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Response of integrated nutrient management practices on growth and tuber yield of potato crop (*Solanum tuberosum* L.) in clay soils of Punjab

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Abstract
Toinvestigate the response of integrated nutrient management (INM) practices on growth and tuber yield of potato crop (*Solanum tuberosum* L.) in clay soils of Punjab was conducted during *rabi* season of 2017-18 at the Campus for Agricultural Research and Advanced Studies Dhablan of the G.S.S.D.G.S. Khalsa College Patiala, Punjab. The field experiment was laid out in randomized block design with 13 different treatments with 3 replications. Integrated nutrient management significantly influenced the growth and tuber yield of potato crop. All the growth parameters like plant height (cm), number of branches plant^{-1}, fresh weight plant^{-1}and tuber yield (200.26 q ha^{-1}) was significantly higher in treatment $T_7$with 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* which was followed by treatment T_6 with 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}.

Keywords: Potato, integrated nutrient management, vermicompost and *Azotobacter*

Introduction
Potato (*Solanum tuberosum* L.) is one of the superior tuber cropbelongs to family Solanaceae. It is the fourth important food crop after Rice, Wheat and Maize. It is also known as king of vegetables and poor man's friend. It is an economical food and they provide a source of low cost energy to the human diet. It is rich source of minerals, vitamin B, C, and starch. It contains 2.15% proteins, 20.6% carbohydrates, 1.1% crude fiber, 18-20% starch content, 0.3% fat and 0.9% ash. It also contains a good amount of essential amino acids like leucine, isoleucine and tryptophane (Khurana and Naik 2003) [10]. The origin of potato is South America (Peru). Evidences indicate that potato where cultivated for Centuries by South American Indians. According to Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), in 2016-17, the total worldwide production is 388.19 million tonnes from 19.30 million hectare. In India, Potato is cultivated in about 1.5 million hectares with total production of 26.1million tonnes. It is cultivated on a large scale in U.P., West Bengal, Bihar and Punjab. In Punjab, potato is cultivated in an area of 94 thousand hectare with production of 2.2million tonnes (Anonymous 2016) [4]. The rising need for integrated nutrient management system due to minimize the requirement of inorganic fertilizers, to restore organic matter in soil, to increase nutrient use efficiency, to improve the soil heath and enhance the crop productivity. Plant nutrition plays an important role for increasing growth and yield in potato. Addition of organic matter through FYM have great significance for enhancing the potato yield as it exerts significant influence an physical, chemical and biological properties of soil. It has been found more effective in supplying N to potato crop and maintain soil fertility status over 100% RDF (Yadav *et al.* 2014) [17].

Materials and Methods
The field experiment was laid out in randomized block design with 13 different treatments with 3 replications. The soil of experimental field was clay, soil pH 7.3, medium in organic carbon (0.52%), low in available nitrogen (262 kg ha^{-1}), medium in available phosphorus (22.6 kg ha^{-1}) and potassium (129 kg ha^{-1}). All the nutrients were applied in basal dose at one day before sowing. The plant material comprised of potato var.

Kufri Jyoti as per treatment was sown on 11 November, 2017 and harvested at 16February, 2018The crop was planted maintaining a distance of 60 cm and 20 cm between the row and plants respectively. Five representative sample plants were randomly selected from each of the plots plant height was recorded in cm. The numbers of branches per plant were counted from the five randomly selected sample plants and the values of these were summed up and averaged. To study the fresh and dry weight of five plants were collected from the sampling rows of each plot at 30 days interval from sowing till harvest of the crop. The plant samples were then weighted to record the average fresh weight. The produce was separated into 3 grades of tubers and weight and number of tubers were recorded separately for each grade. The tubers of each plot the border and sampling row was weighed in kilogram.

Results and Discussion

Integrated nutrient management has significantly effect on growth and tuber yield of potato crop. The result of present study found that the plant height increased significantly with increase in fertilizer combinations. The application of integrated nutrients management with the 100% RDF gave the significantly maximum plant height. The maximum plant height (29.42, 46.00 and 52.88 cm) was recorded under the treatment T_7 with 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter*. The favourable response of integrated nutrient management on highest plant height was also delineated by Mondal *et al.* (2005) [12], Alam *et al.* (2007) [3], Najm *et al.* (2010) [13], Yourtchi *et al.* (2013) [18] and Getie *et al.* (2015) [6].

