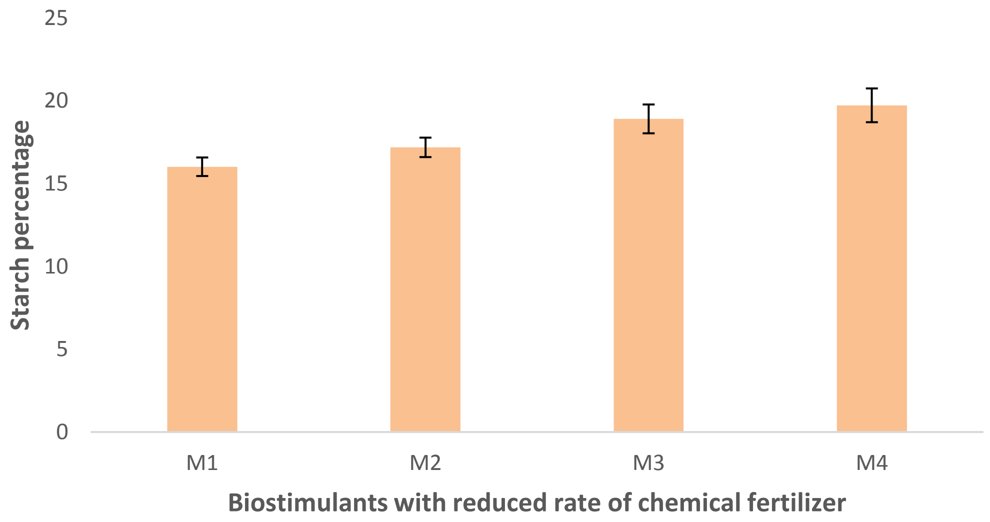
Treatments	Total Soluble Solids	Firmness
M_1I_1	5.15±0.02^{e}	33.00±2.62^{f}
M_1I_2	5.43±0.06^{de}	35.91±0.79^{def}
M_1I_3	5.69±0.05^{cd}	39.81±0.38^{cd}
M_2I_1	5.41±0.08^{de}	34.60±3.10^{ef}
M_2I_2	5.74±0.04^{cd}	42.06±0.49^{bc}
M_2I_3	6.30±0.30^{ab}	44.19±0.33^{ab}
M_3I_1	5.61±0.03^{cde}	35.67±1.83^{def}
M_3I_2	5.95±0.05^{bc}	44.20±0.345^{ab}
M_3I_3	6.43±0.28^{ab}	45.47±0.16^{ab}
M_4I_1	5.60±0.15^{cde}	38.20±0.92^{cde}
M_4I_2	5.98±0.08^{bc}	45.04±0.49^{b}
M_4I_3	6.68±0.24^{a}	46.85±0.41^{a}
Level of Significance	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

4.2.3 Starch (%)

4.2.3.1 Effect of biostimulants with reduced rate of chemical fertilization

Starch percentage has been significantly influenced by biostimulants with reduced rate of chemical fertilization (Figure 11 and Appendix VII). The highest starch value (19.73%) was recorded from the F_4 treatment (80% NPK+ *Trichoderma* 8 kg ha^{-1}) and the minimum (16.02%) was found from the M_1 (Vermicompost 6 t ha^{-1}) treatment. This findings is more or less similar to the result of Chandra (2015).

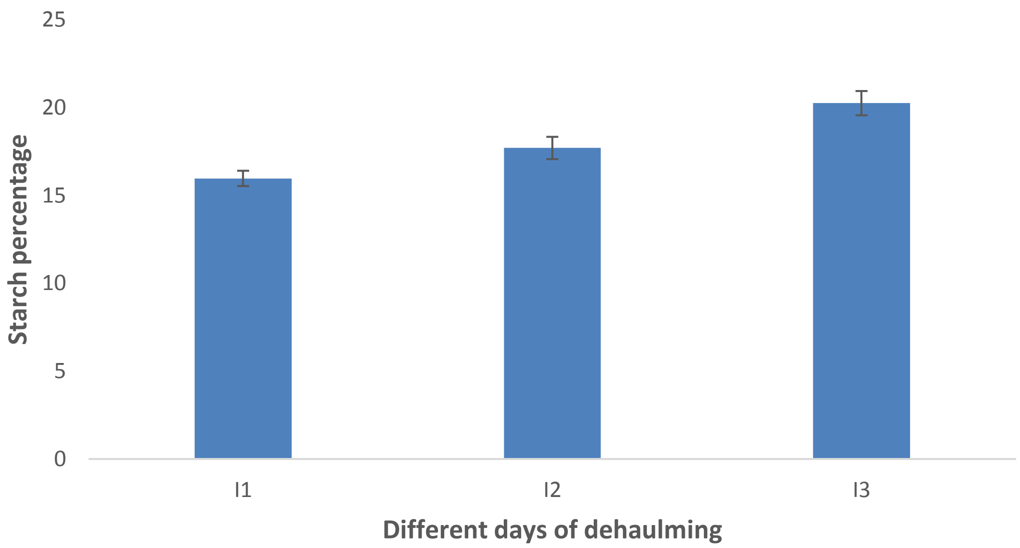


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 11: Effect of biostimulants with reduced rate of chemical fertilization on starch percentage of potato

4.2.3.2 Effect of dehaulming schedule

Different days of dehaulming practices have significant influence on starch percentage (Figure 12 and Appendix VII). The highest starch value (20.24%) was recorded from the I_3 treatment (dehaulming at 85 days) and the minimum (15.96%) was found from the I_3 treatment..



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 12. Effect of dehaulming at different days on starch percentage

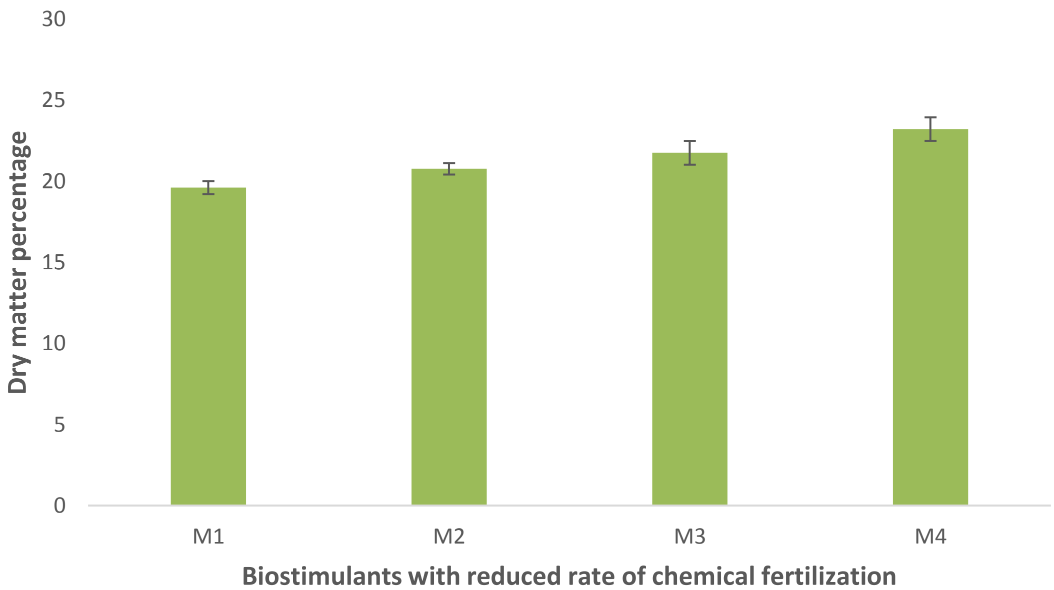
4.2.3.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect on starch content of potato (Table 13 and Appendix VII). The highest starch content (22.38%) was recorded in M_4I_3 treatment and the lowest starch content (14.62%) was observed in M_1I_1 treatment.

