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Assessment of different level of Integrated Nutrient Management to Improve Soil Properties Growth and Yield of Potato (*Solanum tuberosum* L.)

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A B S T R A C T

In Agriculture, chemical fertilizers are not only in limited supply but also expensive in developing countries like India. In the potato crop use of chemical fertilizer is increasing day by day, moreover, the continuous use of these fertilizers adversely affects the soil health, which is a major concerned for farmers because the present field experiment is entitled as "Assessment of different level of Integrated Nutrient Management to Improve Soil properties growth and Yield of Potato (*Solanum tuberosum* L.) Var. Kufri Badshah" was carried out in *Rabi* during 2019 in sandy loam soil with organic matter, available N P K and pH EC are recorded as 0.52 %, 280.24 kg ha^{-1}, 35.50 kg ha^{-1}, 175.14 kg ha^{-1}, 7.33, 0.04 dS m^{-1} at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj district of Uttar Pradesh India. the experiment consisted of 9 treatment combinations and which were replicated thrice and laid out in a randomized block design. The results showed that progressive increase in the soil health, and plant growth parameters was found the best in treatment combination T_8 - [RDF @ 75% + Vermicompost @ 5 t ha^{-1} + 1 kg ha^{-1} PSB] and it was found to be best in the production of potato.

Introduction

Potato (*Solanum tuberosum* L.) native to tropical South America and one of the most efficient food crops which produces more dry matter, dietary fiber, quality protein, minerals, vitamins and richest source of energy (Anonymous, 2015a). The area and production of potato in the country is estimated around 20.85 lakhs hectares and 480.96 lakh million tonnes, respectively with the productivity of 23.07 tonnes per hectare (Anonymous, 2015b). In order of importance for food production in comparison to other

major food crops on the fresh weight basis, potato ranks 6th in developing countries, 4th in developed countries and 3rd in India (Khurana and Naik, 2003). The protein in potato is of good quality with regard to essential amino acids in human nutrition. It also has the substantial amounts of vitamins, minerals and traces of other nutrients. With all these characters, potato undoubtedly a very important crop for countries with the high human population density like India where adequate protein and calories can be supplied cheaply for the nutritional needs calling it as "Poor man's crop" (Shubha, 2018). Inorganic and bio fertilizers are the need of the hour for sustainable productivity and to maintain better soil health (Jagadeesh *et al.*, 1994). To increase the production and quality of potato, judicious combination of organic sources of nutrients along with inorganic and biofertilizers (Azotobacter and phosphobacteria) receive the good response (Nag, 2006). Phosphate solubilizing Bacteria (PSB) are capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds and PSB produce phosphatase like phytase that hydrolyze organic forms of phosphate compounds efficiently. Biofertilizers are living organisms used in the fertilization of soil and are useful in supplementing the usual application of chemical fertilizers and help in enriching the soil. Continuous application of heavy doses of chemical fertilizers without organic manures or bio fertilizers has led to a deterioration of soil health in terms of physical and chemical properties of soil, declining of soil microbial activities, reduction in soil humus, increased pollution of soil, water and air. Hence, considering the economy, environment friendliness and maintain better soil health, it is imperative that plant nutrients are to be used effectively by adopting the integrated nutrient management practices. The basic principle behind this concept is to supply both the chemical fertilizers and organic manures for a sustainable crop production in most efficient manner, although the modern technique of intensive crop production needs the use of chemical fertilizers. Keeping this in mind the experiment was undertaken to find the effect of INM on growth, yield and quality of potato.

Materials and Methods

The experiment was conducted on the research farm of department of soil science and agricultural chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj city on the bank of Yamuna river, the experimental site was located in the sub-tropical region with $25^0$26'41" +N latitude, $81^0$50'35" E longitude and 98 m above from the MSL. The soil of experimental area falls in order of Inceptisols and soil is alluvial in nature with sandy loam texture. The samples randomly collected from five different sites in the experimental plot prior to tillage operations from a depth of 0-15 cm. the size of the entire soil sample was reduced by conning and quartering process the remaining soil was dried under shade and passed through a 2 mm sieve by way of preparing the sample for physical and chemical analysis. The experimental details are given below. The present experiment consist of 9 treatments which were replicated thrice and laid out in a randomised block design and the treatment combinations are T_1- [@absolute control], T_{2-} [@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB], T_{3-} [@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB], T_{4-} [@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB], T_{5-} [@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB], T_{6-} [@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB], T_{7-} [@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB], T_{8-} [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB], T_{9-} [@ 100% RDF]. The general

recommended dose of NPK is 180:65:65 kg ha^{-1} (Table 1–3).

