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YIELD AND YIELD CONTRIBUTING ATTRIBUTES OF POTATO AS INFLUENCED BY VERMICOMPOST AND SEED TUBER SIZE

M. Mostofa[1*], T.S. Roy[2] and R. Chakraborty[2]

[1]Institute of Seed Technology, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[2]Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

ABSTRACT

Low yield is crucial bottleneck for potato production in Bangladesh. The application of vermicompost may enhance the yield of potato. The experiment was consisted of two factors, *i.e.*, Factor A: - Vermicompost level (Vm_{1-4}): Vm_1: 0 t ha^{-1}, Vm_2: 3 t ha^{-1}, Vm_3: 6 t ha^{-1} and Vm_4: 9 t ha^{-1}; Factor B:- Tuber size (T_{1-5}): T_1: 5-10 g, T_2: 10-20 g, T_3: 20-30 g, T_4: 30-40 g and T_5: > 40 g. The experiment was conducted in a split-plot design with three replications. Vermicompost had significant effect on most of the yield contributing parameters investigated under present study. Results revealed that yield parameters increased with increasing vermicompost level irrespective of tuber size. Among the twenty (20) treatment combinations, vermicompost at the rate of 9 t ha^{-1} with tuber size > 40 g produced the maximum yield (31.33 t ha^{-1}) that was 53.53 % higher than that of control with 3273.01 $ of monetary advantage. Therefore, present study suggests that potato growers may use vermicompost for increasing yield of potato in Bangladesh.

Keywords: Potato, tuber size, vermicompost, yield.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the Solanaceae family is cultivated in nearly 150 countries and is the world's single most vital tuberous crop with an important role in the global food network and food security (Singh, 2010). It is the world's fourth largest crop after maize, wheat and rice. The total world potato production is estimated at 381,682,144 ton in 2014 (FAOSTAT, 2015). It is the most cultivated tuber crop in the world with one third of total production harvested in densely populated developing countries, like China and India (CIP, 2008). In the world's top 10 potato producing countries, Bangladesh ranks 7th position (FAOSTAT, 2015).

[*] Corresponding author: marufsau@hotmail.com

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Potato is one of the main vegetable crops in Bangladesh (Hoque, 2010). In Bangladesh, it positions 2nd after rice in production (FAOSTAT, 2015). The total area under potato crop, per ha yield and total production in Bangladesh are 461710 hectares, 21.37 t ha^{-1} and 8,950,000 metric ton, respectively (FAOSTAT, 2015). The total production is increasing day by day because of a substitute food crop against rice and wheat and is a nutrient rich crop as such consumption also quickly increasing in Bangladesh (BBS, 2015). Potato is unique compared to other vegetables in that they are exclusively consumed in processed forms. Approximately 60% of the fresh potato crop is used for industrial processing into products such as French fries and chips, whereas the remaining 40% is sold on the fresh market for home preparation and fresh food service applications (USDA, 2014). Due to the increasing demand of consumers and foreign importers on this important crop, special attention should be given to increase its yield. The area and production of potato in Bangladesh has been increasing during last decades but the yield per unit area remains more or less static. The yield is very low in comparison to that of the other leading potato growing countries of the world, 74.45 t ha^{-1} in Kuwait, 59.53 t ha^{-1} in Belgium, 52.89 t ha^{-1} in France, 51.97 t ha^{-1} in USA, 50.33 t ha^{-1} in Netherlands, 47.53 t ha^{-1} in Denmark and 46.21 t ha^{-1} in UK (FAOSTAT, 2015).

Now-a-days, gradual deficiencies in soil organic matter and reduced yield of crop are alarming problem in Bangladesh. To solve this problem application of organic manure specially vermicompost is a good source over the conventional organic manures to improve the physical, chemical and biological properties of soil against the use of destructive chemical fertilizer in soil. It is a good source of different macro and micronutrients particularly N, P, K and S; available nutrient contents of vermicompost are presented in Table 1 (Sinha et al., 2009). The increased microbial activity improves the availability of soil phosphorous and nitrogen. Vermiculture is the science of rearing of earthworms for mass propagation on organic wastes under semi-natural conditions and vermicomposting is the bioconversion of organic waste materials through earthwormic ways (Senapati et al., 1992).

