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Response of potato (*Solanum tuberosum* L.) to different organic liquid manures in Jharkhand, India

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ABSTRACT

A field trial was made at Divyayan KVK farm, Ramakrishna Mission Ashrama, Morabadi, Ranchi during winter season of 2021-22 to study the influence of organic liquid manures on growth, productivity, and profitability of potato. The experiment followed four times replicated randomized block design consisting of six treatments (Panchagavya @10%, Sasyagavya @10%, Kunapajala @10%, Poudh Sanjeevani @10%, Veeja Sanjeevani @5% and Control or water). Results revealed that potato manured with FYM @10 t ha^{-1} and sprayed twice (30 and 60 days after planting i.e., DAP) with Kunapajala @10% produced tallest plant (32.73 cm at 50 DAP), maximum leaves plant^{-1} (39.50 DAP), tubers plant^{-1}(6.0) and more tuber weight plant^{-1} (250.4g) resulting in higher tuber yield (238.2 q ha^{-1}), biological yield (284.41q ha^{-1}) and harvest index (83.75%). Consequently, it registered maximum net return (` 4,64,044 ha^{-1}) and B:C (4.53). Tuber treatment with Veeja Sanjeevani @5% also performed well. 10% Kunapajala spray can be recommended for organic cultivation of potato.

***Keywords*:** Kunapajala, liquid manure, net return, organic cultivation, potato, yield

Potato is one of key food crop grown in the world for its balanced staple food and nutritional properties (75 to 80% moisture, carbohydrates of 16 to 20%, 2.5 to 3.2% crude protein, 0.6% crude fibre, 0.8 to 1.2 % minerals, 0.1 to 0.2% fat and vitamins) (Schoenemann, 1977). There exists always a growing demand for this crop due to its high consumption in multiple ways by the global population. Potato is known as 'poor man's friend' as it provides low-cost energy and nutrient rich food to people of all economic classes. In India, it is grown as winter vegetables in Uttar Pradesh, West Bengal, Assam, Bihar, Gujarat, Punjab, Karnataka, Haryana, Madhya Pradesh, Chhattisgarh, Jharkhand etc. (Horticulture Statistics Division, 2019). Worldwide, India's position in potato production is second, preceded by China. In India, area under potato cultivation is more than 2.18 million ha, while the production and productivity of this crop are 52.58 million tonnes and 24.07 tonnes ha^{-1} (Horticulture Statistics Division, 2019). Due to its high demand from enormous population, its production must be increased at this moment to address demand-supply gap. Among various interventions that can help to enhance potato production, nutrient management play a key role.

Potato is a nutrient exhaustive, heavy feeder crop and therefore, adequate soil fertility as well as external application of nutrients are extremely helpful for this crop to realize high growth, yield, quality, and profitability (Westermann, 2005; Pandit *et al*., 2018). Potato cultivation is mostly dependent on chemical sources of nutrients (Pandit *et al*., 2018). However, under continuous application of excessive chemical fertilizers, it has been noticed that soil physical, chemical, and biological properties are being highly affected. Further, chemical footprint creates environmental hazards. Deterioration of soil productivity directly reflects on reduction in crop growth and yield. Therefore, it urges for alternative chemical-based agriculture. Organic farming can emerge as potential alternative under this scenario as eco-friendly crop cultivation practices help to revive soil health and improve crop growth, yield, and quality.

Organic liquid manures such as Panchagavya, Sasyagavya, Kunapajala, Sanjeevani etc. act as bio-enhancers and are rich in various nutrients specially, nitrogen, phosphorous and potassium as well as micro-organisms, growth promoting substances etc. which are essential for plant growth and development. It is hypothesized that various organic liquid manure application can boost up growth, yield and economic profit of potato. These bio-enhancers are prepared from active fermentation of plant and animal residues for a certain time period (Ram *et al*., 2018). Application of bio-enhancers improves soil structure, porosity and

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water holding capacity as well as nutrient uptake by the crop. Previously, Sharma *et al*. (2022) also observed positive influence of organic liquid formulation *Jeevamrit* on various soil properties in cauliflower cultivation. Sau *et al*. (2017) similarly observed good growth and yield of mango by applying Panchagavya.These organic liquid manures boost up immunity in plants and help plants to resist against pest and diseases through synthesis of various metabolites (organic acids, hydrogen peroxide, antibiotics etc.) by the micro-organisms. Considering all the things, the present experiment was planned to study the response of potato (*Solanum tuberosum* L.) to different organic liquid manures in Jharkhand, India.

