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Integrated nutrient management system for productivity and profitability of potato (Kufri Chipsona-3) Under Punjab Condition

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Abstract
A field experiment was conducted to study the effect of integrated nutrient management on the vegetative growth, yield and quality of potato cultivar Kufri Chipsona-3 in sandy loam soils of Punjab. The field experiment was laid out in a randomized block design which involved the integrated use of different biofertilizers, organic manures and chemical fertilizers i.e., NPK, FYM (Farm Yard Manure), vermicompost, bio-fertilizers (phosphorus solubilizing bacteria and Vesicular Arbuscular Mycorrhizae) and absolute control to study the yield and quality parameters. The study revealed that maximum yield (27.9 t/ha) was obtained in the treatment which included integrated use of 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha as compared to other treatments. The treatment also had positive effect on growth, quality and other yield attributes viz. plant height (39.85 cm, 48.73 cm and 51.62 cm at 30, 60 and 90 days after sowing respectively), number of compound leaves (41.84, 46.46 and 49.49 at 30, 60 and 90 days after sowing respectively), dry matter content (20.66%) and specific gravity (1.12 g/cm^3) but the treatment had no significant effect on chlorophyll content. The benefit: cost ratio was also higher in the same treatment.

Keywords: Biofertilizers, vermicompost, quality, *Solanum tuberosum*, yield

1. Introduction
Potato (*Solanum Tuberosum* L.) belongs to the night shade family Solanaceae with chromosome number 2n=48. It was first domesticated in the region of modern-day southern Peru and extreme north western Bolivia between 8000 and 5000 BC [1, 2]. It is the fourth most important food crop after rice, wheat and maize [3]. Dry matter provided by potato is 20 g/100 g per unit area and time. It contains practically all the essential dietary constituents like carbohydrates, nutrients, protein, vitamins, and minerals [4]. It is also a considerable source of carbohydrates (17%), starch (88%), protein (2%), fat (0.09%), fiber (2.2%) and sugar (0.78%) [5].

Potato is widely cultivated throughout the world in an area of 19.03 million hectares and the production is about 388 million tonnes. China is now the largest potato producer having a production of 99.2 million tonnes and almost one third of all the potato is harvested in China and India [6]. India has 2.1 million hectares area under potato cultivation with 48.4 million tonnes production and productivity of 23.1 tonnes per hectare [7].

Because of the high dry matter production, potato removes large amount of nutrients from the soil per unit area per unit time, and it is difficult for the soils to supply huge amount of nutrients to plants. So, it becomes essential to add nutrients in the soils from the outer sources. Mostly inorganic fertilizers are used as a source of nutrients in potato. The requirement of nitrogen, phosphorus and potassium is very high in potato as it is a heavy nutrient feeder crop. It requires balanced amount of plant nutrients for better growth and development. Nitrogen (N), Phosphorus (P) and Potassium (K) are among the most important elements that are essential for potato productivity [8]. So, more or less same economic yield could be obtained by the integrated use of half of the recommended dose of fertilizers along with bio-fertilizers and organic manures which can save 50% of the inorganic fertilizers [9]. Organic and inorganic fertilizers have beneficial effects on both soil properties and its long-term productivity.

Many experiments have been conducted to check the effects of organic and inorganic fertilizers on the soil properties, crop yield and agronomical outcomes under different agro-environmental conditions [10].

Materials and Methods

The research work was conducted at the Horticulture Research Farm of Lovely Professional University, Phagwara, Punjab from November 2018 to February 2019. This University is geographically situated at a latitude 31˚ 22'31. 81'N and 75˚23'03. 02 E longitude with altitude of 252 m above the mean sea level, which falls under the central plain zone of Punjab.

The experiment was carried out by using potato variety Kufri Chipsona- 3. The experimental trial has been conducted in randomized complete block design with three replications. The planting of tubers was done at a spacing of 60 cm × 20 cm during November 2018. The number of treatments were eight [T_1- 100% recommended dose of NPK, T_2- 100% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha, T_3- 100% recommended dose of NPK + vermicompost @ 13 t/ha, T_4- 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha, T_5- 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha, T_6- 75% recommended dose of NPK + vermicompost @ 13 t/ha + PSB @ 10 kg/ha, T_7- 75% recommended dose of NPK + vermicompost @ 13 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha and T_8- absolute control]. Five plants in each plot were used for taking the observations. The yield and quality parameters were recorded after harvesting and growth parameters like plant height and number of compound leaves/plant were recorded at 30, 60 and 90 days after planting, respectively. Data were analysed using analysis of variance (ANOVA) to evaluate the differences among treatments while the means were separated using the critical differences (CD) test at 5% level of significance using OPSTAT and Microsoft office excel.

