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EFFECT OF DIFFERENT ORGANIC FERTILIZERS AND BIO-FERTILIZERS ON GROWTH, YIELD, QUALITY AND PROFITABILITY OF ORGANIC POTATO PRODUCTION

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Abstract

The field experiment was conducted to find out the effect of organic manure and bio-fertilizers on growth, yield, quality and profitability of organic potato production. The experiment was conducted at the organic block under Tuber Crops Research Centre (TCRC), Joydebpur during rabi season of two consecutive years 2022-23 and 2023-24. The experiment was laid out in a randomized complete block (RCB) design with 3 replications. The treatments comprised of two bio-fertilizers viz. Azotobacter and Phosphate solublizing bacteria (PSB) each one @8 ml per kg seed potato in liquid form and three organic manures with different dosages namely 10 ton/ha and 8 ton/ha were chosen as the treatment. The treatment combinations were T_1: Control, T_2: Vermicompost 10 t/ha, T_3: Trico-compost 10 t/ha, T_4: ACI Organic Fertilizer 10 t/ha, T_5: Bio-manure (Azotobacter + PSB), T_6: Vermicompost 8 t/ha + (Azotobacter + PSB), T_7: Trico-compost 8 t/ha + (Azotobacter + PSB, T_8: ACI Organic Fertilizer 8 t/ha + (Azotobacter + PSB). Potato variety BARI Alu-25 was used as test crop. The growth parameters, yield attributes, yield and quality parameters were significantly influenced by the integrated use of organic manure and biofertilizer. The maximum (23.8 t/ha) tuber yield was found in T_6 (VC 8 t/ha + Azotobacter 8ml/kg seed + PSB 8ml/kg seed). Moreover, the highest gross return (Tk 1189500/ha) and net return (Tk. 634500/ha) and Benefit Cost Ratio (BCR: 2.14) was also recorded in the same treatment.

Keywords: Organic potato, Organic Fertilizers, Bio-fertilizers, Growth, Yield and Quality

Introduction

The potato (Solanum tuberosum L.) is ranked as the 4th most important harvested food crop after wheat, corn and rice and is considered as the world's most vital non-cereal food crop (De Haan, 2016). Considering its yield potential and nutritional value it may contribute to ensure food and nutritional security. Potato (Solanum tuberosum L.) is a member of solanaceae family and considered as one

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of the most valuable and widely distributed crops that is used for human food in most part of the world. Potato is being a high yielding, nutrient exhaustive and short duration crop needs higher quantities of fertilizers and pesticides as compare to other crops. Bangladesh ranks in the 7^{th} position in potato production among the potato producing countries around the world, and the potato is considered the 2^{nd} most important food crop in the country (FAO-STAT, 2020). It has been reported by Naik and Khurana (2003) that indiscriminate use of chemical fertilizers has affected the soil quality adversely in terms of decreasing organic carbon contents and development of micronutrients deficiencies and ultimately culminating into deterioration of produce quality. Due to consumer concern for excessive use of chemical fertilizers to avoid deleterious effects on the environment, there is increasing interest in the use of organic fertilizers. Hafez *et al*. (2004) reported that organic fertilizers, such as compost, provide a slow release of nutrients as micro-organisms in soil. Bio fertilizers from microorganisms can replace chemical fertilizers to increase crop production. In principle, bio fertilizers are less expensive and are more environmental-friendly than the chemical fertilizers. The benefits from using bio fertilizers, beside their role in saving chemical fertilizers is well known reported by Yazdani *et al.* (2009). This necessitates the immediate attention of researchers to evolve nutrient management strategies solving the problems of crop quality as well as soil conditions in holistic manner. Furthermore; bio fertilizers play a significant role in either synthesizing plant usable form of nutrients or increase the availability of nutrients already present in the soil. They have been shown to improve growth and subsequent yield; colonize the rhizosphere and the interior of the plant, promoting plant growth when applied to the seed, plant surface or the soil reported by Waithaka *et al*. (2019). They not only improve soil fertility and crop productivity by adding nutrients to the soil but also protect the plant from pests and diseases. They have been shown to enhance the growth of the root system, extend its life, degrade harmful microorganisms, increase the survival of seedlings, and reduce the time to flowering (Nosheen *et al.,* 2021). Application of P-solublizing bacteria would help in increasing the efficiency of available P in the soil by converting unavailable P into available form. Similarly, N fixing biofertilizers like Azotobactor take the potential to meet a successful availability of N requirement of potato (Giller and Cadisch, 1995). Biofertilizers are easy to apply, low-cost in nature and eco-friendly. Application of different bio-fertilizers alone or in combination with others as seed, soil and foliar spray revealed that the bio-fertilizers have stimulatory effect on germination, sprouting behavior and growth parameter of potato (Morajdhwaj, 2017). So, farmers need a combined application of bio fertilizers and organic fertilizers in potato production. Studies on the effect of organic manure and bio-fertilizers on potato production in Bangladesh are varied, but they generally indicate that combining organic and bio-fertilizers can improve potato yield and quality by enhancing soil fertility, nutrient availability, and overall plant health. Therefore, the present investigation was initiated to determine the response of potatoes to different combinations of organic manure and bio fertilizers.