Results and Discussion

As data presented in table 4 and fig.1 showed that the maximum bulk density was observed in the treatment combination T_{5}- [@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB] there was a significant value in particle density, Bulk Density, Non-significant values were observed in specific gravity. As data presented in table 5 and fig. 2 there was significant values in Solid Space, Pore space, Water holding capacity and yield. As data presented in table 6 and fig.3 there was significant values in pH, Electrical conductivity, the Organic carbon content observed maximum (0.95%) in T_{8}- [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha-1 PSB]. water holding capacity observed maximum (66.13%) in T_{4}- [@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB]. As data presented in table 7 and fig.4 there was significant values in Available nitrogen, phosphorous and potassium were recorded highest (N- 375.94 kg ha^{-1}, P- 41.26 kg ha^{-1}, K-182.35 kg ha^{-1}) in the treatment combination T_{8}- [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB]. As data presented in table 8 and table 9, as shown in the fig.5 and fig.6 there was significant values in plant height and number of leaves at 30,60 and 90 DAS, T_{8}- [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB] performs well in vegetative growth. As data presented in table 10 and fig. 7 there was significant values in yield, maximum yield was observed in treatment T_{8}- [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB]. Integrated nutrient management is the best approach to supply adequate and balanced nutrients and increase crop productivity in an efficient and eco-friendly manner, without sacrificing soil productivity of future generations.

Table.1 Soil physical parameters

S. No.	Particulars	Method	Scientist and year
1.	Particle Density (Mg m^{-3})	Graduated cylinder method	Muthuaval *et al*., (1992)
2.	Bulk Density (Mg m^{-3})	Graduated cylinder method	Muthuaval *et al*., (1992)
3.	Pore space (%)	Graduated cylinder method	Muthuaval *et al*., (1992)
4.	Water Holding capacity (%)	Graduated cylinder method	Muthuaval *et al*., (1992)
5.	Soil texture	Bouyoucos method	Bouyoucos (1927)
6.	**S**oil colour	Munsell colour chart method	Albert H Munsell (1905)

Table.2 Soil chemical parameters (Jaiswal, 2006)

S. No.	Particulars	Method	Scientist and year
1.	pH	Glass Electrode pH Meter	Jackson(1954)
2.	EC (dS m^{-1})	Conductivity Bridge Meter	Wilcox (1950)
3.	Organic carbon (%)	Wet-oxidation method	Walkley and Black (1947)
4.	Available nitrogen (kg ha^{-1})	Alkaline Permanganate Method	Subbiah and Asija (1956)
5.	Phosphorus (kg ha^{-1})	Olsen method	Olsen *et al.*, (1954)
6.	Potassium (kg ha^{-1})	Flame Photometer Method	Toth and Prince (1949)

Table.3 Plant parameters

S. No.	Plant parameters
1.	Number of leaves
2.	Plant Height (cm)
3.	Yield (q ha^{-1})

Table.4 Interaction effect of integrated nutrient management on soil bulk density, particle density and specific gravity

	Treatment combination	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Specific gravity
T_{1}-	@absolute control	1.23	2.66	2.33
T_{2}-	@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	1.28	2.50	2.53
T_{3}-	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	1.20	2.74	2.41
T_{4}-	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	1.26	2.75	2.40
T_{5}-	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	1.47	2.75	2.53
T_{6}-	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	1.23	2.74	2.61
T_{7}-	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	1.32	2.61	2.37
T_{8}-	@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @1kg ha^{-1} PSB	1.17	2.74	2.44
T_{9}-	@100% RDF	1.39	2.57	2.43
	f-test	S	S	N S
	S.Em. (±)	0.056423	0.057331	0.07939
	C.D. at 5 %	0.1691584	0.171879294	0.238028716