Table 1. Available nutrient contents of vermicompost

Organic carbon	9.5 – 17.98%
Nitrogen	0.5 – 1.50%
Phosphorous	0.1 – 0.30%
Potassium	0.15 – 0.56%
Sodium	0.06 – 0.30%
Calcium and magnesium	22.67 – 47.60 meq per100 g
Copper	2 – 9.50 mg/kg
Iron	2 – 9.30 mg/kg
Zinc	5.70 – 11.50 mg/kg
Sulphur	128 – 548 mg/kg

Senesi et al. (1996) mentioned that vermicomposting is a controlled, aerobic, biological process and able to convert biodegradable humus like organic substances and suitable for the application of soil amendment. Vermicompost (Vm) can play important role in potato productivity. It can reduce the mining of soil nutrient and improve soil organic matter, humus and overall soil productivity (Jenssen, 1993). Soil organic matter acts as "cement" like agent for water holding clay and soil particles together, this contributing to the crumb structure of the soil providing resistant against soil erosion, binds micronutrient metal ions in the soil to check leaching out of surface soils. Organic constituents in the humic substances also act as plant growth stimulants (Jenssen, 1993). It has many outstanding biological properties. They are rich in bacteria, actinomycetes, fungi (Werner and Cuevas, 1996) and cellulose-degrading bacteria (Werner and Cuevas, 1996).

True Potato Seed (TPS) also known as a botanical seed, which sexually produced in potato. It is sown in seedbeds to produce minitubers and later used as a seedling tuber (Sinha et al., 2009). The use of TPS (True Potato Seed) for potato production has increased recently in Europe, North America and Asia, especially in the developing countries (Burton, 1989, Wiersema and Cabellow, 1986). This is due to low transmission of disease, high multiplication rate and good tuber yield (Siddique and Rashid, 2000). In Bangladesh, this technology has been highly promising (Renia and Hest, 1998, Roy et al., 1999, Siddique and Rashid, 2000). Applications of vermicompost singly or in combination with either other chemical fertilizers have been proved effective to enhance yield (Alam et al., 2007). So, using different levels of vermicompost materials may contribute for improving yield of potato in Bangladesh condition. Effect of vermicompost and tuber size on yield of potato are still unknown especially in Bangladesh condition. The objective of this study was to find out yield and yield contributing attributes of potato as influenced by different levels of vermicompost and seed tuber size derived from first clonal generation of true potato seed.

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from November 2014 to April 2015 and November 2015 to April 2016 in Rabi season.

The experimental area was located at 23°77' N latitude and 90°38' E longitude and at an altitude of 8.6 m from the sea level and the area was under the Agro-ecological Zone (AEZ-28) and belonged to the Madhupur Tract (Brammer et al., 1988). The experiment consisted of two factors viz., Factor A: vermicompost level (Vm_1: 0 t ha^{-1}; Vm_2: 3 t ha^{-1}; Vm_3: 6 t ha^{-1}; Vm_4: 9 t ha^{-1}) and Factor B: tuber size (S_1: 5-10 g; S_2: 10-20 g; S_3: 20-30 g; S_4: 30-40 g; S_5: >40 g). The tuber of BARI TPS-1 was used for present study. Experiment was laid out in a split-plot design with 3 replications. After land preparation the experimental soil was fertilized with a recommended dose of

Urea 250 kg ha^{-1}, Muriate of Potash (MOP) 250 kg ha^{-1}, Triple Super Phosphate (TSP) 150 kg ha^{-1}, Gypsum 120 kg ha^{-1}, Zinc Sulfate 10 kg ha^{-1}, and Boric Acid 10 kg ha^{-1}. The total amount of MOP, TSP, Gypsum, Zinc Sulfate, Boric Acid and 50% of the Urea were applied at basal dose during final land preparation. The remaining 50% Urea was side dressed in two equal splits at 35 and 50 days after planting (DAP) during first and second earthing up (Mondal et al., 2011). The total amount of vermicompost was applied at seven days before planting as per treatment. The vermicompost was assigned to main plot and tuber size to sub plot. Distance between row to row was 50 cm and plant to plant was 25 cm. Distance between plot to plot was 75 cm. The size of the unit plot was 2 m × 1.5 m. Seed potatoes were planted last week of November and harvested first week of March. Data on different yield parameters *viz.*, no. of tuber hill^{-1}, weight of tuber hill^{-1}, tuber weight, (t ha^{-1}), yield (t ha^{-1}) and marketable yield (t ha^{-1}), potato yield (t ha^{-1}) and -seed potato yield (t ha^{-1}) were determined. Tuber yield increase (%) and monetary advantage were calculated under study by calculating percent (%) tuber yield increase over control.