4.2.4 Tuber dry matter (%)

4.2.4.1 Effect of biostimulants with reduced rate of chemical fertilization

Dry matter percentage has significantly influenced by biostimulant with reduced rate of chemical fertilization (Figure 13 and Appendix VIII). The highest dry matter value (23.22%) was recorded from the M_4 treatment (80% NPK + *Trichoderma* 8 kg ha^{-1}) and the minimum (19.61%) was found from the M_1 (Vermicompost 6 t ha^{-1}) treatment. This corroborates the result of Rahman (2015).

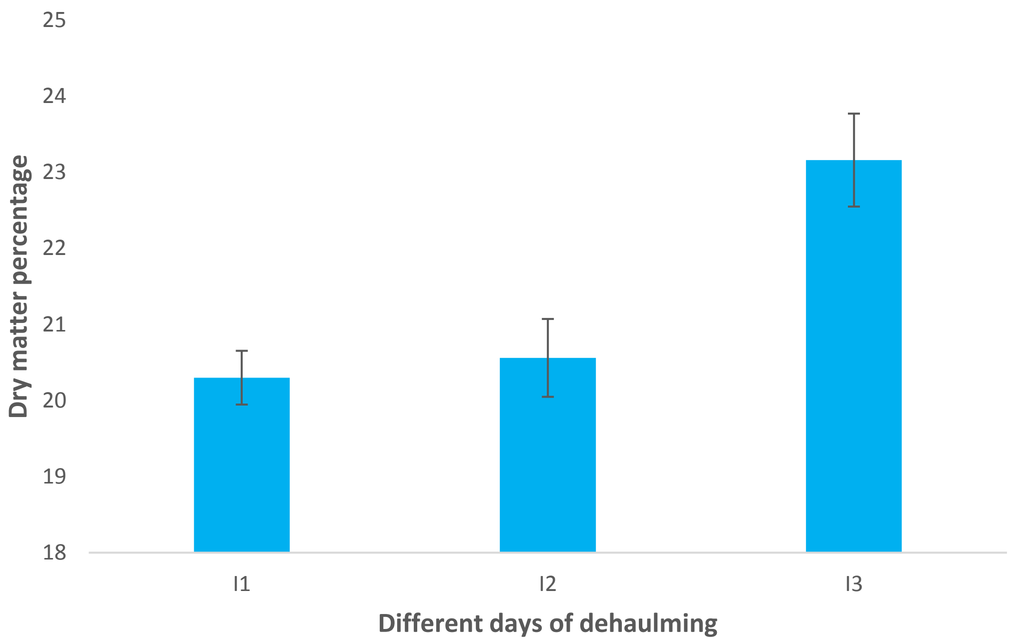


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 13. Effect of biostimulants with reduced rate of chemical fertilization on dry matter percentage of potato

4.2.4.2 Effect of dehaulming schedule

Dry matter percentage has significantly influenced by different date of dehaulming practice (Figure 14 and Appendix VIII). The highest dry matter value (23.16%) was recorded from the I_3 treatment (dehaulming at 85 days) and the minimum (20.30%) was found from the dehaulming at 65 days.



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 14: Effect of dehaulming at different days on dry matter percentage

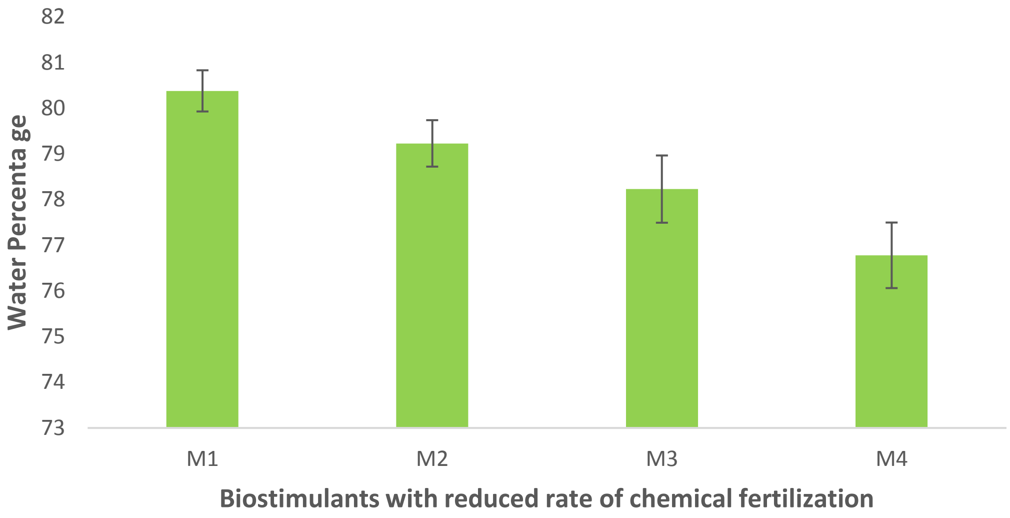
4.2.4.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect on dry matter percentage of potato (Table 13 and Appendix VIII). The highest dry matter content (25.74%) was recorded in M_4I_3 treatment and the lowest dry matter content (18.48%) was observed in M_1I_2 treatment.

4.2.5 Water Percentage (%)

4.2.5.1 Effect of biostimulants with reduced rate of chemical fertilization

Water percentage has been significantly influenced by biostimulants with reduced rate of chemical fertilization (Figure 15 and Appendix VIII). The highest water percentage (80.38%) was recorded from the M_1 treatment (6 t ha^{-1} Vermicompost) and the minimum (76.78%) was found from the M_4 (80% NPK+ 8 kg ha^{-1} *Trichoderma*) treatment. This corroborates the result of Alam *et al.* (2007).

