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Effect of organic components on growth, yield and economic return in potato (*Solanum tuberosum* L.)

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Abstract
An experiment was conducted on potato variety Kufri Jawahar to assess the effect of organic components on growth yield and economic return in potato. The results revealed that combination of crop residues + Azotobacter + Phosphobacteria + biodynamic approach + microbial culture was the best among all the treatments for most of the growth and yield parameters under study and gave highest net return and B: C ratio. Thus, it can be concluded that the biofertlizers (Azotobacter, Phosphobacteria, microbial culture and biodynamic approach) are an advantageous source for sustainable organic agriculture, especially for heavy feeder crops like potato.

Keywords: potato, organic components, yield and economic return

Introduction
Potato (*Solanum tuberosum* L.) is the fourth most important food crop after rice, wheat and maize in the North-East plains of India. India is the second largest potato producing country in the world after China, with annual production of 42.48 million tonnes from area of 1.93 million hectare, while in Uttar Pradesh area, production and productivity of potato is 0.55 m ha, 13.57 m tonnes and 24.67 tonnes ha^{-1}, respectively (Anonymous, 2013). Being a heavy feeder of nutrients, potato required high amount of nitrogen, phosphorus and potassium. Chemical fertilizer is the main source of nutrients use for potato cropping. However, continuous dependence of chemical fertilizer causes nutritional balance and adverse effects on physic-chemicals and biological properties of soil. bitter approach for supplying nutrient or food to the crop by including organic nutrient (Arora, 2008) [2]. Further imbalance and indiscriminate use of chemical fertilizers and pesticides resulted several harmful effects on soil, water and air causing being a high yielding and nutrient exhaustive and short duration crop needs higher quantities of fertilizers and pesticides. Organic sources play a vital role in improving the soil fertility and productivity of soils which has been acknowledged for generations. In recent years organic farming is becoming more popular in India because people are now aware, about the disastrous side effects caused by chemical farming on health and environment and now prefer organically grown foods (Shakila and Anburani, 2008) [7]. Singh (2001) [9] reported that the ability of Azotobacter and Phosphobacteria to proliferate in the rhizosphere of crop suggests an increased nutrient availability to the plants. Pfeffer (1984) defined biodynamic approach as working with the energy from cosmos, earth, cow and plants are systematically and synergistically harnessed, which create and maintain life. Biodynamic approach consisting composition or condensation of organic sources so as to reduce the quantity and enhance the nutrient supply to crop plants. Pathak and Ram (2004-05) [5] reported that the application of Biodynamic compost or field sprays (BD) gave higher yield and better return in vegetables. However, available information on the role of these biofertilizers together with a biodynamic approach in potato is meager. Therefore, an experiment was carried out to examine the effect of different organic components on growth and yield characteristics in potato.

Materials and Methods
A field experiment on potato (c*v*. Kufri Jawahar) was conducted at Practical Horticulture Research Farm, Bharregaon, pt. K.L.S. College of Horticulture & Research Station, Rajnandgaon, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during 2016-17 at spacing of 60 cm x 20 cm in net plot size of 3.6 m x 3.6 m. A set of six treatments - *viz*. T_1:

Crop residues based on recommended dose of NPK (150:100:100 kg/ha), T_2: Crop residues + microbial culture, T_3: Crop residues + Azotobacter + Phosphobacteria + microbial culture, T_4: Crop residues + Azotobacter + Phosphobacteria + biodynamic approach + microbial culture, T_5: Crop residues + Azotobacter + Phosphobacteria + FYM @ 200 qt/ha + microbial culture, T_6: FYM based on recommended dose of NPK (150:100:100 kg/ha) and these were replicated four times in randomized block design. Inoculants (Azotobacter and Phosphobacteria) were applied in equal amounts (10 kg/ka each) as soil incorporation in the furrow during sowing of tubers in all the concerned treatments. Biodynamic approach i.e. BD 501 @ 2.5 g/ha was spray at 2- 4 leaf stage in concerned treatments during sunrise, when moon is opposite to Saturn. BD-501 works on the photosynthetic process in the leaf. It strengthens the quality of plants and the plant product and encourages the development of tubers. Cross residue was taken in form of as farm compost under study and applied in the soil during field preparation based on recommended dose of NPK (150:100:100 kg/ha) in the respective treatments. The percentage of N: P: K content in crop residue was 0.5:0.15:0.5 respectively. The soil was clay loam in texture, slightly neutral in reaction (pH 7.3), organic carbon (0.52 %) with moderate fertility having 217, 12.74 and 246.68 kg/ha available N, P and K, respectively. The growth and yield attributers were recorded on five randomly selected plants in each treatment and replication. The crop was harvested at full maturity and the tubers of each plot were graded in 4 sizes, *viz*. large (>75g), medium (50-75g), small (25-50 g) and very small (<25 g). Gross returns were calculated for different grade size tubers at the current market prize (Rs 700/qt for tubers >75g, Rs 650/qt for tubers between 50-75g, Rs 550/qt for tubers between 25-50 g and Rs 450/qt for tubers <25 g). The data was recorded separately and finally subjected to statistical analysis as per methods suggests by Panes and Sukhatme (1978) [4]. The N, P and K contents in soil samples were determined by standard procedures Percent infection of LCV was calculated as per procedure given by CIP (2005).