The field experiment was executed at the farm of Divyayan Krishi Vigyan Kendra, Ramakrishna Mission Ashrama, Morabadi, Ranchi during *rabi* (winter) season of 2021-22 to observe the influence of different organic liquid manures on growth, yield, productivity and profitability of potato (var. *Karuda*). The experimental soil was clay loam textured, red and lateritic in nature having 6.70 of pH, 1.20% organic carbon, 393.11 kg ha^{-1} of available N, 140.0 kg $ha^{-1}$of available P_2O_5 and 228.0 kg $ha^{-1}$of available K_2O. The experiment was placed in randomized block design having 6 treatments (T_1: Panchagavya @10%, T_2: Sasyagavya @ 10%, T_3: Kunapajala @ 10%, T_4: Poudh Sanjeevani @ 10%, T_5: Veeja Sanjeevani @ 5% and T_6: Control or water), with 4 repetitions. Specifications of the organic liquid formulations are mentioned in Table 1. Individual plot size was 4 m×3 m. Potato tubers were planted on 19th November 2021 at a spacing of 50 cm×20 cm and harvested on 4th March 2022. 10 t ha^{-1} of FYM was applied as basal and organic liquid manures (except Veeja Sanjeevani) were sprayed 2 times at 30 as well as 60 days after planting (DAP) through knapsack sprayer. Veeja Sanjeevani was used for treating the tubers prior to planting. Other agronomic and plant protection practices were followed according to standard organic farming protocol.

Observations included plant height and leaf number $plant^{-1}$ at 25 as well as 50 DAP, plant population m^{-2} at harvest, tuber number, tuber weight $plant^{-1}$, tuber yield (total and size wise), biological yield and harvest index. 4 size categories were taken for gradation of tuber: <25 g, 25-50 g, 50-75 g and >75 g. Finally, production economics was estimated using the following formulas:

Cost of cultivation (` ha^{-1}) = Cost involved in input purchase and all the practices

Gross return (` ha^{-1}) = Tuber yield × market price

Net return (` ha^{-1}) = Gross return- cost of cultivation

Benefit: cost (B:C) = Gross return/ cost of cultivation

Table 1: Details of organic liquid manures

Organic liquid manure	Preparation	Application
Panchagavya	Five cow-based ingredients *i.e*. cow dung, cow urine, milk, curd and ghee were mixed in 5:3:2:2:1 ratio and incubated for 7-9 days in an earthen pot or wide mouth plastic container. Stirring with a stick was done every day two times during morning and evening, clockwise and anti-clockwise.	It wassprayed @10% of mother solution by adding water.
Sasyagavya	Initially, vegetable waste/crop residues were chopped. Then, fresh cow dung, cow urine, chopped organic waste and water were mixed at 1:1:1:2 ratio properly and allowed to ferment for 10-12 days aerobically (stirring twice a day).	It was sprayed @10% of mother solution by adding water.
Sanjeevani	Cow dung, cow urine and water were mixed in the ratio of 1:1:2 in an earthen pot and left aerobically (stirring twice daily) for 7-9 days. Stirring with a stick was done every day two times during morning and evening, clockwise and anti-clockwise.	5% solution of Sanjeevani was used for seed treatment (Veeja Sanjeevani). In case of Poudh Sanjeevani, 10% solution was sprayed by adding water.
Kunapajala	It contains mainly cow dung, cow urine, water and any animal flesh like part of fishes, poultry birds or animals. Fresh cow dung, cow urine, animal waste (flesh of fishes, poultry birds etc.) and water were taken in a bucket at 1:1:1:2 ratio and mixed properly. Then, the mixture is fermented in a shady place for 25-30 days aerobically (stirring twice a day).	It was sprayed @10% of mother solution by adding water.