Statistix 10 (2013 version) computer package was used for analysis following ANOVA and means were compared by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Number of tubers hill^{-1}

Significant variation was found among different levels of vermicompost on number of tubers hill^{-1}. The maximum (11.57) number of tubers was attributed from Vm_2T_4 which was statistically similar to Vm_2T_5, Vm_2T_2 and Vm_2T_1. The minimum (8.39) number of tubers was from Vm_4T_3 which was statistically similar to Vm_1T_1 (Table 2). Batra (1992) reported that tuber number plant^{-1} increased with increase in seedling tuber size. The highest tuber number plant^{-1} was recorded in 20-40 g size seedling tuber planted crop. The number of main stems plant^{-1} has positive bearing on number of tubers plant^{-1}. TPS seedling tubers have tendency to produce a greater number of tubers plant^{-1} (Adhikari, 2005). Harsharin et al. (1983) who have shown that the number of tubers plant^{-1} increased by increasing the size of seed tubers from 25-35 mm to 35-45 mm and 45-55 mm.

Average tuber weight

Profound dissimilarity was found among different combination of vermicompost levels and tuber sizes on average tuber weight. The highest (71.66 g) average tuber weight was from Vm_4T_5. The lowest (34.58 g) average tuber weight was from Vm_1T_1 (Table 2). It was observed that plants from smaller seedling tubers matured later than the larger. This may explain the average tuber weight differences between plants from the different seedling tuber size (Adhikari, 2005). It may be said that, the higher doses of vermicompost have been increased the stored product as dry matter in tuber through photosynthesis resulted in higher average weight than control treatment.

Table 2. Response to vermicompost and tuber size on yield and yield contributing characters of potato (Means were taken from two years study)