The result of the present study indicates that the number of branches and fresh weight (g) was significantly enhanced with increase the integrated nutrient management. The highest number of branches (5.15, 7.03 and 9.63) and fresh weightplant^{-1} (g) (20.81, 33.48 and 43.17) was obtained in the treatment T_7 with 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter*. A similar result on number of branches and fresh weight (g) was also found by Yourtchi *et al.* (2013) [18], Ratna *et al.* (2016) [15] and Shubha *et al.* (2018) [16].

Potato tuber yield in q/ha also responded to the application integrated fertilizers. Treatment T_7 was significantly enhance the tuber yield and commodity value of potato. The maximum tuber yield (200.26 q ha^{-1}) was recorded the treatment T_7 with 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter*. Application of INM provides better nutrition to potato which resulted in higher tuber yield. This similar finding was also reported by Khan *et* al. (2010) [9], Jaipaul *et al.* (2011) [8], Balemi (2012) [5], Islam *et al.* (2013) [7], Narayan *et al.* (2013) [14], Ahmed *et al.* (2015) [1], Mama *et al.* (2016), Ahmed *et al.* (2017) [3] and Shubha *et al.* (2018) [16].

Table 1: Response of integrated nutrient management on plant height (cm) at different growth stages of potato

Treatments	Plant height (cm)		
	30 DAS	60DAS	At harvest
T_1.Control	18.70	34.52	39.98
T_2.100% RDF	19.66	36.33	40.98
T_3. 100% RDF + 2t Poultry manure ha^{-1}	21.43	37.67	42.96
T_4.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1}	22.21	39.00	45.75
T_5.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	23.00	40.83	48.36
T_6 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	27.74	43.63	50.95
T_7.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	29.42	46.00	52.88
T_8. 50% RDF	18.88	34.57	40.88
T_9. 50% RDF + 2t Poultry manure ha^{-1}	20.73	36.28	42.82
T_{10}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1}	21.77	38.65	44.85
T_{11}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	22.55	39.32	46.76
T_{12}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	23.33	40.85	48.40
T_{13}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	26.55	42.73	49.47
SE (d)	1.02	1.47	1.46
CD (0.50)	2.31	3.32	3.31

Table 2: Response of integrated nutrient management on number of branches plant^{-1} at different growth stages of potato

Treatments	Number of branches plant^{-1}		
	30 DAS	60DAS	At harvest
T_1.Control	1.94	3.05	4.70
T_2.100% RDF	2.11	3.48	5.11
T_3. 100% RDF + 2t Poultry manure ha^{-1}	3.00	3.63	5.44
T_4.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1}	3.40	4.88	6.11
T_5.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	4.04	5.22	6.77
T_6 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	4.92	6.23	8.32
T_7.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	5.15	7.03	9.63
T_8. 50% RDF	1.99	3.11	5.02
T_9. 50% RDF + 2t Poultry manure ha^{-1}	2.26	3.51	5.39
T_{10}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1}	3.14	3.84	5.58
T_{11}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	3.87	4.91	6.21
T_{12}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	4.10	5.39	7.12
T_{13}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	4.32	5.63	8.18
SE (d)	0.19	0.47	0.39
CD (0.50)	0.44	1.07	0.88

Table 3: Response of integrated nutrient management on Fresh weight plant^{-1} (g) at different growth stages of potato