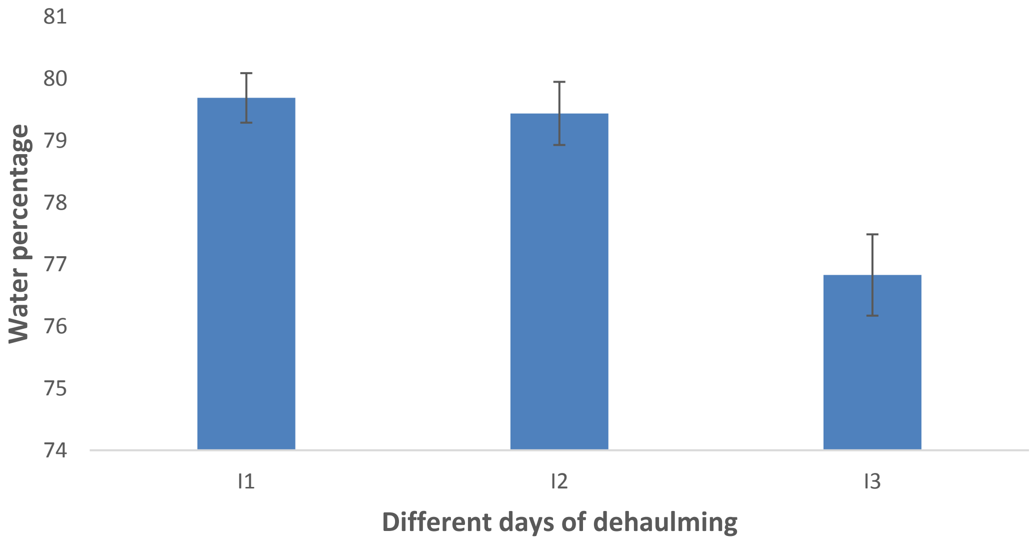


(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 15. Effect of biostimulants with reduced rate of chemical fertilization on water percentage of potato

4.2.5.2 Effect of dehaulming schedule

Water percentage has significantly influenced by different dates of dehaulming practice (Figure 16 and Appendix VIII). The highest water percentage (79.69%) was recorded from the I_1 treatment (dehaulming at 65 days) and the minimum (76.83%) was found from the I_3 treatment.



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 16. Effect of dehaulming at different days on water percentage

4.2.5.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect on water percentage of potato (Table 13 and Appendix VIII). The highest water percentage (80.60%) was recorded in M_1I_1 treatment and the lowest water percentage (74.26%) was observed in M_4I_3 treatment.

Table 13. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on starch, dry matter and water percentage

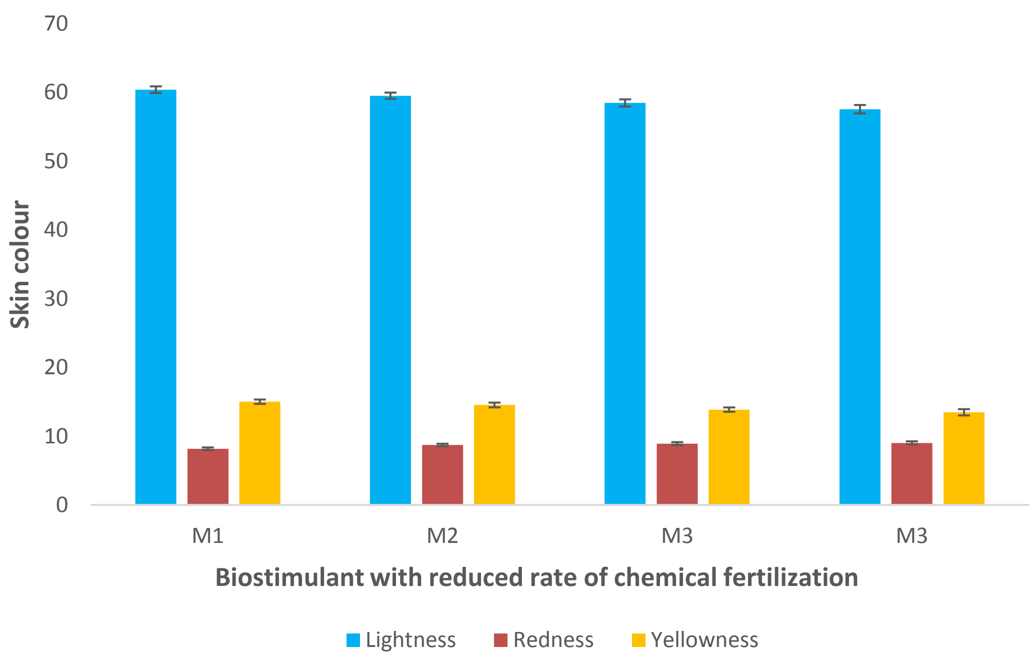
Treatments	Starch (%)	Dry Matter (%)	Water percentage (%)
M_1I_1	14.62 ± 0.34^{e}	19.40 ± 0.50^{e}	80.60 ± 0.30^{ab}
M_1I_2	15.49 ± 0.20^{de}	18.48 ± 0.24^{e}	81.52 ± 0.48^{a}
M_1I_3	17.96 ± 0.78^{cd}	20.96 ± 0.24^{cd}	79.04 ± 0.73^{bcd}
M_2I_1	15.45 ± 0.07^{de}	20.94 ± 0.43^{cd}	79.06 ± 1.24^{bcd}
M_2I_2	17.05 ± 0.44^{cde}	19.67 ± 0.32^{de}	80.33 ± 0.46^{abc}
M_2I_3	19.07 ± 0.78^{bc}	21.70 ± 0.40^{c}	78.30 ± 0.52^{cd}
M_3I_1	16.48 ± 0.73^{cde}	19.44 ± 0.60^{e}	80.56 ± 0.42^{ab}
M_3I_2	18.70 ± 0.92^{bc}	21.60 ± 0.36^{c}	78.40 ± 0.43^{cd}
M_3I_3	21.56 ± 1.10^{ab}	24.26 ± 0.39^{b}	75.74 ± 0.55^{ef}
M_4I_1	17.29 ± 1.20^{cde}	21.43 ± 0.57^{c}	78.57 ± 0.28^{bcd}
M_4I_2	19.53 ± 1.71^{bc}	22.49 ± 0.71^{c}	77.51 ± 0.33^{de}
M_4I_3	22.38 ± 1.26^{a}	25.74 ± 0.64^{a}	74.26 ± 0.96^{f}
Level of Significance	***	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

4.2.6 Skin Color

4.2.6.1 Effect of biostimulants with reduced rate of chemical fertilization

Biostimulants with reduced rate of chemical fertilization had significant effect on lightness (L*), degree of yellowness (b*), redness (a*) for skin (Figure 17 and Appendix IX). The highest L* value (60.40) was recorded from the vermicompost 6t/ha which is statistically similar to the recommended NPK and the minimum value (57.56) was found from the 80% NPK+ *Trichoderma* 8 kg ha^{-1}. In cases of a* numerically highest value (9.02) was recorded from the 80% NPK+ *Trichoderma* 8 kg ha^{-1}. And the minimum (8.16) was found from the Vermicompost 6 t ha^{-1}. The numerically highest b* value (15.01) was recorded from the vermicompost 6 t ha^{-1} and the minimum (13.47) was found from the 80% NPK+ *Trichoderma* 8 kg ha^{-1}