Materials and methods

Experimental site and soil characteristics: The experiment was conducted at 'Organic Block' at the tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur during *rabi season* of two consecutive years 2022-23 and 2023-24. The experimental site was located in the centre of the Madhupur Tract (AEZ-28) at about $24^0 23'$ north latitude and $90^0 08'$ east longitude having a mean elevation of 8.4 m above mean sea level. Organic practices have been being followed in this block since 2015. After harvesting the crops in each year, the land was allowed to grow green manure like *Sesbania* sp. and they were fully decomposed before the commencing of the next season. The experimental plot was a high land having sandy clay loam soil. The soil as well as soil organic amendments were analysed in Soil Science Division, BARI and presented in Table 1 and Table 2, respectively.

Table 1. Initial properties of soil of the experimental plot

Soil Properties	pH	OM (%)	Total-N (%)	K	Ca	Mg	P	S	Zn	B	Pb	Cd	Cr	Ni
				(meq/100 g)			µg/ml							
Value	6.6	1.29	0.068	0.056	5.9	1.7	24.6	21.0	0.76	0.23	2.4	0.10	94.0	34.0
Critical value	-	-	-	0.12	2.0	0.5	7.0	10	0.6	0.2	100	3	100	50

Table 2. Result of the chemical analysis of different types of organic soil amendment

Type of compost	Nutrient content						Heavy metal (ppm)			
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Sulfur (%)	Calcium (%)	Zinc (ppm)	Pd	Cd	Cr	Ni
Trichocompost	1.39	0.61	0.76	0.11	2.18	0.019	0.78	0.76	31.2	5.98
Vermicompost	2.18	0.83	1.13	0.26	3.45	0.020	0.72	0.87	34.5	6.45
ACI Organic Fertilizer	2.91	0.71	1.15	0.28	3.81	0.013	5.35	0.56	19.2	4.01
Critical Value							100	3	100	50

Experimental materials and design

Two bio-fertilizers viz. Azotobacter and Phosphate Solubilizing bacteria (PSB) at the rate of 8 ml per kg seed potato in liquid form and three organic fertilizers at the rate of 10 ton/ha and 8 ton/ha were chosen as the treatment. The number of treatment was eight viz. T_1 : Control, T_2 : Vermicompost 10 t/ha, T_3 : Trico-compost 10 t/ha, T_4 : ACI Organic Fertilizer 10 t/ha, T_5 : Bio-fertilizer (Azotobacter

+ PSB), T_6 : Vermicompost 8 t/ha + (Azotobacter + PSB), T_7 : Trico-compost 8 t/ha + (Azotobacter + PSB), T_8 : ACI Organic Fertilizer 8 t/ha + (Azotobacter + PSB). BARI Alu-25 (Asterix) was used as a test material. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 3.0 m x 3.0 m. Whole tuber of the potato variety 'Asterix' were were planted with a spacing of 60 cm x 25 cm.