Table.5 Assessment of integrated nutrient management on soil solid space, pore space and water holding capacity

	Treatment combination	solid space (%)	pore space (%)	W.H.C (%)
T_{1}-	@absolute control	44.60	55.40	64.50
T_{2}-	@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	41.72	58.28	62.13
T_{3}-	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	36.97	58.96	65.00
T_{4}-	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	37.52	62.48	66.13
T_{5}-	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	36.47	63.53	60.97
T_{6}-	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	40.14	62.70	66.08
T_{7}-	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	39.70	55.47	64.07
T_{8}-	@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	39.62	60.38	65.73
T_{9}-	100% RDF	45.74	54.26	62.26
	f-test	S	S	S
	S.Em. (±)	2.01	1.87	0.70
	C.D. at 5 %	6.05	5.63	2.12

Table.6 Efficiency of integrated nutrient management on soil pH 1:25 (w/v), EC (dS m^{-1}) and Organic

	Treatment combination	soil pH	Electrical Conductivity	Organic Carbon
T_{1-}	@absolute control	7.41	0.03	0.54
T_{2-}	@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	6.69	0.04	0.81
T_{3-}	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	6.82	0.03	0.84
T_{4-}	@ 25% RDF+@5tha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	7.18	0.04	0.91
T_{5-}	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	6.71	0.03	0.91
T_{6-}	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	6.72	0.04	0.82
T_{7-}	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	6.87	0.04	0.91
T_{8-}	@ 75% RDF +@2.5t ha-^{1} Vermicompost + @ 1 kg ha^{-1} PSB	7.34	0.04	0.95
T_{9-}	100% RDF	7.17	0.04	0.85
	f-test	S	S	S
	S.Em. (±)	0.04	0.001	0.02
	C.D. at 5 %	0.13	0.003	0.07

Table.7 Interaction effect of integrated nutrient management on available Nitrogen, Phosphorus and Potassium of the soil

	Treatment combination	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_{1-}	@absolute control	225.40	25.25	139.47
T_{2-}	@ 25% RDF + @ 5 t ha^{-1} Rice straw + @ 1 kg ha^{-1} PSB	330.83	38.06	175.87
T_{3-}	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	337.75	31.18	154.37
T_{4-}	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	325.57	35.93	173.25
T_{5-}	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	329.03	35.75	155.90
T_{6-}	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	341.75	41.26	160.33
T_{7-}	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	350.60	39.67	181.14
T_{8-}	@ 75% RDF + @ 2.5 t ha-^{1} Vermicompost + @ 1 kg ha^{-1} PSB	375.94	41.26	182.35
T_{9-}	@ 100% RDF	355.65	33.30	176.59
	f-test	S	S	S
	S. Em. (±)	1.790	1.639	3.70
	C.D. at 5 %	5.36	4.91	11.11

Table.8 Interaction effect of integrated nutrient management on plant height at 30, 60 and 90 DAS in potato

	Treatment combination	30 DAS	60 DAS	90DAS
T_{1}-	@absolute control	23.82	33.4	39.34
T_{2}-	@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	27.19	39.3	44.83
T_{3}-	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1kg ha^{-1} PSB	26.4	37.1	42.39
T_{4}-	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	27.66	37.16	42.76
T_{5}-	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	25.31	39.7	43.69
T_{6}-	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	25.51	40.3	43.69
T_{7}-	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	28.10	40.02	44.35
T_{8}-	@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @1kg ha^{-1} PSB	26.51	42.01	46.78
T_{9}-	@ 100% RDF	26.50	40.03	43.21
	f-test	S	S	S
	S. Em. (±)	0.66	1.04	1.10
	C.D. at 5 %	2.00	3.12	3.31

Table.9 Interaction effect of integrated nutrient management on number of leaves at 30, 60 and 90 DAS in Potato

