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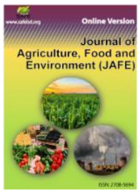

Original Article

Yield and grading of potato tuber for processing purpose as affected by vermicompost and potassium sources

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A B S T R A C T

Gradding of potato tuber for different processing purposes may reduce the main constraints of establishing export industry in Bangladesh. From this perspective the experiment was conducted to assess the effect of potassium sources and vermicompost level on yield and grading of potato tuber. The potato tuber of variety BARI Alu-25 (Asterix) was used as the planting material for this experiment. The experiment consisted of two factors: Factor A: 3 sources of Potassium such as-K_1: KCl, K_2: KNO_3, K_3: K_2SO_4; Factor B: 4 levels of vermicompost such as-Vm_0: 0 t ha^{-1}, Vm_1: 4 t ha^{-1}, Vm_2: 8 t ha^{-1} and Vm_3: 12 t ha^{-1}. The two factor experiment was laid out in a split-plot design with three replications. The highest yield of potato tubers (27.86 t ha^{-1}) was recorded from K_2SO_4, whereas, the lowest (26.02 t ha^{-1}) was found from KNO_3. The number of tubers hill^{-1}, average tuber weight, yield and different categories of potato tuber were increased with the increasing of vermicompost level. Among the 12 treatment combinations, the highest yield of potato tubers (31.17 t ha^{-1}) were found from K_3Vm_3, whereas, the lowest (22.09 t ha^{-1}) was recorded from K_2Vm_0. However, K_1Vm_2, K_1Vm_3, K_3Vm_2, K_3Vm_3 showed statistically similar results regarding yield and grading. So, K_2SO_4 or KCl as a source of potassium and 8 or 12 ton vermicompost ha^{-1} was found to be better in respect of yield and grading of potato tubers compared to the other treatments. Among potassium sources, KCl may be economic and will found available for producing good quality potato in Bangladesh.

Introduction

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae is the fourth-largest food crops in the world after rice, wheat, and maize (Ahmed *et al*., 2017; Ferdous *et al*., 2019). In Bangladesh, the area harvested, total production and yield of potato is 0.48 million hectares, 0.974 crore tonnes and 20.41 t ha^{-1}, respectively and therefore, the yield of potato is relatively low as compared to those of the other potato growing countries in the world such as USA (47.15 t ha^{-1}), France (54.19 t ha^{-1}) (FAOSTAT, 2018). The main reason for the low yield is the use of poor quality seed tubers and inefficient agronomic practices. Potato tuber quality is one of the foremost important quality attributes for consumers and industry (Brown, 2005). Processing quality of potato tubers is decided by high dry matter (Abong *et al.*, 2009). High dry matter content increases chip yield, crispy consistency and reduces oil absorption during cooking (Rommens *et al.,* 2010). Potato yields and tuber quality depend on various factors like soil and climate, agronomic techniques, biological and cultivar specificity, etc. Rational use of fertilizers and manures could ensure 30-50% yield as well as improve the quality while preserving soil fertility. Potato crop yield and quality are often enhanced significantly with balanced fertilization. Potato plants require far more K than the other vegetable crops. Sometimes potato is considered an indicator crop for K^+ availability due to its high K^+ requirement (Ulrich *et al.*, 1966). Potassium is important for the synthesis of straight forward starch and within the translocation of carbohydrates (Smith *et al.*, 1977), the standard of crop produce also can be improved to an excellent extent with