Treatments	Fresh weight plant^{-1} (g)		
	30 DAS	60DAS	At harvest
T_1.Control	12.70	22.37	35.05
T_2.100% RDF	13.50	23.07	36.04
T_3. 100% RDF + 2t Poultry manure ha^{-1}	14.96	23.98	37.18
T_4.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1}	15.68	24.72	37.87
T_5.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	17.46	26.23	39.04
T_6 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	19.67	31.09	41.08
T_7.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	20.81	33.48	43.17
T_8. 50% RDF	13.42	22.55	35.87
T_9. 50% RDF + 2t Poultry manure ha^{-1}	14.71	23.76	36.22
T_{10}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1}	15.64	24.43	37.28
T_{11}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	16.93	25.77	38.12
T_{12}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	17.75	27.39	39.14
T_{13}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	18.22	29.63	40.43
SE (d)	1.09	1.42	1.18
CD (0.50)	2.46	3.21	2.66

Table 4: Response of integrated nutrient management on tuber yield (q ha^{-1}) of potato

Treatments	Tuber yield (q ha^{-1})
T_1.Control	104.40
T_2.100% RDF	153.67
T_3. 100% RDF + 2t Poultry manure ha^{-1}	167.67
T_4.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1}	175.65
T_5.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	185.18
T_6 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	194.37
T_7.100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	200.26
T_8. 50% RDF	143.25
T_9. 50% RDF + 2t Poultry manure ha^{-1}	165.67
T_{10}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1}	171.26
T_{11}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1}	181.61
T_{12}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1}	186.66
T_{13}. 50% RDF + 2t Poultry manure ha^{-1} + 20 kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter* (Seed treatment)	192.74
SE (d)	1.29
CD (0.50)	2.91

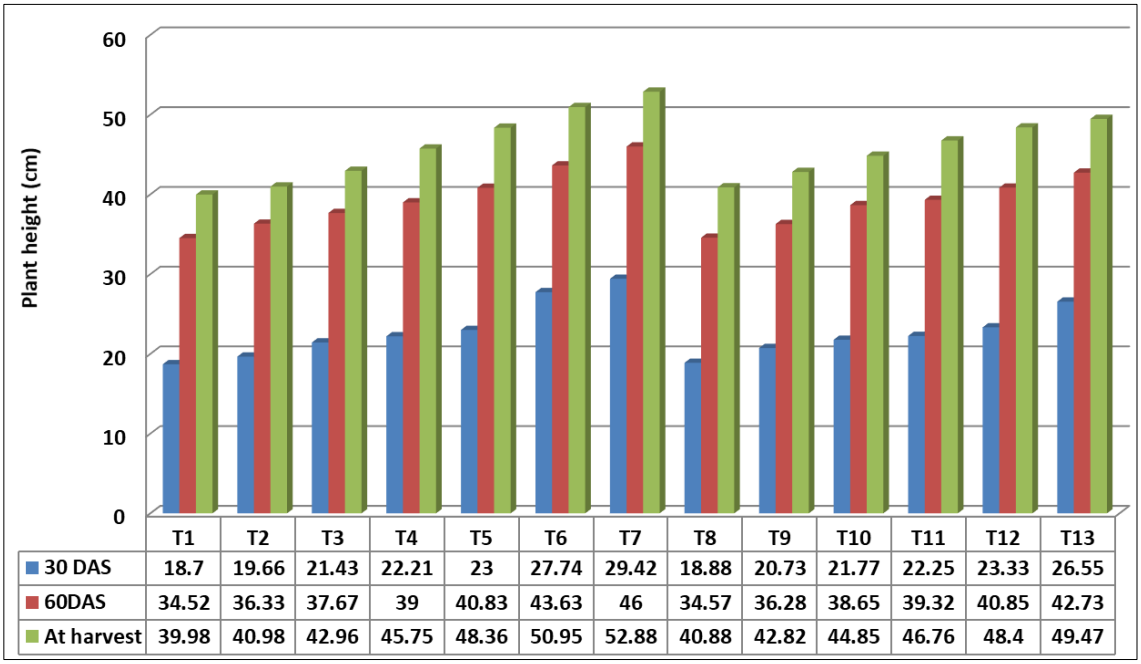
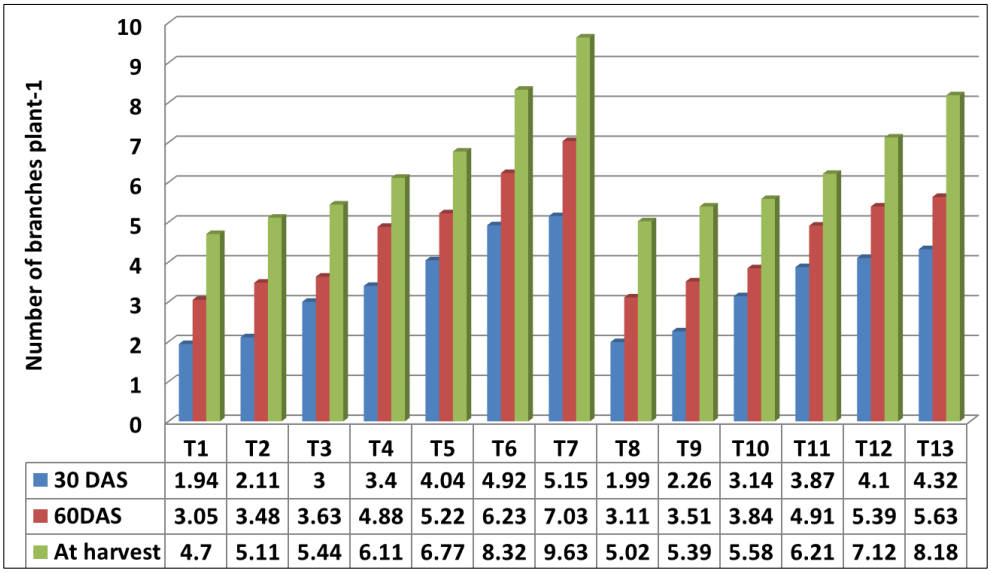