Tuber seed treatment

The jars of Azotobacter and Phosphate solubilizing inoculum each of 500 ml collected from Soil Science Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Seed tubers were treated with two bio-fertilizers namely Azotobacter and Phosphate Solubilizing bacteria (PSB) each was used @ 8 ml per kg seed potato in liquid form. The seed tubers were treated by dipping the tuber in prepared solution separately. Then the tubers were kept in shade for dry. The treatments were given for 2 hours before the sowing of tuber.

Experimental Procedures and Management

Two bio-fertilizer namely Azotobacter and Phosphate solubilizing bacteria-(PSB) 400ml was taken into a large container and mixed with 40 liters water. Then 50 kg seed tuber of BARI Alu-25 (Asterix) was soaked into the bio-fertilizer solution for half an hour. Soaked potato tuber kept spreading on jute sack in shady place so that surface water might dried. The whole tuber were planted set on 1st December 2022 and 25th November, 2023, respectively. At maturity, potato was harvested on 5th March 2023 and 28th February 2024, respectively. Neem oil cake (NOC) @ 5t/ha was applied in equal 3 installments in each plot. The first one is in pit and the other two installments was applied at the side of the row and covered with soil at the time of first and 2nd time of earthing up followed by irrigation. Pest management was done following organic practices and standards. For pest management, Mahogany and karam cha oil @ 2ml/L, each one was applied following the cyclic order at one-week interval at 35 days after planting to second last week of harvesting. In addition, barrier crops (sunflower, wheat and soybean) were planted surrounding the field to reduce the pest and disease infection, mainly virus diseases. The plots were kept weed-free and earthing up done twice. The crops were irrigated three times, at 7, 30and 60 days after planting (DAP). The first irrigation was given at 7 DAP to ensure appropriate tuber emergence; the second and third irrigations were applied at 30 and 60 DAP, respectively. By spading in between the ridges and covering the ridges with loose soil, two hand weeding was done before the second (at 30 DAP) and last (at 60 DAP) irrigations. The haulm was removed 10 days before harvesting to harden the skin of the potato tubers, and they were left for ten days in the field.

Data collection

Data were taken on days to start of emergence, emergence (%) at 30 DAP, plant height at 45 & 60 DAP, number of stem per hill at 45 & 60 DAP, foliage coverage (%) at 45 & 60 DAP, plant vigor (1-10) Scale at 45 and 60 DAP, tuber Grade (% by number & weight), tuber fresh yield (t/ha) at 95 DAP, dry matter percentage, total soluble solids (TSS%), starch content (mg g^{-1} FW) and Cost Benefit Ratio.

Parameters estimation

Determination of Dry Matter Content

Three tubers from the harvested potatoes of each treatment were randomly selected for tuber dry matter estimation. After that, the samples were chopped and weighted to 100 g samples, then were made sundry. After sun drying; the samples are kept in oven (Memmert GmbH, UN-260, Schwabach, Germany) for 72 h at 70° C. The dry matter was computed as a percentage based on the ratio of dry to fresh mass (Mostofa, 2019).

Determination of Total Soluble Solids (TSS)

TSS of harvested fresh tubers was measured in a drop of potato juice by using Hand Sugar Refractometer "ERMA" Japan, Range: 0-32% according to (AOAC 1990) and recorded as percentage (%) Brix from an immediate reading of the instrument.