K use. Different sources of potassium *e.g.*, KCl, KNO_3, K_2SO_4 vary the quality parameters of potato. Vermicompost, the excreta of the earthworm, can improve the health and nutrients of the soil and was found to be better compared to other traditional compost (Joshi *et al.*, 2015). Vermicomposting is one among the organic process during which the organic wastes has been converted into nutrient rich manure by the action of earthworms. The characteristic feature of vermicompost like high porosity and moisture holding capacity increases the expansion of plants (Tisdale *et. al.*, 1985). It has 1.5-2.2% nitrogen (N), 1.8-2.2% phosphorus (P), and 1.0-1.5% potassium (K) on the average with organic carbon in between 9.15 and 17.98%, and has micronutrients like sodium (Na), calcium (Ca), zinc (Zn), sulphur (S), magnesium (Mg), and iron (Fe) (Adhikary, 2012). It helps to increase soil water retention capacity, regulation of soil temperature and structure, enhances the soil nutrient elements, and increases the biomass and community structure of the microbial population (Vivas *et al.*, 2009). Vermicompost used as a fertilizer and soil conditioner (Chakraborty *et al.*, 2003) and liable for the development of the soil physical properties and also make sure the supply of important plant nutrients (Smith *et al.*, 2014). The application of vermicompost may increase yield and quality of potato (Mostofa *et al*., 2019). The potato produced in Bangladesh is not good quality enough in respect of dry matter content. Especially in Bangladesh the work has been done is limited in respect of the effect of potassium sources and vermicompost level on yield and grading of potato. Grading is particularly important for potatoes because the size, shape, color, and defects depend greatly on environmental conditions and handling, and is performed primarily by trained human inspectors who assess the potatoes by “seeing” or “feeling” a particular quality attribute (Pedreschi *et al*., 2016). Therefore, the present study was conducted to study the effect of various sources of potassium and vermicompost level on yield and grading of potato for processing purpose.

Materials and Methods

The experiment was conducted at the Experimental Field of the Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November, 2019 to May, 2020. The experimental area was belonged to 23°7'N latitude and 93°E' longitude at an altitude of 8.6 meter above the sea level. The soil was also characterized by pH-5.62 and organic carbon-0.456% (Analyzed from Soil Resources Development Institute, Dhaka). The research area is occupied with complete annual rainfall was 24.23 mm with average monthly maximum and minimum temperature of 29.64°C and 14.91°C, respectively. The potato variety BARI Alu-25 (Asterix) was used for this experiment. The present experiment comprised two factors *viz.*, Factor A: 3 sources of Potassium; i K_1: KCl (260 kg KCl ha^{-1} @130 kg K ha^{-1}); ii. K_2: KNO_3 (336.09 kg KNO_3 ha^{-1} @130 kg K ha^{-1}); iii. K_3: K_2SO_4 (309.2 kg K_2SO4 ha^{-1} @130 kg K ha^{-1}) and Factor B: 4 Levels of vermicompost; i. Vm_0: 0 ton vermicompost ha-^{1}; ii. Vm_1: 4 ton vermicompost ha^{-1}; iii. Vm_2: 8 ton vermicompost ha^{-1}; iii. Vm_2: 8 ton vermicompost ha^{-1}. iv. Vm_3: 12 ton vermicompost ha-^{1}. The experiment was laid out in split plot design with three replications. Different sources of potassium were assigned to the main plot and vermicompost level to sub-plot. Sprouted potato tubers were used as planting material. The allocated plots were fertilized by recommended doses of urea 325kg ha^{-1}, Triple Super Phosphate (TSP) 200kg ha^{-1}, gypsum 100 kg ha^{-1}, zinc sulphate 8 kg ha^{-1} and except treatments (BARI, 2019). All the intercultural operations and plant protection measures were taken as and when needed. After haulm cutting, the tubers were kept under the soil for 7 days for field curing. Average weight of individual tubers was estimated by dividing the total weight of tubers $plot^{-1}$ with the number of tubers of the respective $plot^{-1}$. Tubers of each plot were collected separately and recorded in kilogram and converted to t ha^{-1}**.** Potato tuber below 20g was discarded for counting table potato yield ha^{-1}. This yield was counted by the weight of tubers from a plot which was recorded in kilogram and converted to t ha^{-1}. Tubers harvested from each treatment were classified for different purposive uses on the basis of diameter *i.e.*, canned <30 mm, flakes 30-45 mm, chips 45-75 mm, french fry>75mm (Marwaha *et al.*, 2010) and expressed in percentage. A special type of frame (potato riddle) was used to differentiate the tuber. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test using MSTAT-C software. The difference among the treatments and treatment combinations of means under the experiment was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Average weight of tuber (g)