	Treatment combination	30 DAS	60 DAS	90DAS
T_{1}-	@absolute control	51.53	101.00	110.93
T_{2}-	@ 25% RDF +@5t ha^{-1}Rice straw+@ 1kg ha^{-1}PSB	57.60	103.86	118.53
T_{3}-	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	57.40	103.46	117.86
T_{4}-	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	60.07	110.60	122.60
T_{5}-	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	59.73	110.00	122.20
T_{6}-	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	60.80	108.20	120.90
T_{7}-	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	59.27	107.73	120.46
T_{8}-	@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	60.93	112.73	129.60
T_{9}-	@ 100% RDF	57.60	107.13	123.08
	f-test	S	S	S
	S. Em. (±)	1.50	2.19	1.35
	C.D. at 5 %	4.51	6.59	4.05

Table.10 Interaction effect of integrated nutrient management on tuber yield of Potato

	Treatment combination	Yield (q ha^{-1})
T_{1}-	@absolute control	30.32
T_{2}-	@ 25% RDF + @ 5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	41.91
T_{3}-	@ 25% RDF + @ 5 t ha^{-1} Poultry manure + @ 1 kg ha^{-1} PSB	42.06
T_{4}-	@ 25% RDF + @ 5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	43.03
T_{5}-	@ 50% RDF + @ 2.5 t ha^{-1} FYM + @ 1 kg ha^{-1} PSB	45.27
T_{6}-	@ 50% RDF + @ 2.5 t ha^{-1} Poultry Manure + @ 1 kg ha^{-1} PSB	43.95
T_{7}-	@ 50% RDF + @ 2.5 t ha^{-1} Rice straw+ @ 1 kg ha^{-1} PSB	41.67
T_{8}-	@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB	49.31
T_{9}-	@ 100% RDF	48.20
	f-test	S
	S.Em. (±)	0.69
	C.D. at 5 %	2.08

Fig.1 Interaction effect of integrated nutrient management on soil bulk density, particle density and Specific gravity

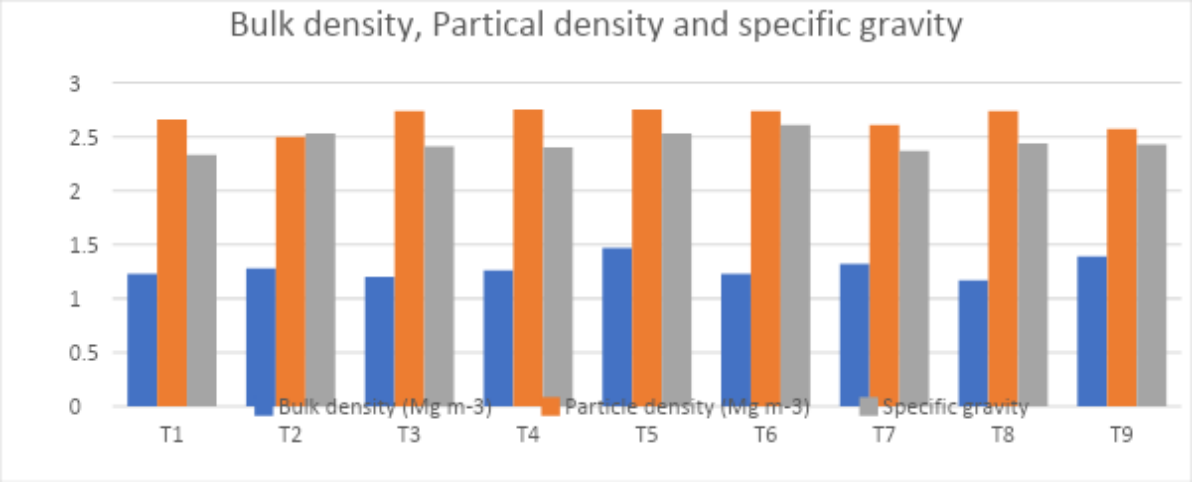


Fig.2 Interaction effect of integrated nutrient management on solid space, water retaining capacity and pore space of soil