Extraction of Sugar

For the analysis of sugar contents like reducing sugar (glucose) and non-reducing sugar (sucrose), potato flesh was extracted from each treatment. Sugars were extracted using 5 ml of 80% ethanol heated at 80°C for 30 min in a dry block heat bath and the extracts were centrifuged at 5000 rpm for 10 min and decanted the supernatant and it was repeated 4 and 5 times in total. All the supernatants were mixed properly and the final volume was made 25 ml using 80% ethanol. For starch analysis the residue was used 100 ˚C. Then 1 ml Amyloglucosidase solution was added and mixed properly and heated at 50-60˚C

Measurement of Starch content (mg/g FW) in potato tubers

After extraction of sugar, the remained residue was washed for several times with water to ensure that there was no more soluble sugar in the residues. After that using tap water marked up to 250 ml in a beaker and stirred properly by using a magnetic stirrer. During the stirring, 0.5 ml solution was taken from the beaker and boiled for 10 min at for 2 hrs. in hot water. After cooling, a 0.5 ml copper solution was added and mixed properly, heated at 100^0C for 10 min. Then cooled in tap water, added 0.5 ml nelson solution, mixed properly and added

7 ml distilled water (final volume was 9.5 ml) and measured the absorbance at 660 nm. The starch content was calculated using the glucose standard curve and expressed as mg/g FW.

Statistical analysis

Analysis of variance for yield parameters and yield were done following the ANOVA test and the mean values were compared by LSD (p <_0.05). Statistix 10 software was used to analyse the data.

Results and Discussion

Growth characteristics

The growth characteristics namely days to start of emergence, emergence percentage, plant height and number of stem per hill were significantly variable among the treatments (Table 3). The days to start of emergence was earlier in T_8 (11.7 days) where ACI organic manure+Azotobacter+PSB was applied which was followed by T_5 and T_6 whereas the latest germination (13.8) occurred in T_1. The highest emergence percentage (95.5%) at 30 DAP was found in T_6 which was followed by T_8 and T_2 whereas the lowest value (76.5%) was noted in the control (Table 3). The highest plant height (51.6 cm) was found in T_6 which was statistically at par with T_8, T_2 and T_7 whereas the lowest (33.4 cm) was recorded in T_1 (control). Similar trend was found in 60 DAP.

Table 3. Effect of different organic manures and bio-fertilizers on days to start of emergence, emergence percentage, plant height, number of stem/hill (pooled of two years)

Treatments	Days to start of emergence	Emergence Percentage at 30 DAP	Plant height at 45 DAP	Plant height at 60 DAP	Number of stem/hill at 45DAP
T_1	13.8a	76.5d	33.4c	39.88d	3.38b
T_2	12.6b	90.1abc	50.0ab	55.05bc	3.88b
T_3	12.6b	86.2c	43.7b	49.15c	3.58b
T_4	12.5bc	87.1c	45.2b	52.70bc	4.58a
T_5	11.8bc	85.9c	45.2b	50.17c	3.83b
T_6	11.8bc	95.5a	51.6a	56.29ab	4.48a
T_7	12.0bc	89.2bc	48.2ab	58.72a	3.78b
T_8	11.7c	93.6 ?ab	50.8a	59.41a	3.73b
Level of significance	**	**	**	**	**
CV (%)	5.99	5.35	10.10	9.01	11.56

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability by DMRT.

*= Significant at 5% level of probability, **= Significant at 1% level of probability

T_1= (Control), T_2 = (Vermicompost 10 t/ha), T_3 = (Trico-compost 10 t/ha), T_4 = (ACI Organic Fertilizer 10 t/ha), T_5 = (Bio-fertilizer (Azotobacter + PSB), T_6 = (Vermicompost 8 t/ha + Azotobacter + PSB), T_7 = (Trico-compost 8 t/ha + Azotobacter + PSB) and T_8 = (ACI Organic Fertilizer 8 t/ha+ Azotobacter + PSB).