Statistically significant variation was recorded in terms of average weight of tuber due to different sources of potassium (Table 1). The highest average weight of individual tuber (52.55 g) was recorded from K_3 which was statistically similar (49.64 g) to K_1, whereas, the lowest (46.29 g) was found from K_2. Different levels of vermicompost showed statistically significant differences in terms of average weight of tuber (Table 1). Average weight of tuber increased with the increasing amount of vermicompost. Average weight of tuber showed statistically significant differences due to the combined effect of various sources of potassium and levels of vermicompost (Table 2). The highest average weight of individual potato tubers (54.49 g) was found from K_3Vm_3 which was statistically similar to K_3Vm_2, K_3Vm_1, K_3Vm_0, K_1Vm_2 (52.25, 51.61, 51.84, 51.09 g, respectively) whereas, the lowest (44.86 g) was observed from K_2Vm_0 treatment combination. Kumar *et al*. (2007) reported potassium increased crop osmotic potential, crop vegetative growth, tuber bulking and finally crop weight. For improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil Cation Exchange Capacity (CEC) and increasing crop yields the application of vermicomposts have been recognized as an effective means (Mirdad, 2010 and Hargreaves *et al*., 2008). Kumar *et al*. (2007) reported significant differences with greater yield increases was found using K_2SO_4 over KC1. Potassium as sulphate form increased crop osmotic potential, crop vegetative growth and finally crop yield and Karam *et al*. (2009) also reported that plants treated with K_2SO_4 translocated almost twice the photosynthate from the leaves and stems to the tubers compared with plants treated with KCl. Because chloride form decreased photosynthesis and resulting lower carbohydrate synthesis in tuber. But we did not found such yield differences from our present study. On the other hand, nitrate form may damage the leaf petiole and root also as a result it did not gave the yield as chloride and sulphate source.

Yield of potato tubers (t ha^{-1})

Statistically significant variation was recorded in terms of yield of potato tubers ha^{-1} due to different sources of potassium (Table 1). The maximum yield of potato tubers (27.86 t ha^{-1}) was recorded from K_3 which was statistically similar (27.33 t ha^{-1}) to K_1, while the lowest yield (26.02 t ha^{-1}) was found from K_2. Silva *et al*. (2018) recorded no significant effect of potassium source on yield of potato. Different levels of vermicompost showed statistically significant differences in terms of yield of potato tubers ha^{-1} (Table 1). Yield of tuber increased with the increasing amount of vermicompost. Ferdous *et al*. (2019b) reported that increasing vermicompost level is responsible for achieving better yield with ensuring optimum yield attributes. Yield of potato tubers ha^{-1} showed statistically significant differences due to the combined effect of various sources of potassium and levels of vermicompost (Table 2). The highest yield of potato tubers (31.17 t ha^{-1}) was found from K_3Vm_3 which was statistically similar to K_3Vm_2, K_1Vm_2 and K_1Vm_3 (29.04, 30.18 and 29.43 t ha^{-1} respectively), whereas the lowest yield (22.09 t ha^{-1}) was observed from K_2Vm_0 treatment combination. Balanced supply of nutrients resulting more luxuriant growth, more foliage and leaf area and highest supply of photosynthesis, proliferous root growth enhancing water and nutrient absorption, activation of enzymes, starch synthesis, nitrogen uptake and protein synthesis could be responsible for highest yield (Novoa and Loomis, 1981; Tisdale *et al*., 1985). Kumar *et al*. (2007) reported potassium increased crop osmotic potential, crop vegetative growth, tuber bulking and finally crop weight. For improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil Cation Exchange Capacity (CEC) and increasing crop yields the application of vermicomposts have been recognized as an effective means (Mirdad, 2010 and Hargreaves *et al*., 2008). The higher yield may be attributed from higher weight of individual weight in each plot resulting higher yield per hectare.

Yield of table potato (t ha^{-1})

Statistically significant variation was recorded in terms of yield of table potato hectare^{-1} due to several sources of potassium (Table 1). The highest yield of table potato (26.36 t ha^{-1}) was recorded from K_3 which was statistically similar (24.02 t ha^{-1}) to K_1, while the lowest yield (23.03 t ha^{-1}) was found from K_2. Silva *et al*. (2018) recorded no significant effect of potassium source on yield of table potato. Different levels of vermicompost showed statistically significant differences in terms of yield of table potato hectare^{-1} (Table 1). Yield of table potato increased with the increasing level of vermicompost. Yield of table potato hectare^{-1} showed statistically significant differences due to the combined effect of different sources of potassium and levels of vermicompost (Table 2). The highest yield of table potato (29.30 t ha^{-1}) was found from K_3Vm_3 and statistical similar results were observed in K_3Vm_2, K_1Vm_2 and K_1Vm_3 (27.85, 27.80 and 26.52 t ha^{-1} respectively), whereas, the lowest yield (18.33 t ha^{-1}) was observed from K_2Vm_0 treatment combination.