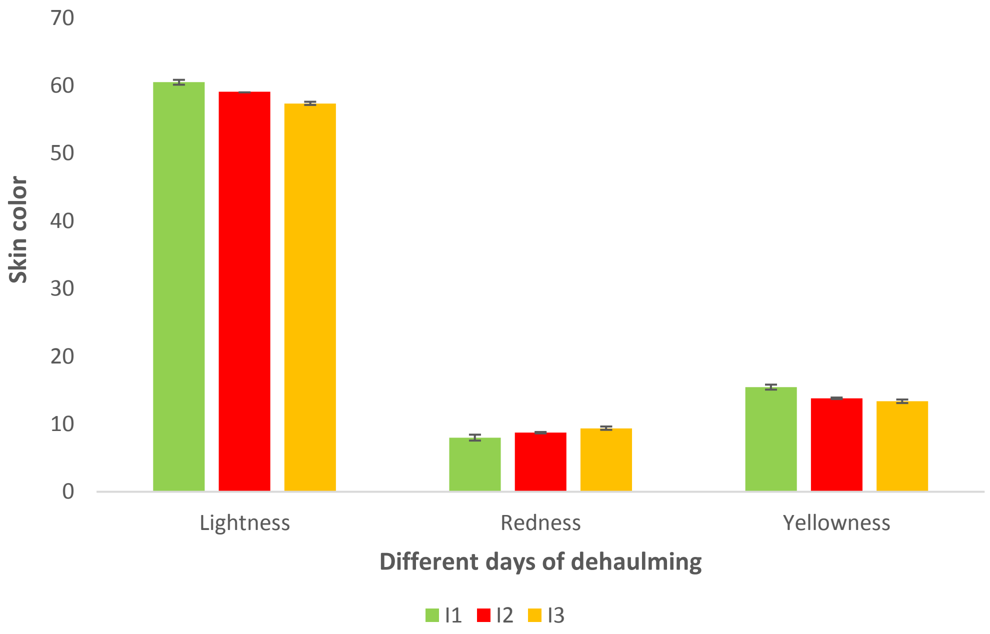
(Here, M_1= Vermicompost (6 t ha^{-1}), M_2= Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK+ *Trichoderma* 8 kg ha^{-1} and I indicates standard error)

Figure 17. Effect of biostimulants with reduced rate of chemical fertilization on skin color of potato

4.2.6.2 Effect of dehaulming schedule

Different date of dehaulming practices had significant effect on lightness (L*), degree of yellowness (b*), redness (a*) for skin (Figure 18 and Appendix IX). The highest L* value (60.50) was recorded from the vermicompost 6 t ha^{-1} which is statistically similar to the recommended NPK and the minimum value (57.36) was found from the

I_3 treatment. In cases of a* numerically highest value (9.38) was recorded from the I_3 treatment. And the minimum (8.00) was found from the I_1 treatment. The numerically highest b* value (15.46) was recorded from the I_1 treatment and the minimum (13.37) was found from the I_3 treatment.



(Here, I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and I indicates standard error)

Figure 18. Effect of dehaulming at different days on skin color

4.2.6.3 Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule

Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule had significant effect on lightness (L*), degree of yellowness (b*), redness (a*) for skin (Table 14 and Appendix IX). The highest L* value (61.93) was recorded from M_1I_1 which is statistically similar M_1I_2 and the minimum value (55.89) was found from M_4I_3. In cases of a* numerically highest value (9.74) was recorded from the M_4I_3 treatment. And the minimum (7.49) was found from the M_1I_1 treatment. The numerically highest b* value (16.23) was recorded from the vermicompost M_1I_1 treatment and the minimum (12.58) was found from the M_4I_3 treatment.

Table 14. Interaction effect of biostimulants with reduced rate of chemical fertilization and dehaulming schedule on skin color of potato

Treatments	L	a	b
M_1I_1	61.93±0.35[a]	7.49±0.07[f]	16.23±0.08[a]
M_1I_2	60.48±0.04[b]	8.16±0.03[e]	14.64±0.05[cd]
M_1I_3	58.79±0.44[cde]	8.84±0.06[d]	14.15±0.13[cd]
M_2I_1	60.41±0.15[b]	8.09±0.07[e]	15.89±0.04[ab]
M_2I_2	60.27±0.09[b]	8.77±0.06[d]	14.01±0.18[cde]
M_2I_3	57.89±0.64[efg]	9.30±0.02[b]	13.69±0.12[def]
M_3I_1	60.17±0.20[bc]	8.19±0.10[e]	14.71±0.37[cd]
M_3I_2	58.38±0.71[def]	8.95±0.10[cd]	13.79±0.29[def]
M_3I_3	56.86±0.03[gh]	9.63±0.04[a]	13.07±0.52[efg]
M_4I_1	59.48±1.03[bcd]	8.23±0.09[e]	15.00±0.25[bc]
M_4I_2	57.31±0.42[fgh]	9.08±0.08[bc]	12.81±0.40[fg]
M_4I_3	55.89±0.11[h]	9.74±0.07[a]	12.58±0.69[g]
Level of Significance	***	***	***

(Here, M_1= Vermicompost 6 t ha^{-1}, M_2= Recommended NPK, M_3= 90% NPK + *Trichoderma* 4 kg ha^{-1}, M_4= 80% NPK + *Trichoderma* 8 kg ha^{-1} and I_1= Dehaulming at 65 days, I_2= Dehaulming at 75 days, I_3= Dehaulming at 85 days and *** Indicates significant at <1% level of probability)

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out the effect of reduced rate of chemical fertilization and different days of dehaulming on yield and quality of potato during the period from November 2019 to March 2020. The experiment consisted of two factors: Factor A: Biostimulants with reduced rate of chemical fertilization as M_1 = Vermicompost 6 t ha^{-1}, M_2 = Recommended NPK, M_3= 90% NPK+ *Trichoderma* 4 kg ha^{-1}, M_4 = 80% NPK+ *Trichoderma* 8 kg ha^{-1}. Factor B: Different days of dehaulming I_1 = 65 DAP, I_2 = 75 DAP, I_3 = 85 DAP. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield contributing parameters and quality attributes were recorded and statistically analyzed using the SPSS computer package program. Biostimulants with reduced rate of chemical fertilization and different days of dehaulming and also their combinations showed a significant influence of different yield and quality contributing parameters of potato.