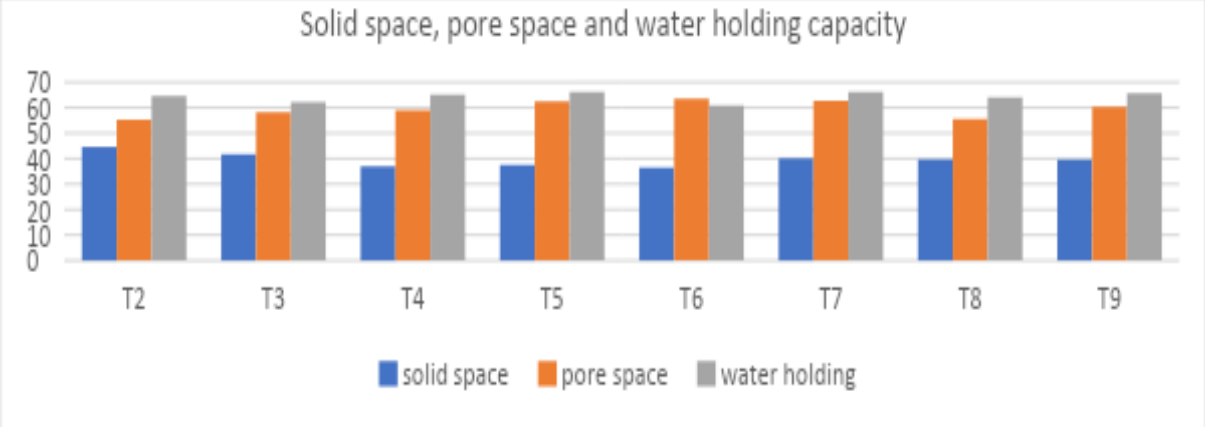


Fig.3 Efficiency of integrated nutrient management on soil pH, Electrical Conductivity and O.C

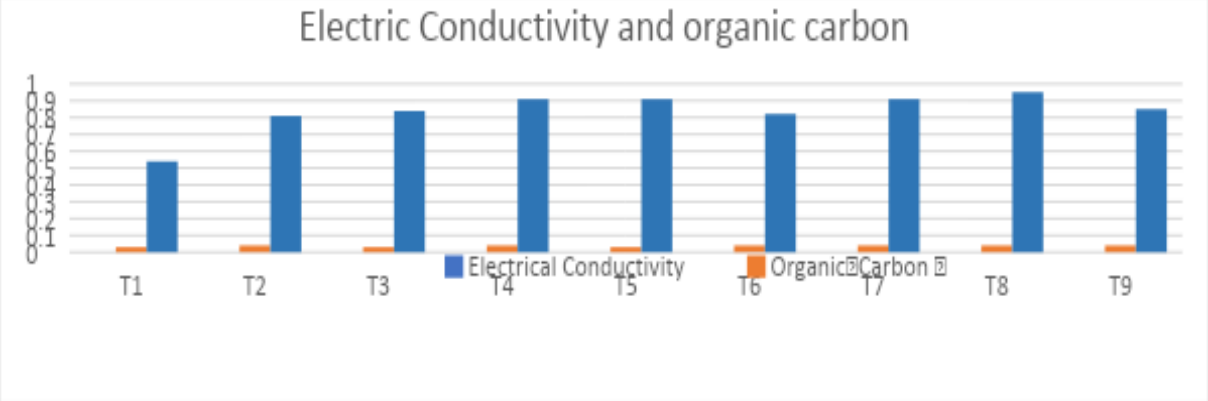


Fig.4 Interaction effect of integrated nutrient management on available Nitrogen, Phosphorus and Potassium of the soil