The benefit: cost ratio was calculated with the help of following formula (Reddy *et al.*, 2004):

$$\text{Benefit: cost ratio} = \frac{\text{Gross return (Rs.)}}{\text{Total cost of cultivation (Rs)}}$$

Results and Discussion

Growth parameters

Analysis of variance suggests that, all the parameters assessed were significantly affected by the treatments under study. The result revealed that the highest plant emergence (%) at 30 days after planting (89.27%) was recorded in treatment receiving crop residues + Azotobacter + Phosphobacteria + biodynamic approach + microbial culture (T_4) followed by crop residues + Azotobacter + Phosphobacteria + microbial culture (85.96%; T_3), while minimum plant emergence (69.11%) was noticed in T_1, where, crop residues based on recommended dose of NPK (150:100:100 kg/ha) had been applied (Table 1). The treatment T_4 exhibited minimum days to 50% flowering (54.75), even though the difference was not significant, significantly higher number of shoots/plant (5.45) than T_1, T_5 and T_6, higher fresh weight of plant (117.60g) than T_1, T_2, T_5 and T_6, highest weight of tubers /plant (342.75g) and lover percent infection of LCV at 30 days after planting (3.75), compared with T_1 and T_2 whereas T_3, T_4 and T_5 significantly increased number of tubers /plant (8.30) while significantly lower plant height (33.69 cm) was recorded for T_1 compared with T_3. This may be due to an increased availability of nutrients to the plant in the presence of biofertilizers and/or biodynamic preparations in these treatments. Azotobacter might have fixed higher amounts of N in soil and therefore, available to the plants resulting in higher uptake of N by plants. Phosphobacteria would have caused more mobilization and solubilization of insoluble P in the soil and improved the availability of P, which may have resulted in an increased uptake of P by plants. BD-501 increases the photosynthetic activity in leaf of plant and shoots growth. On the other hand, lowest percent plant emergence (69.11%), maximum days to 50% flowering (58.75), minimum number of shoots/plant (3.50), lowest fresh weight of plant (96.75g), lowest weight of tubers /plant (270.25g) and maximum percent infection of LCV at 30 days after planting (10.00) was shown by T_1, receiving crop residues, based on recommended dose of NPK (150:100:100 kg/ha). These findings are in agreement with those reported earlier by Thilakavathy and Ramaswamy (1999) [10].

Table 1: Effect of organic sources on growth parameters in potato.

Treatment	Percent plant emergence at 30 days	Days to 50% flowering	No of shoots/plant	Fresh wt of plant (g)	No of tubers/plant	Wt. of tubers/plant (g)	Plant height (cm)	Per cent infection (leaf curl virus) (30 DAP)
T_1 (Crop residues based on recommended dose of NPK/ha)	69.11	58.75	3.50	96.75	6.70	270.25	28.18	10.00
T_2 (Crop residues + microbial culture)	72.99	56.25	3.55	110.35	6.85	283.75	30.45	6.25
T_3 (Crop residues + Azotobacter + Phosphobacteria + microbial culture)	85.96	55.00	4.40	114.25	8.30	301.75	33.69	4.00
T_4 (Crop residues + Azotobacter + Phosphobacteria + biodynamic + microbial culture)	89.27	54.75	5.45	117.60	7.80	342.75	32.11	3.75
T_5 (Crop residues + Azotobacter + Phosphobacteria + FYM @ 200 qt/ha + microbial culture)	84.99	56.75	4.25	108.50	7.70	292.25	30.63	4.00
T_6 (FYM based on recommended dose of NPK/ha)	74.89	56.50	3.90	101.25	6.85	278.50	30.92	4.00
CD at 5%	6.34	5.46	1.31	6.07	0.78	18.16	5.27	1.06

Tuber number and weight

The highest number of tubers per hectare (473 thousand) was recorded in T_4 (Table-2) followed by T_3 (457 thousand). It may be due to the presence of biofertlizers (Azotobacter & Phosphobacteria) facilitating higher availability of nutrients in both the treatments and increasing different tubers size grades. Similarly, the number of large size tubers (>75g) was higher (58 thousand) in T_4 followed by T_3 (57 thousand) without biodynamic treatment. On other hand, the lowest total number of tubers/hectare (359 thousand) was recorded in T_1 receiving crop residues, based on recommended dose of NPK. Application of biofertlizers (Azotobacter + Phosphobacteria) with (T_4) and without (T_3) biodynamic inputs, the combination of biofertilizers with FYM @ 200 qt/ha (T_5) and FYM (T_6) gave significantly higher number of medium size tubers (50-75g) while highest weight of medium size tubers (50-75g) was recorded for T_4 and T_5 followed by T_6. The maximum number of small size tubers (25-50g) were recorded in T_3 (156 thousand), whereas, very small size tuber (<25g) was found maximum (206 thousand) in T_4. Thus in the present study, both Azotobacter and Phosphobacteria increased the number of different size- graded tubers as well as tuber yield. The results confirm the findings of Saxena & Tilak (1994) [6] and Sharma *et al*. (1996) [8].