Different yield and quality parameters significantly influenced by biostimulants with reduced rates of chemical fertilization. The highest number of tuber per hill (6.80) was obtained from M_4 (80% NPK+ *Trichoderma* 8 kg ha^{-1}) treatment, while lower number (5.36) was obtained from M_1 (6 t ha^{-1} vermicompost) treatment. The highest and lowest weight of tubers per hill (367.88 g) and (304.96) was obtained from M_4 and M_1 treatment, respectively. The highest and lowest mean tuber weight (54 g) and (42.21) was obtained from M_4 and M_1 treatment, respectively. The highest and lowest yield of tuber per hill (4.18 g and 2.71 g) was recorded in M_4 and M_1 treatment, respectively. The highest and lowest yield of tuber per hectare (24.50 t ha^{-1} and 15.08 t ha^{-1}).The highest and lowest marketable yield (20.67 t ha^{-1} and 10.47 t ha^{-1}) was recorded in M_4 and M_1, respectively and The highest and lowest non-marketable yield (4.59 t ha^{-1} and 3.73 t ha^{-1}) was obtained from M_1 and M_4 treatment, respectively. The highest and lowest value for the production of extra-large (> 55 mm) tubers is 33.15% and 16.74% respectively in case of M_4 and M_1 treatment. For (40-55 mm) tuber production the highest and lowest value was (31% and 25.46%) respectively for M_4 and M_1 treatment. The highest and lowest value for the production of (28- 40 mm) tuber is 32.55% and

18.33% for the treatment of M_1 and M_4 respectively and highest and lowest value for (<28 mm) tuber production is 25.22 % and 17.17% respectively for M_1 and M_4 treatment. The maximum and minimum total soluble solids value (5.42 and 6.08), maximum and minimum value of firmness (43.36 and 36.24), starch percentage (19.73 and 16.02), dry matter percentage (23.22 and 19.61) was found from M_4 and M_1 treatment, respectively. The highest and lowest water percentage (80.38 and 76.78) for M_1 and M_4 treatment. M_1 treatment had the highest L* value compared to those of others whereas the lowest was M_4 treatment. For a^* the highest value was observed on M_4 and lowest from the M_1 treatment. M_1 treatment had the highest b^* value compared to those of others whereas the lowest was M_4 treatment.

Regarding different days of dehaulming practice, there was no significant variation observed in case of yield parameters but significantly influenced all the quality characters of potato. The highest number of tubers per hill (6.21) was obtained from I_2 treatment, while lower number (5.96) was obtained from I_1 treatment. The highest and lowest weight of tubers per hill (304.19 g) and (286.96 g) was obtained from I_2 and I_1 treatment, respectively. The highest and lowest mean tuber weight (48.38 g) and (47.72 g) was obtained from I_2 and I_1 treatment, respectively. The highest and lowest yield of tuber per hill (3.50 g and 3.44 g) was recorded in I_3 and I_1 treatment, respectively.

The highest and lowest yield of tuber per hectare (20.29 t ha^{-1} and 19.12 t ha^{-1}) was recorded in I_2 and I_1 treatment. The highest and lowest marketable yield (16.27 t ha^{-1} and 15.11 t ha^{-1}) was recorded in I_2 and I_1, respectively and the highest and lowest non-marketable yield (4.02 t ha^{-1} and 3.99 t ha^{-1}) was obtained from I_2 and I_3 treatment, respectively. The highest and lowest value for the production of extra-large (>55 mm) tubers is 25.36% and 22.60% respectively in case of I_3 and I_1 treatment. For (40-55 mm) tuber production the highest and lowest value was (28.35% and 25.05%) respectively for I_3 and I_1 treatment. The highest and lowest value for the production of (28-40 mm) tuber is 25.45 % and 25.06% for the treatment of I_1 and I_3 respectively and highest and lowest value for (<28 mm) tuber production is 21.92 % and 21.19% respectively for I_1 and I_3 treatment. The maximum and minimum total soluble solids value (6.27 and 5.44) was recorded for the treatment of I_3 and I_1 respectively, maximum and minimum value of firmness (44.08 and 35.37), starch percentage

(20.24 and 15.96), dry matter percentage (23.16 and 20.30) was found from I_3 and I_1 treatment, respectively. The highest and lowest water percentage (79.69 and 76.83) for I_1 and I_3 treatment. I_1 treatment had the highest L* value compared to those of others whereas the lowest was I_3 treatment. For a^* the highest value was observed on I_3 and lowest from the I_1 treatment and I_1 treatment had the highest b^* value compared to those of others whereas the lowest was I_3 treatment.

In terms of the combined effect of biostimulants with reduced rate of chemical fertilization and different date of dehaulming practice, all the studied yield and quality parameters were significantly influenced. The highest number of tubers per hill (7.20) was obtained from M_4I_2 treatment, while lower number (5.19) was obtained from M_1I_1 treatment. The highest and lowest weight of tubers per hill (400.10 g) and (219.46) was obtained from M_4I_2 and M_1I_1 treatment, respectively. The highest and lowest mean tuber weight (55.56 g) and (42.25 g) was obtained from M_4I_2 and M_1I_1 treatment, respectively. The highest and lowest yield of tubers per hill (4.28 kg and 2.63 kg) was recorded in M_4I_1 and M_1I_1 treatment, respectively. The highest and lowest yield of tuber per hectare (26.63 t ha^{-1} and 14.63 t ha^{-1}) was recorded in M_4I_2 and M_1I_1 treatment. The highest and lowest marketable yield (22.09 t ha^{-1} and 9.67 t ha^{-1}) was recorded in M_4I_2 and M_1I_1, respectively and the highest and lowest non-marketable yield (4.89 t ha^{-1} and 3.22 t ha^{-1}) was obtained from M_1I_1 and M_3I_2 treatment, respectively. The highest and lowest value for the production of extra-large (>55 mm) tuber by is 34.13% and 16.80% respectively in case of M_4I_3 and M_1I_1 treatment. For (40-55 mm) tuber production the highest and lowest value was (31.40% and 24.93%) respectively for M_4I_3 and M_1I_1 treatment. The highest and lowest value for the production of (28-40 mm) tuber is 32.62 % and 17.51% for the treatment of M_1I_2 and M_4I_3 respectively and highest and lowest value for (<28 mm) tuber production is 25.15 % and 16.85% respectively for M_1I_3 and M_4I_3 treatment. The maximum and minimum total soluble solids value (6.68 and 5.15) was recorded for the treatment of M_4I_3 and M_1I_1 respectively, maximum and minimum value of firmness (46.85 and 33) was found in M_4I_3 and M_1I_1 treatment respectively, highest and lowest starch percentage (22.38 % and 14.62%) was found in M_4I_3 and M_1I_1 treatment respectively, The highest dry matter content (25.74%) was recorded in M_4I_3 treatment and the lowest dry matter content (18.48%) was observed in M_1I_2 treatment respectively. The highest water percentage (80.60%) was recorded in M_1I_1 treatment and the lowest water percentage (74.26%) was observed in M_4I_3 treatment.

Interaction of biostimulants with reduced rate of chemical fertilization and different days of dehaulming, M_1I_1 treatment had the highest L* value compared to those of others whereas the lowest was M_4I_3 treatment. For a^* the highest value was observed on M_4I_3 and lowest from the M_1I_1 treatment and M_1I_1 treatment had the highest b^* value compared to those of others whereas the lowest was M_4I_3 treatment.

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

i. Biostimulants with reduced rate of chemical fertilization had a positive effect on yield attributes and quality contributing characters of potato. 90% NPK+ *Trichoderma* 4 kg ha^{-1}seemed to be promising for getting higher yield and quality of potato tuber but 80% NPK+ *Trichoderma* 8 kg ha^{-1} seemed to be more promising for getting highest yield and quality of potato.

ii. Dehaulming at different days had a positive effect on quality contributing characters of potato. Dehaulming at 85 days seemed to be suitable for higher quality potato tuber production.

iii. The combined effect of biostimulants with reduced rate of chemical fertilization and dehaulming at different days had a positive effect on yield contributing characters and quality of potato. Application of 80% NPK+ *Trichoderma* 8 kg $ha^{-1}$and dehaulming at 75 days interaction seemed to be suitable for getting higher yield and quality of potato. But application of 80% NPK+ *Trichoderma* 8 kg ha^{-1} and dehaulming at 85 days interaction seemed to be more suitable for getting higher yield and highest quality of potato.