Table 2: Influence of organic liquid manures on plant height, leaf number and population of potato

Treatments	Plant height (cm)		Total number of leaves plant^{-1}		Plant population m^{-2} at harvest
	25 DAP	50 DAP	25 DAP	50 DAP	
T_1: Panchagavya @10%	14.85	28.63	10.25	34.75	7.8
T_2: Sasyagavya @ 10%	14.43	24.53	10.20	31.75	7.8
T_3: Kunapajala @ 10%	14.53	32.73	10.75	39.50	8.0
T_4: Poudh Sanjeevani @10%	14.60	26.40	10.40	32.75	7.8
T_5: Veeja Sanjeevani @5%	15.93	29.73	11.25	36.25	8.0
T_6: Control or water	15.40	21.00	9.95	22.75	7.5
SEm(±)	**0.54**	**0.83**	**0.67**	**1.04**	**0.53**
LSD (0.05)	**NS**	**2.49**	**NS**	**3.12**	**NS**

Data collected from the field was statistically analysed using ANOVA method as highlighted by Panse and Sukhatme (1985) and critical difference was used for comparing treatment means at 5% significance level.

Growth attributes

It was revealed from Table 2 that growth attributes of potato such as plant height and total numbers of leaves plant^{-1}were significantly influenced by various organic liquid manures at 50 DAP. However, statistically non-significant effects of organic liquid manures were noted on plant height and total numbers of leaves plant^{-1}at 25 DAP as application of those manures except Veeja Sanjeevani was first done at 30 DAP. Similarly, plant population m^{-2} at harvest was not significantly influenced by the organic liquid manures. During emergence and early stand establishment, there was no application of organic liquid manures and genetic characters as well as viability potential of tuber possibly helped to emerge and establish seedlings which reflected to final plant population at harvest. At 25 DAP, tuber treatment with Veeja Sanjeevani recorded the tallest plant (15.93 cm) and total numbers of leaves plant^{-1}(11.25). It was probably due to positive influence of tuber treatment with that liquid formulation on seedling growth.

Organic liquid manures enhanced various growth attributes of potato over control. Among the liquid manures, application of Kunapajala @10% (T_3) significantly influenced plant height and total numbers of leaves plant^{-1} and registered best outcomes (plant height: 32.73 cm and total numbers of leaves plant^{-1}: 39.50 at 50 DAP), which was closely followed by tuber treatment with Veeja Sanjeevani @ 5% (T_5) (plant height: 29.73 cm and total numbers of leaves plant^{-1}: 36.25 at 50 DAP) and spray of Panchagavya @ 10% (T_1) (plant height: 28.63 cm and total numbers of leaves plant^{-1}: 34.75 at 50 DAP). Lowest plant height (21.00 cm) and leaves plant^{-1} (22.75) were observed from control (T_6) at 50 DAP. Plant population m^{-2} ranged from 7.5 in control to 8 in T_3 and T_5 treatments. Organic liquid manures specially, Kunapajala was superior to control due to their high nutritional properties as well as growth regulating potential which might exert beneficial influence on cell division and elongation, photosynthesis etc. Kavya and Ushakumari (2020) similarly noticed highest plant height, branch number, LAI and yield of bhindi under application of 50% N as FYM and foliar application of 5% non-herbal Kunapajala.

Yield attributes

Statistically significant impacts of various organic liquid manures were found on tuber numbers plant^{-1} and tuber weight plant^{-1}(Table 3). Like the growth attributes, organic liquid manures improved various yield attributes of potato over control. Application of Kunapajala @10% (T_3) recorded maximum numbers of tuber plant^{-1} (6.0) and tuber weight plant^{-1} (250.4 g), followed by tuber treatment with Veeja Sanjeevani @ 5% (T_5) (tuber numbers plant^{-1}: 5.5 and tuber weight plant^{-1}: 224.2 g) and spray of Panchagavya @ 10% (T_1) (tuber numbers plant^{-1}: 5.5 and tuber weight plant^{-1}: 220.4 g). Treatments T_1 and T_5 remained statistically indifferent to each other in registering those yield attributes. Kunapajala enhanced tuber numbers plant^{-1} and tuber weight plant^{-1}by 50% and 37.13%, respectively, over control or water application (tuber numbers plant^{-1}: 4 and tuber weight plant^{-1}: 182.6 g). It might be due to presence of macro and micronutrients, amino acids, hormones, vitamins, growth promoting substances as well as beneficial micro-organisms in organic formulations specially in Kunapajala, which improved photosynthetic efficiency as well as partitioning and translocation of dry matter to reproductive parts *i.e.* tuber.