Stem per hill, foliage coverage and plant vigor were significantly varied among the treatments (Table 4). The highest (5.58cm) number of stem/hill was recorded in T_4 which was significantly higher than the other treatments. The lowest number of stem per hill (3.77) was found in the control. In case of foliage coverage (%) at 45 DAP, T_6 (Vermicompost 8 t/ha + (Azotobacter + PSB) showed the highest foliage coverage (89.0%) followed by T_8 (Table 4). The lowest foliage coverage (57.0%) was found in the control. The similar trend was followed in 60 DAP. In case of plant vigority, at 45 DAP; the maximum vigorous plant (8.88) was found in T_6 (Vermicompost 8 t/ha + (Azotobacter + PSB) while the minimum value (5.78) was noted in the control. The similar trend was followed in 60 DAP. It was observed that (Vermicompost 8 t/ha + Azotobacter + PSB) was found to be superior to other dose of organic manures and bio fertilizers and had significant effect on growth characteristics of potato which was followed by T_8 and T_7. This might be due to presence of enzymes, hormones, growth regulators along with plant nutrients in vermicompost while Azotobacter and PSB are bio fertilizers which improves the nutrient up take and provide better condition for plant growth. Azotobacter and PSB are improves the availability of nitrogen and phosphorus by nitrogen fixation and phosphorus solubilization. Similar, results were also reported by Ali *et al*. (2020), Saxena and Singh (2020) and Gangele *et al*. (2020).

Table 4. Effect of different organic manures and bio-fertilizers on number of stem/hill, foliage coverage (%) and plant vigor (pooled of two years)

Treatments	Number of stem/hill at 60DAP	Foliage coverage (%) at 45 DAP	Foliage coverage (%) at 60 DAP	Plant vigor at 45 DAP (1-10 scale)	Plant vigor at 60 DAP (1-10 scale)
T_1	3.77e	57.0d	67.3f	5.78d	6.57d
T_2	4.37cd	79.6bc	85.0de	8.43ab	8.58b
T_3	4.05de	79.7bc	87.18cd	8.11b	8.68b
T_4	5.58a	80.15bc	89.1bc	8.28ab	8.60b
T_5	4.32cd	75.5c	82.8e	7.48c	7.94c
T_6	4.93b	89.0a	93.4a	8.88a	9.38a
T_7	5.00b	82.3b	88.0bcd	7.87bc	8.54b
T_8	4.75bc	84.40ab	91.2ab	8.82a	9.05ab
Level of significance	**	**	**	**	**
CV (%)	8.47	5.80	3.99	6.76	5.51

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability by DMRT.

*= Significant at 5% level of probability, **= Significant at 1% level of probability

T_1= (Control), T_2 = (Vermicompost 10 t/ha), T_3 = (Trico-compost 10 t/ha), T_4 = (ACI Organic Fertilizer 10 t/ha), T_5 = (Bio-fertilizer (Azotobacter + PSB), T_6 = (Vermicompost 8 t/ha + Azotobacter + PSB), T_7 = (Trico-compost 8 t/ha + Azotobacter + PSB) and T_8 = (ACI Organic Fertilizer 8 t/ha+ Azotobacter + PSB).

Yield parameters

At 95 DAP, the number of tubers per plant, tuber weight (g) per hill and fresh tuber yield (t/ha) were varied significantly due to treatments effects as depicted in (Table 6). The maximum (9.03) number of tubers per hill at harvest was observed in T6 which was statistically similar to T8 and T7 while the minimum (6.41) number of tubers perplant at harvest was found in the control (Table 6). The maximum (424.4 g) tuber weight per hill at harvest was found in T6 (ACI Organic Fertilizer 8 t/ha + (Azotobacter + PSB) followed by T8 and T7. The minimum (205.8 g) tuber weight per hill was found in the control. The maximum (23.8 t/ha) tuber yield was found in T6 (Vermicompost 8 t/ha + (Azotobacter + PSB) which was identical to T7 and T8 but different from the rest of the treatments. The minimum tuber yield (11.44 t/ha) was recorded in the control (Table 4). The increase in the tuber numbers per plant could be attributed to the increased vegetative growth observed due to the balanced nutrient levels, which stimulated the initiation of more stolon, thus increasing the number of tubers per hill. The increased production is attributed to better photosynthetic activity and the accumulation of carbohydrates which helps in better growth of the crop. It is also known that phosphatic fertilizers affect potato tuber yield by influencing the number of tubers produced and the size of tubers. The result was corroborated with the findings of Kumar *et al.* (2013) who reported that applying sole bio fertilizers as seed treatment without inorganic fertilizers, and farmyard manure showed inferior performance productivity. Therefore, bio fertilizers need an organic fertilizer for enhanced early establishment, which is necessary to affect the tuber yield positively. Bio fertilizers required organic manuring for its early establishment necessary for exerting a beneficial effect on crop productivity reported by Kumar *et al* (2013). The application of organic fertilizers, Azotobacter and PSB might have enhanced the availability of native macro and micro nutrients, vitamins, enzymes, antibiotics, growth hormones and insoluble nutrients to the plants, as consequence of which increase the yield of potato tubers and plant. The increase in yield with the application of organic manures, Azotobacter and PSB could be attributed to corresponding increase in insoluble nutrients to soluble form, which was responsible for synthesizing photosynthate and increase in number and weight of tuber. The results are in agreement with the findings of Islam *et al*. (2017), Ali *et al.* (2020) and Saxena and Singh (2020).