Recommendation

- 80% NPK+ *Trichoderma* 8 kg ha^{-1} with the interaction of dehaulming at 85 days was suitable for getting higher yield and highest quality of potato.
- The study might be conducted at the same Agro Ecological Condition for the conformation of the result.
- Further study should be needed in different locations of Bangladesh for accuracy of the results obtained from the present experiment.

REFERENCES

Abdeldaym, E.A., Elsawy, M.B.I. and Elhelaly, M.A. (2019). Combined application of different sources of nitrogen fertilizers for improvement of potato yield and quality. *Plant Archives*. pp. 2513-2521.

Ahmed, M., Mondal, M.A. and Akter, M.B. (2019). Organic fertilizers effect on potato (*Solanum tuberosum* L.) tuber production in sandy loam soil. *Int. J. Plant & Soil Sci.* **29(**3): 1-11.

Alam, M. N., Jahan, M. S., Ali, M. K., Ashraf, M. A. and Islam, M. K. (2007). Effect of vermicompost and chemical fertilizers on growth, yield and yield components of potato in Barind soils of Bangladesh. *J Appli. Sci. Res.* **3**(12):1879-1888.

Alam, M.S., Islam, N., Hossain M.J. and Bhyuan, M.S.R. (2017). Effect of varied planting time and dehaulming on the yield potential, processing quality and economic benefit in potato. *Bangladesh J. Agril. Res*. **42**(2): 273-288.

Anonymous. (1988a). The Year Book of Production. FAO, Rome, Italy.

Anonymous. (1988b). Land Resources Appraisal of Bangladesh for Agricultural Development. Report No. 2. Agroecological Regions of Bangladesh, UNDP and FAO. pp. 472-496.

Anonymous. (1989). Annual Report. (1987-88). Bangladesh Agricultural Research.

Arora S. (2008). Balanced nutrition for sustainable crop production. Krishi World (Pulse of Indian Agriculture), pp. 1–5.

BBS (Bangladesh Bureau of Statistics). (2019). Monthly statistical year book. Ministry of Planning, Govt. People's Repub. Bangladesh. p. 64.

Beukema, H.P. and Zaag, V.D. (1990). Crop ecophysiology, In: Introduction to potato production. PUDOC, Wageningen, The Netherlands. pp. 42-60.

Bhuiyan, N.I. (1994). Crop production trend and need for sustainability in agriculture. A paper presented in a three-day workshop on Integrated Nutrient Management for Sustainable Agriculture, SRS1, June 26-28.

Boke, S. (2014). Effect of organic and inorganic fertilizer application and seedbed preparation on potato yield and soil properties on alisols of Chencha. *Int J Nat Sci Res.* **2**(8): 123–132.

Brady, N.C. (1990). The Nature and Properties of Soils. 10Ul Edn, Published by Macmillan Publishing Co., 886 Third Avenue, New york. 10022. pp. 173,410.

Champouret, N. (2010) Functional genomics of phytophthora infestans effectors and Solanum resistance genes. Ph.D. Thesis. Wageningen University, Wageningen, Netharland.

Chandra, G. (2015). Influence of vermicompost on growth, yield and processing quality of potato varieties. M.S. thesis, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

Choudhary, A.K., Rahi. S., Singh, A. and Yadav, D.S. (2010). Effect of vermicompost and biofertilizers on productivity and profitability in potato in north-western Himalayas. *Current Adv. Agri. Sci.* **2**(1): 18-21.

Ferdous, J., Roy, T.S., Chakrabarty, R., Mostofa, M., Noor, R., Nowroz, F., Kundu, B.C. (2019). Vermicompost influences processing quality of potato tubers. *SAARC J. Agri.* **17**(2): 173-184.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedure for agricultural research (2nd edn.). Int. Rice Res. Inst., A Willey Int. Sci. pp. 28-192.

Goutam, K.C., Bhunia, G. and Chakraborty, S.K. (2011). The effect of vermicompost and other fertilizers on cultivation of tomato plants. *J. Hortic. Forestry.* **3**(2): 42-45.

Haque, M.E. (2007). Evaluation of exotic potato germplasm on yield and yield contributing characters. M.S. thesis, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

Haque, M.M., Haque, M.A., Ilias, G.N.M. and Mollal, A.H. (2012). *Trichoderma*-Enriched Biofertilizer: A Prospective Substitute of Inorganic Fertilizer for Mustard (*Brassica campestris*) Production. *The Agri.* **8**(2): 66-73.

Harman, G.E., Howell, C.R., Viterbo, A., Chet, I. and Lorito, M. (2004). *Trichoderma* species-opportunistic, avirulent plant symbionts. *Nature Rev. Microb.* **2**(1):43-56

Hashem, A., (1990). An introduction to the potato seed industry of Bangladesh. Proceeding of the International Seminar on Seed Potato. Bangladesh Agricultural Development Corporation. Dhaka. p. 1.

Hermosa, R., Viterbo, A., Chet, I., Monte, E. (2012). Plant-beneficial effects of *Trichoderma* and of its genes. *Microbiol.* **158**(1): 17–25.

Hossain, A.B.M.S., Hakim, M.A. and Onguso, J.M. (2003). Effect of manure and fertilizers on the growth and yield of potato. *Pak. J. soil. Sci.* **6**(14): 1243-1246.

Hossain, M.S. (2000). Effects of different doses of nitrogen on the yield of seed tubers of four potato varieties. M.S. thesis, Department of Horticulture, Bangladesh Agricultural University, Mymensingh, Bangladesh.
Institute. Joydebpur, Gazipur. p. 133.

Jeyabal, A. and Kupuswamy, G. (2001). Recycling of organic wastes for the production of vermicompost and its response in ricelegume cropping system and soil fertility. *European J. of Agro.* **15**(3): 153-170.

Kale, R.D. (1998). Earthworm Cinderella of Organic Farming. Prism Book Pvt Ltd, Bangalore, India. P. 88.

Kashem, M.A., Ashoka, S., Imam, H. and Islam M.S. (2015). Comparison of the effect of vermicompost and inorganic fertilizers on vegetative growth and fruit production of tomato (*Solanum lycopersicum* L.). *Open J. Soil Sci.* **5**: 53-58.

Kumar, D., Ezekiel, R., Singh, B. and Ahmed, I. (2005). Conversion table for specific gravity, dry matter and starch content from under water weight of potatoes grown in north-indian plains. *Potato J.* **32**(1-2): 79-84.