Yield and harvest index

Yield and harvest index were shown in Table 3. Tuber yield was graded as per the 4 sizes of tubers (<25 g, 25-

Table 3: Influence of organic liquid manures on yield attributes and tuber yield of potato

Treatments	Tuber no. plant^{-1}	Tuber weight plant^{-1} (g)	Tuber yield (q ha^{-1})					Biological yield (q ha^{-1})	Harvest index (%)
			<25 g	25-50 g	50-75 g	>75 g	Total		
T_1: Panchagavya @10%	5.5	220.4	74.5	55.5	40.4	26.4	196.7	253.41	77.62
T_2: Sasyagavya @ 10%	4.5	200.8	63.2	43.7	31.7	23.1	161.7	221.83	72.89
T_3: Kunapajala @ 10%	6.0	250.4	82.5	64.7	51.3	39.7	238.2	284.41	83.75
T_4: Poudh Sanjeevani @ 10%	4.1	202.1	72.3	50.2	42.6	25.7	190.8	235.08	81.16
T_5: Veeja Sanjeevani @ 5%	5.5	224.2	78.7	55.2	43.5	32.5	209. 9	257.17	81.62
T_6: Control or water	4.0	182.6	62.4	43.4	30.8	23.1	159.7	220.63	72.38
SEm(±)	0.27	5.17	2.58	2.13	2.21	1.87	5.44	7.35	0.68
LSD (0.05)	0.81	15.5	7.7	6.4	6.6	5.6	16.4	22.03	2.04

50 g, 50-75 g and >75 g). It was found that among different sizes, tubers having <25 g registered maximum tuber yield, followed by 25-50 g, 50-75 g and >75 g, irrespective of the treatments (Fig. 1). It indicated that, potato variety mostly produced tubers of <25 g, followed by 25-50 g, 50-75 g and >75 g. Among the organic liquid manures, application of Kunapajala @ 10% (T_3) recorded maximum tuber yield (<25 g: 82.5 q ha^{-1}, 25-50 g: 64.7 q ha^{-1}, 50-75 g: 51.3 q ha^{-1}, >75 g: 39.3 q ha^{-1} and total: 238.2 q ha^{-1}), followed by tuber treatment with Veeja Sanjeevani @ 5% (T_5) (<25 g: 78.7 q ha^{-1}, 25-50 g: 55.2 q ha^{-1}, 50-75 g: 43.5 q ha^{-1}, >75 g: 32.5 q ha^{-1} and total: 209.9 q ha^{-1}) and spray of Panchagavya @ 10% (T_1) (<25 g: 74.5 q ha^{-1}, 25-50 g: 55.5 q ha^{-1}, 50-75 g: 40.4 q ha^{-1}, >75 g: 26.4 q ha^{-1} and total: 196.7 q ha^{-1}). Both Veeja Sanjeevani and Panchagavya remained statistically indifferent. Spray of Kunapajala increased tuber yield by 49.15% over control (tuber yield: 159.7 q ha^{-1}). Similar trend was noted from biological yield of potato, where maximum biological yield was recorded by spray of Kunapajala @10% (T_3) (284.41 q ha^{-1}), followed by tuber treatment with Veeja Sanjeevani @ 5% (T_5) (257.17 q ha^{-1}) and spray of Panchagavya @ 10% (T_1) (253.41 q ha^{-1}), while lowest biological yield was found from control (T_6) (220.63 q ha^{-1}). Because of high tuber yield, Kunapajala @10% (T_3) ensured highest harvest index of potato (83.75%), followed by tuber treatment with Veeja Sanjeevani @5% (T_5) (81.62%) and spray of Poudh Sanjeevani @10% (T_4) (81.16%), while lowest harvest index was recorded from control (T_6) (72.38%) (Fig. 2). The result was in agreement with the finding of Bhat and Vasanthi (2008) in brinjal. Kunapajala was superior in registering maximum tuber yield, biological yield, and harvest index possibly due to its high nutrient contents, other growth regulating substances, vitamins, micro-organisms etc. Martinez (2008) earlier stated that Kunapajala contained carbohydrates, proteins, alkaloids, ample amount of phosphorus, triacylglycerides, esters, sterolester, phospholoipids, vitamins A, D and E etc. and was rich in microorganisms like *rhizobium*, *azotobacter*, *azospirillum*, PSB, *trichoderma* and *pseudomonas*.