Table-2 also indicates that except very small size tubers (<25 g) application of crop residues + Azotobacter + Phosphobacteria + biodynamic approach + microbial culture gave maximum tubers yields in all size grades, which finally increased the total tuber yield (197.97 qt/ha). When this combination was applied without biodynamic inputs very small size tubers (<25 g) gave highest yield 42.98 qt/ha, with total tuber yield of 189.12 qt/ha. It indicates that use of biofertilizers (Azotobacter and Phosphobacteria) with biodynamic approach may increase total tuber yield. BD-501 strengthens the quality of plants and the plant product and encourages the development of tubers. Singh (2001) [9] has also reported similar results. When these biofertilizers were used along with FYM @ 200 qt/ha, tuber yield (186.2 qt/ha) was slightly lower. Results indicates that biofertilizer with biodynamic inputs increase the nutrient uptake at whereas, application of organic manures decreases the uptake. The grade wise distribution reveals that the increase in yield is due to cumulative effect of both increased number as well as weight of tubers. Upadhyay *et al.* (1994) [11] have also observed a similarly beneficial effect of biofertilizer viz. Azotobacter in potato.

Table 2: Response of numbers of tubers and tuber yield in potato to organic sources

Treatment	Number of tubers (thousand/ha)					Tuber yield (qt/ha)				
	<25g	25-50g	50-75g	>75g	Total	<25g	25-50g	50-75g	>75g	Total
T_1 (Crop residues based on recommended dose of NPK(150:100:100 kg/ha)	155	110	55	39	359	30.91	43.81	35.83	32.75	143.30
T_2 (Crop residues + microbial culture)	155	120	61	44	380	36.95	36.10	39.65	37.64	150.35
T_3 (Crop residues + Azotobacter + Phosphobacteria + microbial culture)	164	156	80	57	457	42.98	52.20	46.42	47.52	189.12
T_4 (Crop residues + Azotobacter + Phosphobacteria + biodynamics + microbial culture)	206	126	83	58	473	32.13	62.74	53.82	49.28	197.97
T_5 (Crop residues + Azotobacter + Phosphobacteria + FYM @ 200 qt/ha + microbial culture)	189	120	81	56	446	37.89	48.24	52.57	47.51	186.21
T_6 (FYM based on recommended dose of NPK(150:100:100 kg/ha)	158	106	76	34	374	31.53	42.37	49.58	28.90	152.37
CD at 5%	20	9	6	6	38.43	3.44	5.22	5.36	5.37	17.24

Economic feasibility

Table 3 indicates the highest net return (Rs 75819.50/ha) and B: C ratio (2.78) in T_4 followed by T_3 with corresponding values of Rs 70583.00/ha and 2.73 respectively. The minimum net return (Rs 43914.50/ha) and B: C ratio (2.09) was calculated for T_1.Gross return for different grade size tubers was calculated as current market prizes of different grade size tubers.

On the basis of the presented results, it can be stated that the combined application of crop residues + Azotobacter + Phosphobacteria + biodynamic inputs + microbial culture has may be the best approach among all the treatments to increase tuber yield and therefore, economic return for the farmer. It can therefore be concluded that the biofertlizers (Azotobacter & Phosphobacteria) and biodyanamic inputs are a beneficial sources of nutrients for sustainable organic agriculture in crop that require high amounts of nutrients, like potato.

Table 3: Economics of different organic treatments in potato crop as affected by different organic sources.

Treatments	Input Cost (Rs/ha)	Gross Return (Rs/ha)					B:C ratio	Net return (Rs/ha)
		<25g	25-50g	50-75g	>75g	Total		
T_1 (Crop residues based on recommended dose of NPK(150:100:100 kg/ha)	40305	13909.50	24095.50	23289.50	22925	84219.50	2.09	43914.50
T_2 (Crop residues + microbial culture)	40605	16627.50	19855	25772.50	26348	88603.00	2.18	47998.00
T_3 (Crop residues + Azotobacter + Phosphobacteria + microbial culture)	40905	19341	28710	30173	33264	111488.00	2.73	70583.00
T_4 (Crop residues + Azotobacter + Phosphobacteria + biodynamic + microbial culture)	42625	14458.50	34507	34983	34496	118444.50	2.78	75819.50
T_5 (Crop residues + Azotobacter + Phosphobacteria + FYM @ 200 qt/ha + microbial culture)	42555	17050.50	26532	34170.5	33257	111010.00	2.61	68455.00
T_6 (FYM based on recommended dose of NPK(150:100:100 kg/ha)	40305	14188.50	23303.5	32227	20230	89949.00	2.23	49644.00

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