Table 6. Effect of different organic manures and bio-fertilizers on tuber yield, number of tubers per hill and tuber weight (g) per hill at final harvest (pooled of two years)

Treatments	Tubers/ hill (no)	Weight of tuber/hill (g)	Yield (t/ha)
T_1	6.41c	205.8e	11.44e
T_2	7.69b	319.6bc	17.76bc
T_3	7.53b	295.8cd	16.21cd
T_4	7.96b	307.8bcd	17.10bcd
T_5	5.88c	250.3de	13.91de
T_6	9.03a	424.4a	23.79a
T_7	8.39ab	369.3ab	20.52ab
T_8	8.41ab	398.9a	22.16a
Lev. of sig.	**	**	**
CV (%)	10.82	16.92	17.09

Means bearing same letter (s) do not differ significantly at 1 or 5% level of probability by DMRT

*= Significant at 5% level of probability, **= Significant at 1% level of probability

T_1= (Control), T_2 = (Vermicompost 10 t/ha), T_3 = (Trico-compost 10 t/ha), T_4 = (ACI Organic Fertilizer 10 t/ha), T_5 = (Bio-fertilizer (Azotobacter + PSB), T_6 = (Vermicompost 8 t/ha + Azotobacter + PSB), T_7 = (Trico-compost 8 t/ha + Azotobacter + PSB) and T_8 = (ACI Organic Fertilizer 8 t/ha+ Azotobacter + PSB).

Quality characteristics

The quality parameters like dry matter percentage, total soluble solid (TSS % Brix) and starch content (mg g-1 FW) of tubers were significantly variable among the treatments (Table 7). The highest dry matter percentage (22.6), total soluble solid (4.85 % Brix) and starch content (33.4 mg g-1 FW) of tuber were found in T_6 which was followed by T_7 and T_8. The lowest (18.58%, 3.60% and 22.30 mg g-1 FW), respectively dry matter percentage, total soluble solid (% Brix) and starch content (mg g-1 FW) of tubers were observed in Control. It was observed that Vermicompost 8 t/ha + Azotobacter + PSB showed better performance producing quality potatoes in comparison to other manures and bio fertilizers. Increasing dry matter content was recorded when bio fertilizers were incorporated in combination with organic manures. It might be due to application of vermicompost, Azotobacter and PSB played positive role influencing quality parameters of potato like dry matter content, TSS and starch content. The highest TSS content might be due to maximum moisture content; dry weight of tuber because organic manures carry almost all micro and macro nutrients that are required for the plants growth and development. These results are in agreement with the findings of Abdel and Shams (2012), Islam et al. (2017) and Gangele et al. (2020).