Treatments	No of tubers $hill^{-1}$	Average tuber weight (g)	Weight of tuber $hill^{-1}$ (kg)	Tuber yield ($t\ ha^{-1}$)	Marketable yield ($t\ ha^{-1}$)	Non-marketable yield ($t\ ha^{-1}$)	Seed potato yield ($t\ ha^{-1}$)	Non-seed potato yield ($t\ ha^{-1}$)
Vermicompost levels								
Vm_1	10.10 b	37.77 d	382.77 d	17.86 d	13.39 d	4.47 a	10.09 d	7.77 b
Vm_2	11.11 a	43.94 c	488.01 c	22.77 c	18.30 c	4.47 a	14.90 c	7.88 a
Vm_3	10.15 b	54.40 b	551.32 b	25.73 b	21.49 b	3.88 b	18.78 b	6.95 d
Vm_4	9.32 c	63.24 a	587.59 a	27.42 a	23.66 a	3.79 c	19.86 a	7.56 c
CV (%)	3.40	2.33	3.86	3.86	3.20	1.33	2.29	1.21
$LSD_{0.05}$	0.3087	1.0353	17.344	0.8094	0.5498	0.0495	0.3261	0.0815
Tuber size								
T_1	9.93 b	44.65 e	444.39 e	20.74 e	16.68 e	4.06 d	14.18 e	6.56 e
T_2	10.19 b	45.78 d	465.25 d	21.71 d	17.53 d	4.18 b	14.40 d	7.31 d
T_3	9.96 b	50.13 c	489.80 c	22.86 c	18.70 c	4.16 c	14.59 c	8.27 a
T_4	10.55 a	52.55 b	548.61 b	25.60 b	21.17 b	4.18 b	17.89 b	7.71 c
T_5	10.22 ab	56.07 a	564.07 a	26.32 a	21.97 a	4.20 a	18.47 a	7.85 b
CV (%)	3.85	0.54	3.41	3.41	0.79	0.39	0.57	1.50
$LSD_{0.05}$	0.3258	0.2235	14.237	0.6644	0.1269	0.0133	0.0760	0.0940
Combination								
Vm_1T_1	8.95 hi	34.58 q	309.64 k	14.45 k	10.49 p	3.96 ij	7.60 q	6.85 h
Vm_1T_2	9.76 e-g	37.09 p	361.93 j	16.89 j	12.78 o	4.11 h	9.32 p	7.57 f
Vm_1T_3	10.60 b-d	38.02 o	402.86 i	18.80 i	13.92 n	4.88 a	9.79 o	9.01 c
Vm_1T_4	10.49 cd	39.35 n	412.71 i	19.26 i	14.63 m	4.63 cd	10.00 n	9.26 b
Vm_1T_5	10.72 b-d	39.82 m	426.71 i	19.91 i	15.13 l	4.78 b	13.74 l	6.17 j
Vm_2T_1	11.09 a-c	41.40 l	459.02 h	21.42 h	16.91 k	4.51 e	14.78 j	6.64 i
Vm_2T_2	11.11 a-c	42.01 k	466.64 gh	21.78 gh	17.11 k	4.67 c	14.55 k	7.23 g
Vm_2T_3	10.58 b-d	44.95 j	475.62 fh	22.20 fh	17.99 j	4.21 g	12.44 m	9.76 a
Vm_2T_4	11.57 a	45.08 j	521.64 de	24.34 de	19.71 gh	4.63 d	18.01 f	6.33 j
Vm_2T_5	11.18 ab	46.25 i	517.14 de	24.13 de	19.78 gh	4.35 f	14.70 j	9.43 b
Vm_3T_1	10.09 d-f	48.71 h	491.60 e-g	22.94 eg	19.05 i	3.89 k	17.43 g	5.51 k
Vm_3T_2	10.18 d-f	49.03 h	499.07 ef	23.29 ef	19.32 h	3.97 i	16.48 i	6.81 hi
Vm_3T_3	10.28 de	49.81 g	512.21 de	23.90 de	20.08 g	3.82 l	16.79 h	7.11 g
Vm_3T_4	10.59 b-d	57.87 d	612.64 b	28.59 b	23.64 d	3.81 l	21.11 d	7.48 f
Vm_3T_5	9.63 fg	66.57 c	641.07 ab	29.92 ab	25.37 c	3.92 j	22.08 c	7.84 d
Vm_4T_1	9.60 f-h	53.90 f	517.29 de	24.14 de	20.28 g	3.86 kl	16.91 h	7.23 g
Vm_4T_2	9.70 e-g	54.97 e	533.36 d	24.89 d	20.91 f	3.98 i	17.25 g	7.64 ef
Vm_4T_3	8.39 i	67.74 b	568.50 c	26.53 c	22.81 e	3.72 m	19.32 e	7.21 g
Vm_4T_4	9.53 f-g	67.91 b	647.43 a	30.21 a	26.69 b	3.63 n	22.43 b	7.78 de
Vm_4T_5	9.37 gh	71.66 a	671.36 a	31.33 a	27.59 a	3.74 m	23.37 a	7.96 d
CV (%)	3.85	0.54	3.41	3.41	0.79	0.39	0.57	1.50
$LSD_{0.05}$	0.6579	1.1074	30.709	1.4331	0.5934	0.0548	0.3525	0.1864
Level of significance	**	**	**	**	**	**	**	**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly. ** = Significant at 1% level of probability; Vm_1 – Control, Vm_2 – 3 t ha^{-1}, Vm_3 – 6 t ha^{-1}, Vm_4 – 9 t ha^{-1}, T_1 5-10 g, T_2 – 10-20g, T_3 – 20-30 g, T_4 – 30-40 g, T_5 - >40 g

Weight of tuber hill^{-1}

Weight of tuber hill^{-1} due to different combination of vermicompost levels and tuber sizes was statistically significant. The highest (671.36 g) weight of tuber hill^{-1} was obtained from Vm_4T_5 which was statistically similar to Vm_4T_4 and Vm_3T_5. The lowest (309.64 g) weight of tuber hill^{-1} was attributed from Vm_1T_1 (Table 2). It was observed that plants from smaller seedling tubers mature later than the larger. The larger seedling tuber may increase the dry matter hill^{-1} than smaller seedling tuber. The increase in yield with the application of vermicompost could be attributed to corresponding increase in leaf area, which was responsible for synthesizing photosynthetic and increase in weight of tuber (Gangele, 2017).