Following observations were recorded

1. Plant height (cm)
2. Number of compound leaves/plant
3. Dry matter content (%)
4. Specific gravity (g/cm^3)
5. Yield (t/ha)

Results and Discussion

Growth parameters

The highest plant height (39.85 cm, 48.73 cm and 51.62 cm) at 30, 60 and 90 days after planting was recorded in treatment T_4 (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was found to be statistically significant over the other treatments, while the minimum plant height (13.28 cm, 24.27 cm and 27.41 cm) at 30, 60 and 90 days after sowing was recorded in treatment T_8 (absolute control) (Table 1). The maximum number of compound leaves (41.84, 46.46 and 49.49) at 30, 60 and 90 days after planting was recorded in treatment T_4 (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was found significant over other treatments, while the minimum number of compound leaves (30.14, 35.75 and 38.49) at 30, 60 and 90 days after planting was recorded in T_8 (absolute control). The maximum values for plant height and compound leaves were recorded in treatment T_4 (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which might be due to the integrated use of organic manures, bio-fertilizers and inorganic fertilizers that enhanced the plant's nitrogen utilization ability [11]. Moreover bio-fertilizers like PSB makes available necessary nutrients to plants because of the microorganism present in them that colonizes in rhizosphere and therefore increases the growth of the pant. Similar results were also reported in earlier studies [12].

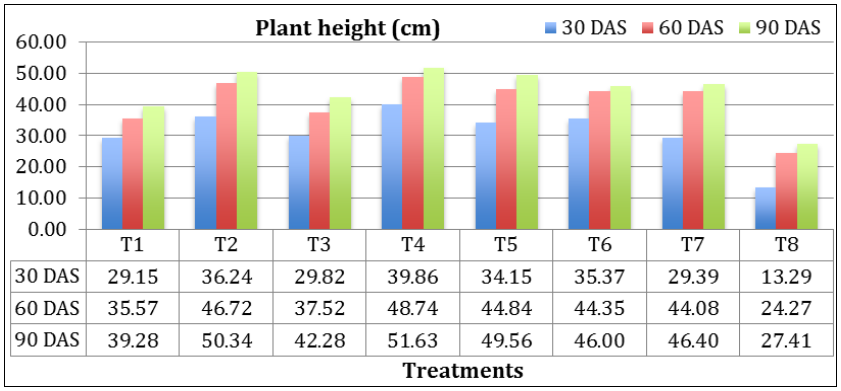
The highest chlorophyll index (50.33) was recorded in treatment T_3 (100% RDF of NPK + vermicompost @ 13 t/ha) which was at par with the treatment T_1- 100% RDF of NPK (47.56) while the minimum chlorophyll index was found in treatment T_5 [75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha]. The highest value of chlorophyll index in T_3 might be due to the application of vermicompost with higher dose of nitrogen that supplies plant growth regulating substances which directly increases the plant growth. Similar results have also been reported [13].

Quality parameters

The highest dry matter content (20.66%) and specific gravity (1.12 g/cm^3) was recorded in the treatment T_4 (75 % RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) which was significant over the other treatments. The minimum value of dry matter (16%) and specific gravity (1.05 g/cm^3) was recorded in treatment T_7 [75% recommended dose of NPK/ha + vermicompost @ 13 t/ha + VAM (Vesicular-Arbuscular Mycorrhiza) @ 10 kg/ha]. The highest value of dry matter and specific gravity might be due to the combined application of inorganic fertilizers with organic manures like FYM (Farm Yard Manure) which enhanced the microbial activity and led to the greater availability of nutrients, translation of unavailable to available forms and improved properties (physical, biological and chemical) of soil [14].

Yield parameters

The highest total yield (27.9 t/ha) was recorded in treatment T_4 (75% RDF of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha) while the minimum yield (7.4 t/ha) was recorded in treatment T_8 (absolute control). It was also reported that the integrated use of 50% recommended dose of NPK with FYM (Farm Yard Manure) produced higher tuber bulking rate that ultimately increased the yield/ha of potato [15]. Also, the increase in yield/ha might be due to the fact that bio-fertilizers provide a better supply of nutrients especially P and N because of greater biological nitrogen fixation, phosphorus solubilization, development of better root system and secretion of plant hormones [16].