Production economics

Production economics (Table 4) revealed that control or water application (T_6) required lowest cost of cultivation of potato (` 95,600 ha$^{-1}$) over organic liquid manures, while Panchagavya @10% ($T_1$) fetched maximum cost of cultivation (` 1,38,312 ha^{-1}), followed by Kunapajala @ 10% (T_3) (`1,31,456 ha$^{-1}$) and Sasyagavya @10% ($T_2$) (` 1,22,230 ha^{-1}). The difference in cost of cultivation was possibly due to requirements of different raw materials at variable quantities for preparation of organic liquid manures. However, spray

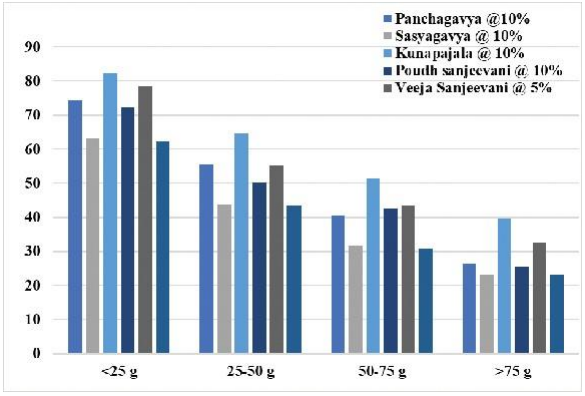

Fig. 1: Size-wise tuber yield (q ha^{-1}) of potato as influenced by various organic liquid manures

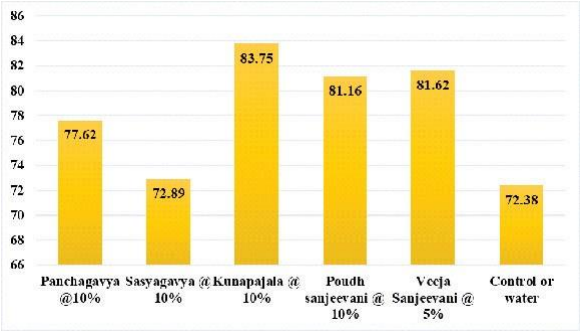

Fig. 2: Harvest index (%) of potato as influenced by various organic liquid manures

Table 4: Influence of organic liquid manures on production economics of potato

Treatments	Cost of cultivation (` ha^{-1})	Gross return* (` ha^{-1})	Net return (` ha^{-1})	B:C
T_1: Panchagavya @10%	1,38,312	4,91,750	3,53,438	3.56
T_2: Sasyagavya @ 10%	1,22,230	4,04,250	2,82,020	3.31
T_3: Kunapajala @ 10%	1,31,456	5,95,500	4,64,044	4.53
T_4: Poudh Sanjeevani @ 10%	1,19,345	4,77,000	3,57,655	4.00
T_5: Veeja Sanjeevani @ 5%	1,20,321	5,24,750	4,04,429	4.36
T_6: Control or water	95,600	3,99,250	3,03,650	4.18
SEm(±)	-	13,591	11,457	0.061
LSD (0.05)	-	40,958	34,370	0.18

*Market price of potato was ` 2.5 kg^{-1}

of Kunapajala @10% (T_3) registered maximum gross and net returns (` 5,95,500 ha$^{-1}$and ` 4,64,044 ha^{-1}, respectively), followed by tuber treatment with Veeja Sanjeevani @5% (T_5) (` 5,24,750 ha$^{-1}$and ` 4,04,429 ha^{-1}, respectively). Highest B:C (4.53) was thereby recorded by spray of Kunapajala @ 10% (T_3), followed by tuber treatment with Veeja Sanjeevani @5% (T_5) (4.36), while lowest B:C (3.31) was noted from use of Sasyagavya @10% (T_2). It was due to higher growth and tuber yield production which fetched high economic return and profit.

The study confirmed the efficacy of various organic liquid manures on growth and yield of potato. Besides, it directly reflected on economic profitability of potato cultivation. Overall, it can be concluded that potato can be cultivated using Kunapajala @10% foliar spray at 30 and 60 days after planting to achieve best growth, tuber yield and economic profitability.

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