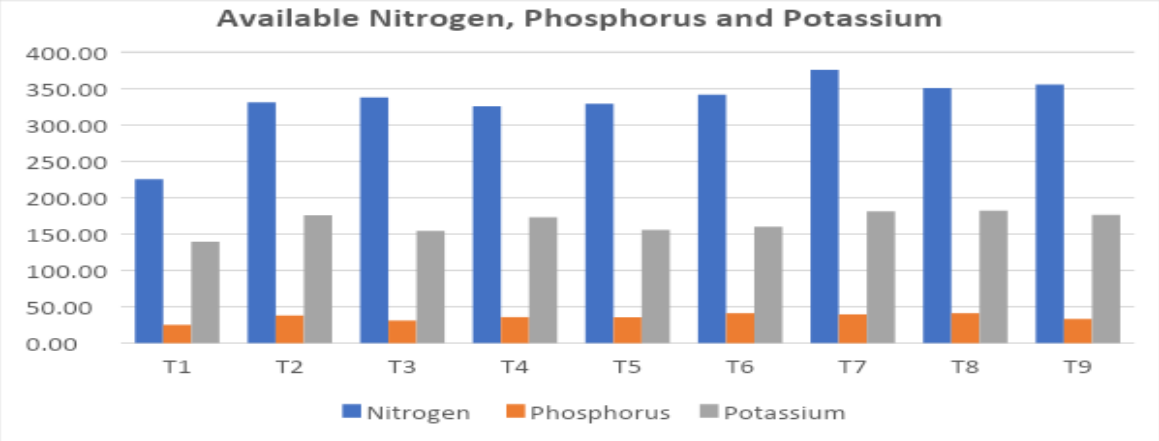


Fig.5 Interaction effect of integrated nutrient management on plant height (cm) at 30, 60, and 90 DAS in Potato

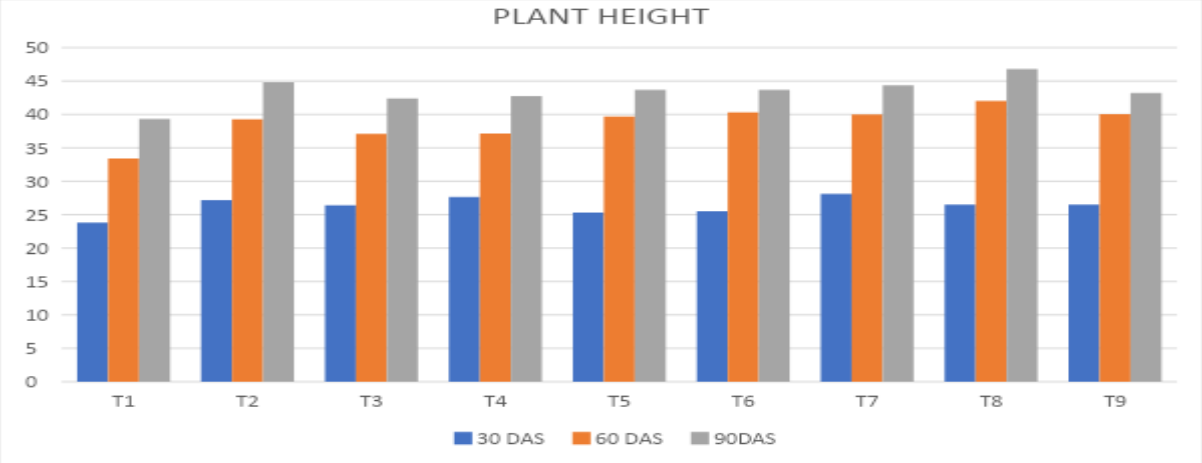


Fig.6 Interaction effect of integrated nutrient management on number of leaves at 30, 60 and 90 DAS in Potato var. Kufri Badshah