	T1	T2	T3	T4	T5	T6	T7	T8
30 DAS	29.15	36.24	29.82	39.86	34.15	35.37	29.39	13.29
60 DAS	35.57	46.72	37.52	48.74	44.84	44.35	44.08	24.27
90 DAS	39.28	50.34	42.28	51.63	49.56	46.00	46.40	27.41

Fig 1: Mean data of plant height (cm)

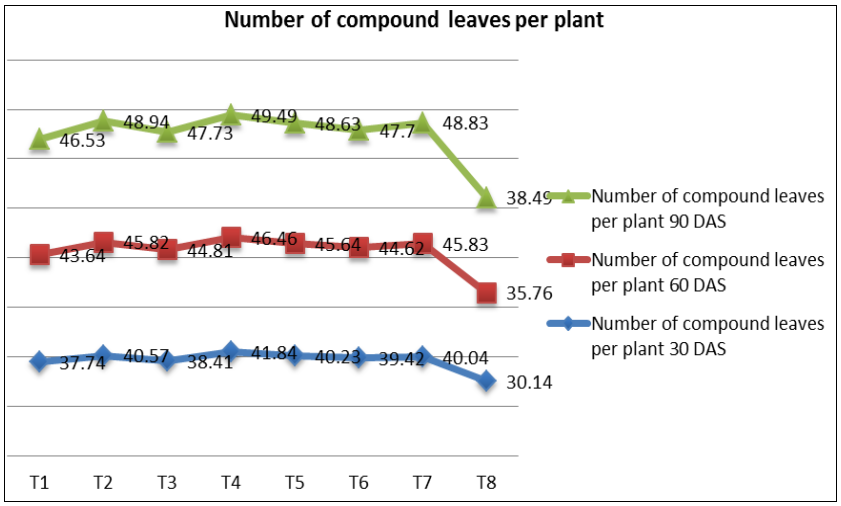


Fig 2: Mean data of number of compound leaves per plant

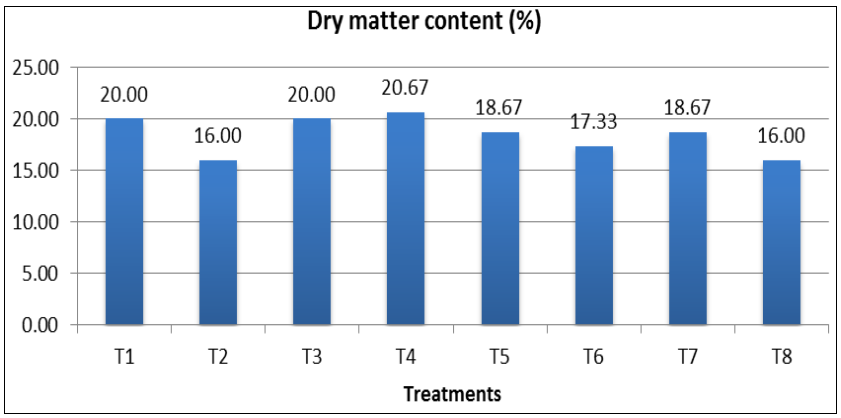


Fig 3: Dry matter content (%)

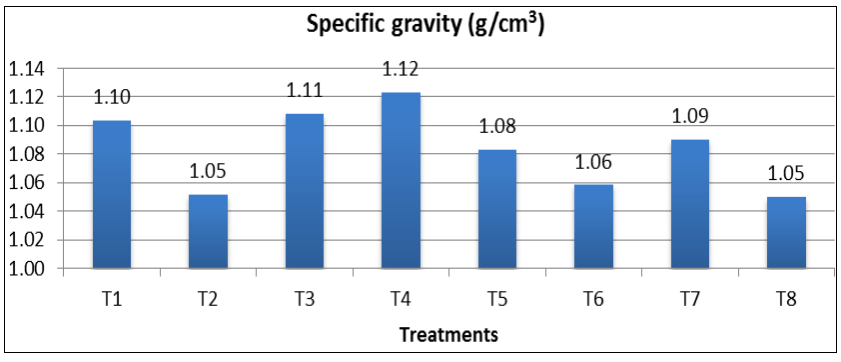


Fig 4: Specific gravity (g/cm^3)

Benefit: Cost ratio of potato production under integrated nutrient management: Higher money value of produce and less cost of management are desirable traits for getting higher returns. Hence, economics of the treatments was worked out. Price of inputs used, total cost of cultivation and economics of different treatments is depicted in Table 2, 3 and 4 respectively.

The present study indicated that, among the various treatments the benefit: cost ratio was higher in treatment T_4 having 75% recommended dose of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha (2.21) followed by T_1 having 100% recommended dose of NPK (2.13). Similar findings were obtained in previous studies [17, 18] by the use of chemical fertilizers with organic manures.