Table 7. Effect of different organic manures and bio-fertilizers on dry matter percentage, total soluble solid (TSS % Brix) and starch content (mg g-1 FW)

Treatment Code	Dry matter content (%)	Total Soluble Solid (TSS % Brix) at harvest	Starch content (mg g-1 FW) of tubers at harvest
T_1	18.6e	3.60d	22.3f
T_2	21.2bc	4.17bc	29.2c
T_3	20.1cd	4.05bc	27.2de
T_4	20.7bcd	4.20bc	28.2cd
T_5	19.8d	3.85cd	26.3e
T_6	22.6a	4.85a	33.4a
T_7	21.2bc	4.30b	30.7b
T_8	21.6ab	4.21bc	31.9b
Lev. of sig.	**	**	**
CV (%)	4.62	8.42	4.11

Means bearing same letter (s) do not differ significantly at 5% level of probability by DMRT

*= Significant at 5% level of probability, **= Significant at 1% level of probability

T_1= (Control), T_2 = (Vermicompost 10 t/ha), T_3 = (Trico-compost 10 t/ha), T_4 = (ACI Organic Fertilizer 10 t/ha), T_5 = (Bio-fertilizer (Azotobacter + PSB), T_6 = (Vermicompost 8 t/ha + Azotobacter + PSB), T_7 = (Trico-compost 8 t/ha + Azotobacter + PSB) and T_8 = (ACI Organic Fertilizer 8 t/ha+ Azotobacter + PSB).

Economic analysis

T_6 showed the highest gross (Tk 1189500/ha) and net return (Tk. 634500/ha) and Benefit Cost Ratio (BCR: 2.14) which was followed by T_8 and T_7. The lowest gross return (Tk. 572000/ha), net return (Tk. 9700/ha and BCR-1.20) were found in the control (Table 8). It was observed that (Vermicompost 8 t/ha + (Azotobacter + PSB), is the suitable combination of organic manure and biofertilizers and showed significant effect on economical yield of potato. These results corrborated with the findings of Verma et al. (2011), and Gangele et al. (2020).

Table 8. Cost of potato cultivation through different organic manures and bio-fertilizers per hectare.

Variable cost		Fixed cost		Total cost of production (VC + FC)
Heads	Tk.	Heads	Tk.	
Labour	80000	Land use	15000/=	
Power tiller	12000			(595000+20000) /=
Seed	40000			
Khaul	300000	Interest on operating capital	5000 /=	
Organic fertilizer Biofertilizer	100000 40000			
Pesticides	8000			
Irrigation charge	15000			
Total	531000 /=	Total	14000/=	615000/=

Table 9. Cost and return analysis in potato cultivation through different organic manures and bio- fertilizers (pooled of two years)

Treatments	Organic Potato Yield (t/ha)	Avg Gross return (Tk)	Avg Cost of prod^n (tk)	Avg Net return (Tk)	BCR
T_1	11.44	572000	475000	97000	1.20
T_2	17.76	888000	575000	313000	1.54
T_3	16.21	810500	575000	235500	1.40
T_4	17.10	855000	575000	280000	1.48
T_5	13.91	695500	515000	180500	1.35
T_6	23.79	1189500	555000	634500	2.14
T_7	20.52	1026000	555000	471000	1.84
T_8	22.16	1108000	555000	553000	1.99

- PSB= Phosphate Solubilizing bacteria
- BCR= Benefit Cost RatioT_1= (Control), T_2 = (Vermicompost 10 t/ha), T_3 = (Trico-compost 10 t/ha), T_4 = (ACI Organic Fertilizer 10 t/ha), T_5 = (Bio-fertilizer, Azotobacter + PSB), T_6 = (Vermicompost 8 t/ha + Azotobacter + PSB), T_7 = (Trico-compost 8 t/ha + Azotobacter + PSB) and T_8 = (ACI Organic Fertilizer 8 t/ha+ Azotobacter + PSB)
- Organic Potato = 50Tk/Kg

Conclusion

Addition of organic manure along with bio fertilizer showed significant effect on yield parameters and yield of potato. The combination of vermicompost 8 t/ha + Azotobacter 8 ml/kg seed + PSB 8 ml/kg seed was found best for the cultivation of organic potato. The higher BCR was also recoded in this combination. Therefore, VC 8t/ha + Azotobacter (8 ml/kg seed) + PSB (8 ml/kg seed) can be recommended for the cultivation of organic potato in the study area (organic practice field).

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