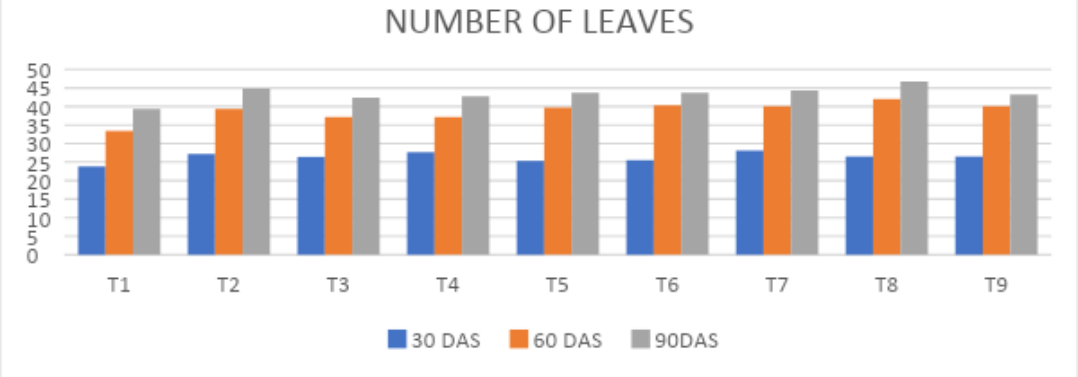
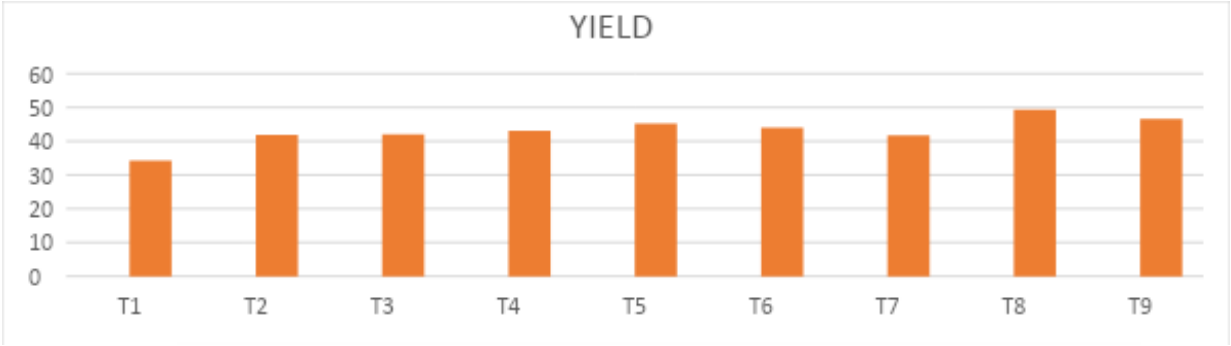


Fig.7 Interaction effect of integrated nutrient management on yield in Potato



Summary

The experiment was conducted at the Research Farm of Soil Science and agricultural chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during *Rabi* season 2019-2020 to study the "Assessment of different level of Integrated Nutrient Management to Improve Soil Properties Growth and Yield of Potato" in Prayagraj Soil.

The treatments were allocated in a randomized block design with three replications. The treatments consisted of combination of different levels of NPK, organic manures and a bio-fertilizer.

The plot treated with treatment combination T_8-@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB there was significant increase in vegetative growth and yield attributes. Soil properties like Bulk density, Particle density, solid space, pore space, water holding capacity, soil pH, Electrical conductivity, organic carbon, Available nitrogen, phosphorous and potassium shows significant values except specific gravity. The combinations of different level of organic, inorganic and biofertilizers performed good results in treatment T_8 - [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB] resulted in plant growth, number of leaves and yield of Potato. Economics for all treatments were calculated according to expenditure included from the land preparation to till harvesting of the crop. gross return, net return and cost of cultivation were calculated. From the economical point of view the treatment combination T_8 - [@ 75% RDF + @ 2.5 t ha^{-1} Vermicompost + @ 1 kg ha^{-1} PSB] gave the maximum profit of 47312.00 Rs. ha^{-1} with C:B ratio of 1:1.47.

It was concluded from the trail that, the treatment T_8 - [@ 75% RDF + @ 2.5 t ha^{-1} vermicompost + @ 1 kg ha^{-1} PSB] particularly 2.5 t ha^{-1} vermicompost in combination with 75% recommended dose of fertilizers was found to be significant and showing significant results in the terms of Soil health (bulk density, particle density, solid space, pore space, water holding capacity, soil pH, Electrical conductivity, organic carbon, Available nitrogen, phosphorous potassium) and growth parameters (plant height, number of leaves per plant and tuber yield) and from the economical point of view the same treatment combination gave the maximum profit of 47,312.00 Rs. ha^{-1} with C:B ratio of 1:1.47.

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