Kumar, M., Baishaya, L.K., Ghosh, D.C. and Gupta, V.K. (2012). Productivity and soil health of potato (*Solanum tuberosum* L.) field as influenced by organic manures, inorganic fertilizers and biofertilizers under high altitudes of eastern Himalayas. *J. Agril. Sci.* **4**(5): 223-234

Mahmood, S. (2005). A study of planting methods and spacing on the yield of potato using TPS. *Asian J. Plant Sci.* **4**: 102-105.

Mahmud, A.A., Akhter, S., Hossain, M.J., Bhuiyan M.K.R. and Haque, M.A. (2009). Effect of dehaulming on Yield Of Seed Potatoes. *Bangladesh J. Agril. Res.* **34**(3): 443-448.

Marwaha, R.S., Pandey, S.K, Singh, S.V. and Khurana, S.M.P. (2005). Processing and nutritional qualities of Indian and exotic potato cultivars as influenced by harvest date, tuber curing, pre-storage holding period, storage and reconditioning under short Days. *Adv Hort Sci* **19**(3): 130-40.

Meenakumari, T. and Shekhar, M. (2012). Vermicompost and other fertilizers effect the growth, yield and nutritional status of tomato (*Lycopersicon esculentum*) plant. *World Res. J. Agril. Biotech*. **1**(1): 14-16.

Mia, M.A. and Shamsuddin, Z. H. (2010). *Rhizobium* as a crop enhancer and biofertilizer for increased cereal production. *African J. of Biotech.* **9**(37): 6001-6009.

Mojtaba, S.Y., Mohammadreza, H.S.H. and Mohammad, T.D. (2013). Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato (Agria CV.). *Intl. J. Agric. Crop Sci.* **5**(18): 2033-2040.

Mondal, M. and Das, S.K. (2020). Effect of intra row spacing, dates of haulm cutting and fertilizer dose on disease free quality seed tuber production of potato (Solanum *tuberosum* L.) under new Alluvial Zone of West Bengal. *J. Appl. Nat. Sci.* **12**(1): 1-8.

Mondal, M.R.I., Islam, M.S., Jalil, M.A.B., Rahman, M.M., Alam, M.S. and Rahman, M.H.H. (2011). Krishi Projukti Hatboi (Handbook of Agro-technology), 5th edition. Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh, p. 307.

Mostofa, M., Roy, T.S., Chakraborty, R., Modak, S., Kundu, P.K., Zaman, M.S., Rahman, M. and Shamsuzzoha, M. (2019). Effect of Vermicompost and Tuber Size on Processing Quality of Potato during Ambient Storage Condition. *Intl. J. Plant & Soil Sci*. **26**(3): 1-18.

Munroe, G. (2007). Manual of on-farm vermicomposting and vermiculture. Organic Agriculture Centre of Canada. pp. 1–56.

Pulok, M.A.I. (2014). Potassium and mulch effects on growth, yield, quality and storage performance of potato. M.S. thesis, Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh.

Rahman, M.S. (2015). Growth and yield of two indigenous potato varieties as influenced by organic manures. M.S. thesis, Department of Horticulture, Patuakhali Science and Technology University, Dumki, Patuakhali–8602.

Rajesh, C. Reddy, K.S., Naidu, M. and Ramavatharam, N. (2003) Production and evaluation of composts and vermicomposts from solid organic wastes. *Asian J Microb Biotech Env Sci.* **5**(3): 307–311.

Rouphael, Y., Cardarelli, M., Bonini, P., Colla, G., (2017). Synergistic action of a microbialbased biostimulant and a plant derived-protein hydrolysate enhances lettuce tolerance to alkalinity and salinity. *Front. Plant Sci*. **8**(131): 55-57.

Saikia, M., Rajkhowa, D.J. and Saikia, M. (1998). Effect of planting density and vermicompost on yield of potato raised from seeding tubers. *J. Indian Potato Assoc.* **25**(3-4): 141-142.

Sandhu, K.S., Chinna, G.S., Marwaha, R. and Pandey, S.K. (2012). Effect of staggered planting and dehaulming schedule on yield and processing quality of potato cultivars in Punjab. *Potato J.* **39**(1): 39-47.

Shweta, S. and Sharma, R.P. (2011). Influence of Vermicompost on the performance of potato in an acid alfisol. *Potato J*. **38** (2): 182-184.

Sikder, R.K., Rahman, M.M., Bari, S.M.W. and Mehraj, H. (2017). Effect of organic fertilizers on the performance of seed potato. *Tropical P. Res.* **4**(1): 104–108.

Sood, M.C. and Sharma, R.C. (2001). Value of Growth Promoting Bacteria, Vermicompost and *Azotobacter* on potato production in shimla hills. *J. Indian Potato Assoc.* **28(**1): 52-53.

Struik, P.C., & Wiersema, S. G. (1999). Seed Potato Technology. Wageningen Pers. The Netherlands. p.323.

Upadhayay, A. and Bashyal, S. (2020). Effects of dehaulming in potato cultivation: a review. *International J. Environ. Agric. Biotech*. **5**(4): 0994-1000.

Verzaux, E. (2010) Resistance and susceptibility to late blight in *Solanum:* Gene mapping, cloning and stacking, Ph.D. Thesis. Wageningen University, Wageningen, Netharland.