Grading of potato tubers for different uses

Grading (Canned 20-35 mm; Flakes 35-45; Chips- 45-75 mm; and French fry- >75 mm) of potato tubers due to different sources of potassium was not significant (Table 1). For Canned, Chips and French fry potato, the highest category (35.56%, 31.69% and 5.25%, respectively) was observed from K_1, whereas, the lowest (34.48%, 30.43% and 5.14%, respectively) was recorded from K_2. But for potato tubers used for flakes, the highest result was recorded from K_2 (29.95%) while lowest (27.51%) from K_1. Different levels of vermicompost showed statistically significant differences in terms of percentage of grading of tubers for different uses (Table 1). Percentages of grading increase with the increasing level of vermicompost except canned. In case of canned, percentage decreases with the increasing level of vermicompost. Combined effect of different sources of potassium and levels of vermicompost showed statistically significant differences in terms of grading (Canned 20-35 mm; Flakes 35-45mm Chips-45-75mm; and French fry- >75 mm) of potato tubers (Table 2). For Canned, highest result found from K_1Vm_0 (39.67%) and lowest was observed in K_2Vm_3 (29.73%) which was similar to K_3Vm_3 and K_1Vm_3 (31.40% and 31.39%). For flakes, highest result was found in K_2Vm_0 (32.58%) which was statistically similar to K_2Vm_3 and K_3Vm_0 (32.17% and 31.76%) and the lowest was found from K_1Vm_1 (25.52%) which was statistically similar to K_2Vm_2, K_3Vm_1 and K_1Vm_2 (27.71%, 26.55% and 25.54%). For Chips and French fry potato, the highest (34.17% and 6.08%) was found from K_1Vm_3 (34.17%) which was statistically similar to K_1Vm_2, K_3Vm_1, K_3Vm_2 and K_3Vm_3 (33.14%, 31.33%, 32.62% and 32.83%) in case of chips and in terms of french fry statistically similar result was found from K_1Vm_2, whereas, the lowest (26.59% and 3.83%) was recorded from K_2Vm_0 treatment combination. Stark et al. (2004) described that K can increase the proportion of process-grade tubers from different sources of application in field trials. This has an agreement with the finding of present study. The also stated that, the potassium chloride returns superior grading of potato tuber for making different processing products.

Table 1. Effect of different sources of potassium and levels of vermicompost on average weight of individual tubers, yield of potato, yield of table potato, grading of potato tubers for different uses.

Treatments	Average individual tuber weight (g)	Yield of potato (t ha^{-1})	Yield of table potato (t ha^{-1})	Grading of potato tubers (%) for different uses			
				Canned (20-35 mm)	Flakes (35-45 mm)	Chips (45-75 mm)	French fry (>75 mm)
Source of potassium							
K_1	49.64 ab	27.33 ab	24.02b	35.56	27.51	31.69	5.25
K_2	46.29 b	26.02 b	23.03c	34.48	29.95	30.43	5.14
K_3	52.55 a	27.86 a	26.36a	35.00	28.74	31.08	5.18
Sx	1.039	0.353	0.517	0.356	0.502	0.644	0.054
Level of significance	*	*	**	NS	NS	NS	NS
CV(%)	7.27	4.52	1.84	3.52	4.28	3.61	3.61
Levels of vermicompost							
Vm_0	47.72 b	23.34 c	20.34c	37.82a	26.59b	27.45c	3.90 c
Vm_1	49.13 ab	26.44 b	23.76b	37.00a	27.30b	31.07b	5.34 b
Vm_2	50.21 a	28.89 a	26.66a	34.38b	30.83a	32.60a	5.70 a
Vm_3	50.91 a	29.61 a	27.12a	30.84c	30.21a	33.13a	5.82 a
Sx	0.655	0.459	1.170	0.456	0.520	0.494	0.061
Level of significance	**	**	**	**	**	**	**
CV(%)	3.97	5.09	4.75	3.91	3.84	4.77	3.52