Tuber yield

Tuber yield due to different combination of vermicompost levels and tuber sizes was statistically significant. The highest (31.33 t ha^{-1}) tuber yield was attributed from Vm_4T_5 which was statistically similar to Vm_4T_4 and Vm_3T_5. The lowest (14.45 t ha^{-1}) tuber yield was obtained from Vm_1T_1 (Table 2). The variation may be due to better haulm growth and average tuber weight. Weight of the TPS seedling tubers significantly affected the total tuber yields. The significantly maximum total tuber yield was obtained when larger seedling tubers were planted. Seedling tuber 20-40 g size produced the highest total (30.93 t ha^{-1}) (Adhikari, 2005). An increase in seedling tuber size gradually increased the yield of tubers. It was primarily due to high food reserve in large seed tubers which ultimately contributed to produce high yield through increased vegetative growth of plants and development of tubers (Sultana et al. 2001). The increase in tuber yield was due to vermicompost has high porosity, aeration drainage and water-holding capacity which effects on tuber development and total yield (Joshi et al., 2015).

Marketable yield

Noticeable variation was observed among different combination of vermicompost levels and tuber sizes on marketable tuber yield. The highest (27.59 t ha^{-1}) marketable tuber yield was observed from Vm_4T_5 and the lowest (10.49 t ha^{-1}) was from Vm_1T_1 (Table 2). Marketable tuber yield increase due to vermicompost at higher levels may be associated with the increment of total tuber yield and also due to the increment of the proportion of large tuber yield percentage. Seedling tuber 20-40 g size produced the highest marketable yield (27.14 t ha^{-1}) (Adhikari, 2005).

Non-marketable yield

Significant dissimilarity was observed among different combination of vermicompost levels and tuber sizes on non-marketable tuber yield. The highest (4.88 t ha^{-1}) non-marketable tuber yield was observed from Vm_1T_3 and the lowest (3.63 t ha^{-1}) non-marketable tuber yield was observed from Vm_4T_4 (Table 2). Non-marketable tuber yield reduction due to vermicompost at higher levels may be associated with the increment of both marketable and total tuber yield and also due to the increment of the proportion of large tuber yield percentage.

Seed potato yield

Significant variation was observed among different combination of vermicompost levels and tuber sizes on seed tuber yield. The highest (23.37 t ha^{-1}) seed tuber yield was observed from Vm_4T_5 and the lowest (7.60 t ha^{-1}) seed tuber yield was observed from Vm_1T_1 (Table 2). The present study revealed that, an increased in seedling tuber size gradually increased the yield of seed tubers. But the result of present research exhibited an antagonist agreement with Sultana et al. (2001) who stated that, an increased in seedling tuber size gradually decreased the yield of non-seed tubers.

Non-seed potato yield

Remarkable variation was observed among different combination of vermicompost levels and tuber sizes on non-seed tuber yield. The highest (9.76 t ha^{-1}) non-seed tuber yield was found from Vm_2T_3 and the lowest (5.51 t ha^{-1}) non-seed tuber yield was found from Vm_3T_1 (Table 2). The present study revealed that, an increased in seedling tuber size gradually decreased the yield of non-seed tubers. But the result of present research exhibited an antagonist agreement with Sultana et al. (2001) who stated that, an increased in seedling tuber size gradually increased the yield of non-seed tubers.

Tuber yield merit and monetary advantage (US \$ ha^{-1})

Vermicompost performed the better for increasing tuber yield of potatoes. Among the four vermicompost levels, Vm_4 exhibited the best percentage (%) tuber yield increase (53.52 %) than that of control treatment (Table 3). Using vermicompost in potato field has shown a better monetary advantage on tuber yield. The result showed that, Vm_4 treatment gave the highest money return (3273.01 $) over control treatment (Table 3).

Table 3. Tuber yield increase and monetary advantage of potato under vermicompost application

Vermicompost levels	Tuber yield increase (%)	Monetary advantage (\$ ha^{-1})
Vm_1	00.00	2131.87
Vm_2	27.49	2717.96
Vm_3	44.07	3071.28
Vm_4	53.53	3273.01

Vm_1 – Control, Vm_2 – 3 t ha^{-1}, Vm_3 – 6 t ha^{-1}, Vm_4 – 9 t ha^{-1}

Price of potato tuber: 0.12 \$ kg^{-1}

CONCLUSIONS

From the above discussion, it was observed that yield sharply increased with increasing vermicompost level up to 6 t ha^{-1} and thereafter, exhibited statistically similar yield. Among the twenty (20) treatment combinations, although Vm_4T_5 i.e., vermicompost 9 t ha^{-1} and tuber size >40 g produced the highest yield (31.33 t ha^{-1})

but Vm_4T_4 and Vm_3T_5 showed statistically similar yield. Potato growers of Bangladesh can use vermicompost 6 t ha^{-1} and tuber size >40 g to get maximum economical potato yield.

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