Table 1: Effect of integrated nutrient management on the growth, yield and quality attributes of potato

Treatments		Plant height (cm)			Number of compound leaves			Dry matter (%)	Specific gravity (g/cm^3)	Yield (t/ha)
		30 days after sowing	60 days after sowing	90 days after sowing	30 days after sowing	60 days after sowing	90 days after sowing			
T_1	100% RDF of NPK	29.14	35.57	39.28	37.74	43.64	46.53	20.00	1.11	24.01
T_2	100% RDF of NPK + FYM @ 50 t/ha	36.24	46.71	50.34	40.57	45.82	48.94	16.00	1.05	24.36
T_3	100% RDF of NPK + vermicompost @ 13 t/ha	29.82	37.52	42.27	38.41	44.81	47.72	20.00	1.10	20.25
T_4	75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha	39.85	48.73	51.62	41.84	46.46	49.49	20.66	1.12	27.90
T_5	75% RDF of NPK + FYM @ 50 t/ha + VAM @ 10 kg/ha	34.15	44.84	49.56	40.23	45.64	48.62	18.66	1.08	22.96
T_6	75% RDF of NPK + vermicompost @ 13 t/ha + PSB @ 10 kg/ha	35.37	44.34	46.00	39.41	44.61	47.69	17.33	1.06	22.00
T_7	75% RDF of NPK + vermicompost @ 13 t/ha + VAM @ 10 kg/ha	29.39	44.08	46.39	40.04	45.82	48.83	16.00	1.05	18.92
T_8	Absolute control	13.28	24.27	27.41	30.14	35.75	38.49	18.66	1.09	7.49
	Grand mean	30.90	40.73	49.18	38.54	44.06	47.03	18.33	1.08	20.98
	C.D. @ 5 %	1.183	0.866	4.239	0.432	0.487	0.371	2.592	0.026	6.550
	SE(m)	0.386	0.283	1.384	0.141	0.159	0.121	0.846	0.009	2.139
	SE(d)	0.546	0.400	1.957	0.200	0.225	0.171	1.197	0.012	3.025
	C.V.	2.165	1.202	5.434	0.634	0.625	0.446	7.960	1.366	17.649

Table 2: Price of inputs used

S. No.		Amount	Price	Total cost (Rs.)
1.	**Organic manures and Bio-fertilizers (Rs.)**			
a.	Vermicompost	13 t/ha	Rs. 6/kg	Rs. 78000
b.	FYM	50 t/ha	Rs. 300/ton	Rs. 15000
c.	PSB	10 kg/ha	Rs. 100/kg	Rs. 1000
d.	VAM	10 kg/ha	Rs. 100/kg	Rs. 1000
2.	**Inorganic fertilizers**			
a.	Urea	187.5 kg/ha	Rs. 350/50 kg	Rs. 1312
b.	DAP	62.5 kg/ha	Rs. 1175/50 kg	Rs. 1468
c.	MOP	62.5 kg/ha	Rs. 560/50 kg	Rs. 700
3.	Total Cost of cultivation			Rs. 1,11,505
4.	Market price of potato			Rs.15/kg

Table 3: Treatment wise total cost of cultivation (Rs. /ha)

S. No.	Treatments	Fertilizer cost (Rs. /ha)	Fixed cost + Variable cost (Rs. /ha)	Total cost (Rs. /ha)
1.	T_1	3,480	1,11,505	1,14,985
2.	T_2	18,480	1,11,505	1,29,985
3.	T_3	81,480	1,11,505	1,92.985
4.	T_4	18,610	1,11,505	1,30,115
5.	T_5	18,610	1,11,505	1,30,115
6.	T_6	81,610	1,11,505	1,93,115
7.	T_7	81,610	1,11,505	1,93,115
8.	T_8	0	1,11,505	0

Table 4: Benefit: Cost ratio of different treatments

Treatments	Total cost of cultivation (Rs.)	Yield (t/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	Benefit: cost ratio
T_1	1,14,985	24.01	3,60,150	2,45,165	2.13
T_2	1,29,985	24.36	3,65,400	2,35,415	1.05
T_3	1,92,985	20.25	3,03,750	110765	0.57
T_4	1,30,115	27.90	4,18,500	2,88,385	2.21
T_5	1,30,115	22.96	3,44,400	2,14,285	1.64
T_6	1,93,115	22.00	3,30,000	136885	0.70
T_7	1,93,115	18.92	2,83,800	90685	0.46
T_8	1,11,505	7.49	1,12,350	845	0.007

Conclusion

On the basis of results obtained from the present investigation it may be concluded that application of 75% recommended dose of NPK + FYM (Farm Yard Manure) @ 50 t/ha + PSB @ 10 kg/ha increased the vegetative growth parameters [plant height (51.62 cm), number of compound leaves/plant (49.49)], quality parameters [dry matter (20.66%) and specific gravity (1.12 g/cm^3)] and total yield (27.90 t/ha) of potato.

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