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability; NS=Non-significant; * = Significant at 5% level; ** = Significant at 1% level; K_1: KCl, K_2: KNO_3, K_3: K_2SO_4, Vm_0: 0 ton ha^{-1}, Vm_1: 4 ton ha^{-1}, Vm_2: 8 ton ha^{-1}, Vm_3: 12 ton ha^{-1}

Table 2. Combined effect of different sources of potassium and levels of vermicompost on average weight of individual tubers, yield of potato, yield of table potato, grading of potato tubers for different uses.

Interaction	Average individual tuber weight (g)	Yield of potato (t ha^{-1})	Yield of table potato (t ha^{-1})	Grading of potato tubers (%) for different uses			
				Canned (20-35 mm)	Flakes (35-45 mm)	Chips (45-75 mm)	French fry (>75 mm)
K_1Vm_0	46.44 e	23.15 fg	20.56f	39.67a	28.15cd	28.25cd	3.93 e
K_1Vm_1	50.62 bcd	24.80 ef	21.20 f	38.19ab	25.51e	31.19b	5.11 d
K_1Vm_2	51.09 abc	30.18 ab	27.80ab	32.97de	28.02cd	33.14ab	5.87 ab
K_1Vm_3	50.40 bcd	29.43 abc	26.52bc	31.39ef	28.36cd	34.17a	6.08 a
K_2Vm_0	44.86 e	22.09 g	18.33 g	37.00bc	32.58a	26.59d	3.83 e
K_2Vm_1	45.15 e	26.34 de	23.90de	36.14bc	27.71d	30.70bc	5.45 c
K_2Vm_2	47.30 de	27.44 cd	24.34d	35.04cd	27.36de	32.03ab	5.57 bc
K_2Vm_3	47.84 cde	28.21 bcd	25.56d	29.73f	32.17ab	32.39ab	5.71 bc
K_3Vm_0	51.84 ab	24.78 ef	22.12 ef	36.79bc	31.76ab	27.52d	3.93 e
K_3Vm_1	51.61 ab	28.19 bcd	26.19 bc	36.67bc	26.55de	31.33ab	5.45 c
K_3Vm_2	52.25 ab	29.04 abc	27.85ab	35.14cd	26.54de	32.62ab	5.68 bc
K_3Vm_3	54.49 a	31.17 a	29.30a	31.40ef	30.11bc	32.83ab	5.66 bc
Sx	1.134	0.795	1.88	0.790	0.902	0.856	0.106
Level of significance	*	*	**	*	*	*	*
CV(%)	3.97	5.09	4.75	3.91	3.84	4.77	3.52

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability* = Significant at 5% level; ** = Significant at 1% level; K_1: KCl, K_2: KNO_3, K_3: K_2SO_4, Vm_0: 0 ton ha^{-1}, Vm_1: 4 ton ha^{-1}, Vm_2: 8 ton ha^{-1}, Vm_3: 12 ton ha^{-1}

Conclusion

Findings revealed that yield and grading of potato varied significantly due to the use of different levels of potassium and vermicompost. Among the sources, KCl and K_2SO_4 performed better than KNO_3 considering yield and grading of potato. Among the different levels of vermicompost 12 ton vermicompost ha^{-1} performed better but it was statistically simialr with 8 ton vermicompost ha^{-1}. KCl and K_2SO_4 as a source of potassium and 8 and 12 ton vermicompost ha^{-1} produced good yield of potato. However, from the availability of potassium sources and economic point of view, KCl combined with 8 ton vermicompost ha^{-1} would be used for producing higher yield and grading of potato tubers in Bangladesh.

Conflict of interest

No part of this research has been published elsewhere in any form. So, the authors declared that they have no conflict of interest.

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Author's Contribution

A. B: Conceptualization, methodology, investigation and article writing. T.S.R: Conceptualization, supervision, funding acquisition, project administration. B.C.K., S.C.S and M.M: Investigation. A.B: Statistical analysis. R.C: Article writing, critical review and editing.

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