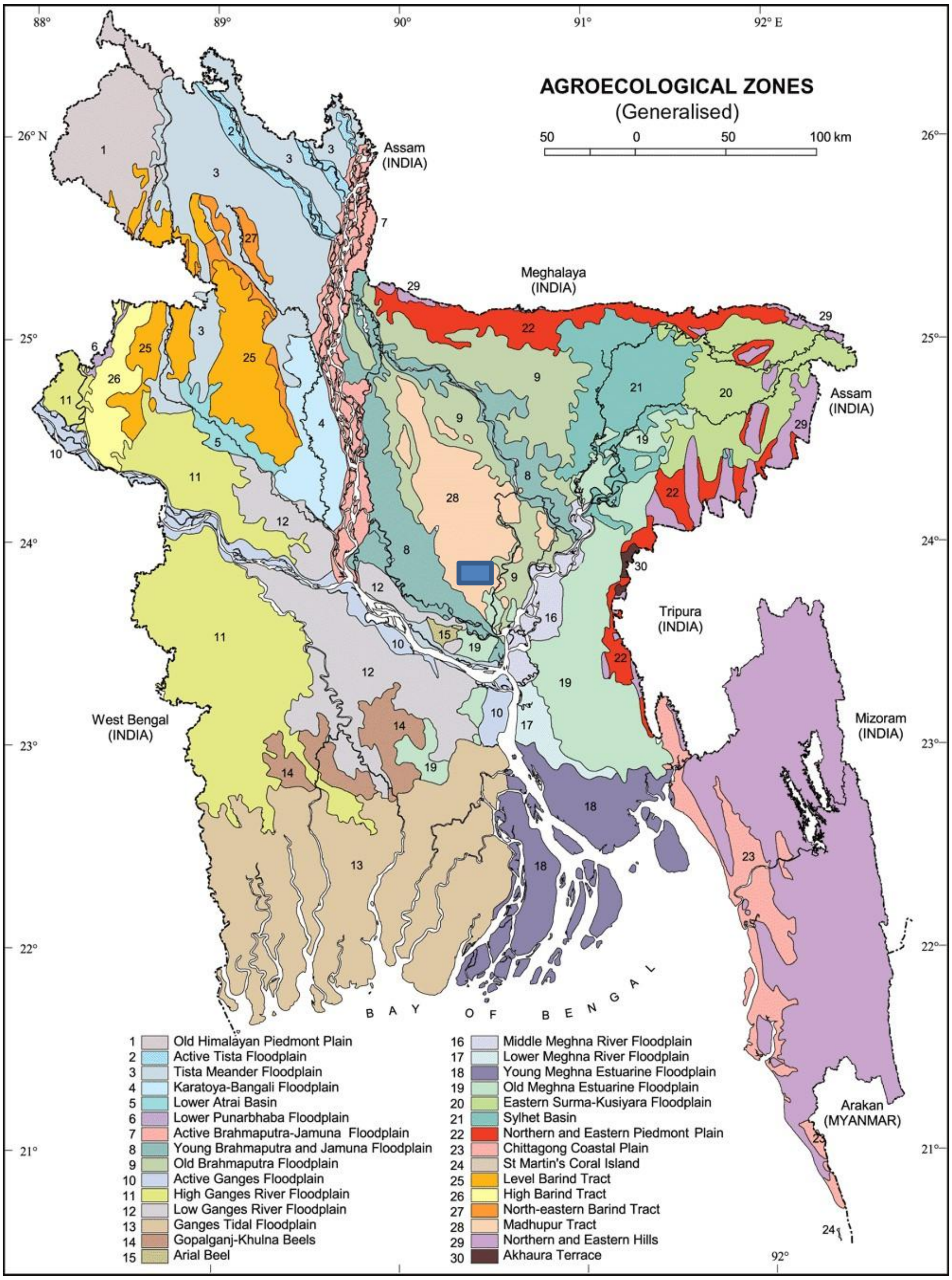
Virtanen, E. (2013). Effects of production history and gibberellic acid on seed potatoes. *J. Agri Sci.* **5**(12): 145-153.

Yedidia, I., Srivastva, A.K., Kapulnik, Y. and Chet, I. (2001). *Trichoderma harzianum* on microelement concentrations and increased growth of cucumber plants. *Plant Soil*. **235**:235-242.

Ye, L., Zhao, X., Bao, E., Li, J., Zou, Z.and Cao, K. (2020). Effects of *Trichoderma* reduced rates of chemical fertilization improves soil fertility and enhances tomato yield and quality. *Nature Res.* **10**(177): 67-68.

APPENDICES

Appendix I. Experimental location on the map of agro-ecological zones of Bangladesh



The Experimental site under study

Appendix II: Monthly recorded air temperature, rainfall, relative humidity and sunshine hours during the period from November 2019 to March 2020.

Year	Month	Average air temperature (^{0}C)		Total rainfall (mm)	Average humidity (%)	Total sunshine hours
		Max.	Min.			
2019	November	29.6	19.2	34.4	53	8
-	December	26.4	14.1	12.8	50	9
2020	January	25.4	12.7	7.7	46	9
-	February	28.1	15.5	28.9	37	8.1
-	March	32.5	20.4	65.8	38	7

Source: Dhaka meteorology centre

Appendix III. The physical and chemical characteristics of soil of the experimental site as observed prior to experimentation (0-15 cm depth)

Morphological features	**Characteristics**
Location	Horticulture Garden ,SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly level
Flood level	Above flood level

Source: Soil Resources Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
Sand (%)	28
Silt (%)	42
Clay (%)	30
Textural class	Silty clay
pH	5.47 –5.63
Organic matter (%)	0.83%
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	23

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka

Appendix IV. Analysis of variance (mean square) of number of tubers per hill, weight of tuber per hill, mean tuber weight

Source of Variation	**df**	**Mean Square**		
		Number of tubers per hill	**Weight of tuber per hill**	**Mean tuber weight**
Biostimulants with reduced rate of chemical fertilization	3	3.458***	32715.887***	223.359***
Dehaulming schedule	2	0.191^{NS}	937.822^{NS}	1.610^{NS}
Combination	11	1.034***	9465.188***	62.734***

^{NS} Indicates non-significant
***Indicates significant at <1% level of probability

Appendix V. Analysis of variance (mean square) of yield of tuber per plot (kg), tuber yield (t ha^{-1}), marketable yield and non-marketable yield

Source of Variation	df	Mean Square			
		Yield of tuber per plot (kg)	Tuber yield (t ha^{-1})	Marketable yield	Non-marketable yield
Biostimulants with reduced rate of chemical fertilization	3	3.602***	144.328***	175.156***	2.581***
Dehaulming schedule	2	0.014^{NS}	4.327^{NS}	4.790^{NS}	0.660^{NS}
Combination	11	0.999***	41.723***	49.531***	1.042***

^{NS} Indicates non-significant
***Indicates significant at <1% level of probability

Appendix VI. Analysis of variance (mean square) of grade of tuber

Source of Variation	df	Mean Square			
		>55 mm	40-55 mm	28-40 mm	<28 mm
Biostimulants with reduced rate of chemical fertilization	3	422.358***	55.926***	317.420***	101.782***
Dehaulming schedule	2	24.223^{NS}	1.780^{NS}	0.497^{NS}	1.916^{NS}
Combination	11	132.887***	15.939***	88.043***	28.545***

^{NS} Indicates non-significant
***Indicates significant at <1% level of probability

Appendix VII. Analysis of variance (mean square) of total soluble solids, firmness, starch content

Source of Variation	df	Mean Square		
		Total soluble solids	Firmness	Starch content
Biostimulants with reduced rate of chemical fertilization	3	0.770^{***}	83.945^{**}	25.175^{**}
Dehaulming schedule	2	2.112^{***}	245.058^{***}	55.680^{***}
Combination	11	0.617^{***}	69.958^{***}	17.381^{***}

**Indicates significant at 1% level of probability
***Indicates significant at <1% level of probability

Appendix VIII. Analysis of variance (mean square) of dry matter percentage and water percentage

Source of Variation	df	Mean Square	
		Dry matter percentage	Water percentage
Biostimulants with reduced rate of chemical fertilization	3	21.068^{**}	21.072^{**}
Dehaulming schedule	2	30.092^{***}	30.100^{***}
Combination	11	13.107^{***}	13.110^{***}

**Indicates significant at 1% level of probability
***Indicates significant at <1% level of probability

Appendix IX. Analysis of variance (mean square) of skin color of potato

Source of Variation	df	Mean Square		
		Lightness	Yellowness	Redness
Biostimulants with reduced rate of chemical fertilization	3	13.773**	1.324**	4.250**
Dehaulming schedule	2	29.661***	5.725***	14.481***
Combination	11	9.466***	61.410***	3.914***

**Indicates significant at 1% level of probability
***Indicates significant at <1% level of probability

LIST OF PLATES

Plate 1. Experimental view

Plate 2. Haulm cutting

Plate 3. Harvesting stage

Plate 4. Processing stage