Fig 1: Response on integrated nutrient management on plant height (cm) at different growth stages of potato



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
30 DAS	1.94	2.11	3	3.4	4.04	4.92	5.15	1.99	2.26	3.14	3.87	4.1	4.32
60DAS	3.05	3.48	3.63	4.88	5.22	6.23	7.03	3.11	3.51	3.84	4.91	5.39	5.63
At harvest	4.7	5.11	5.44	6.11	6.77	8.32	9.63	5.02	5.39	5.58	6.21	7.12	8.18

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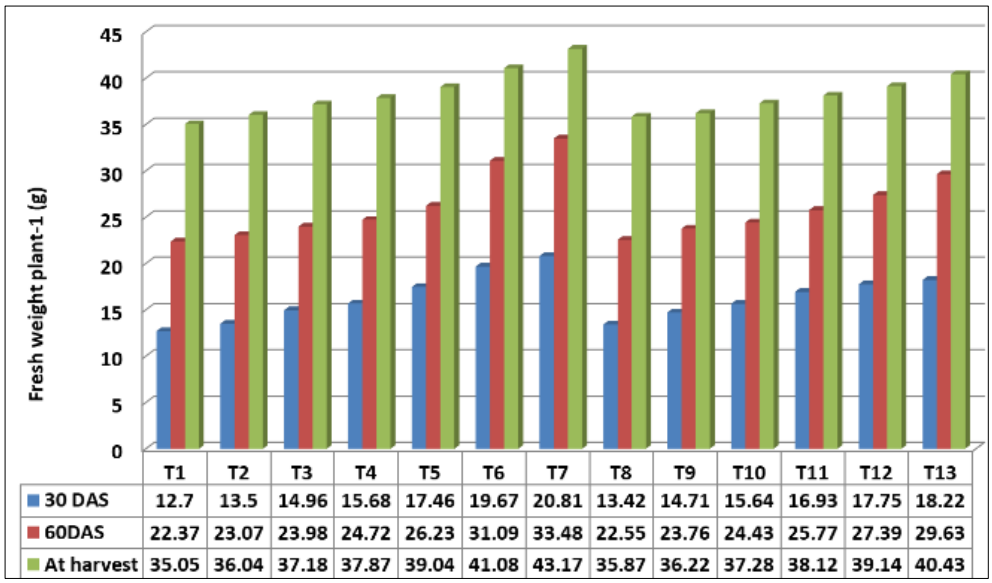
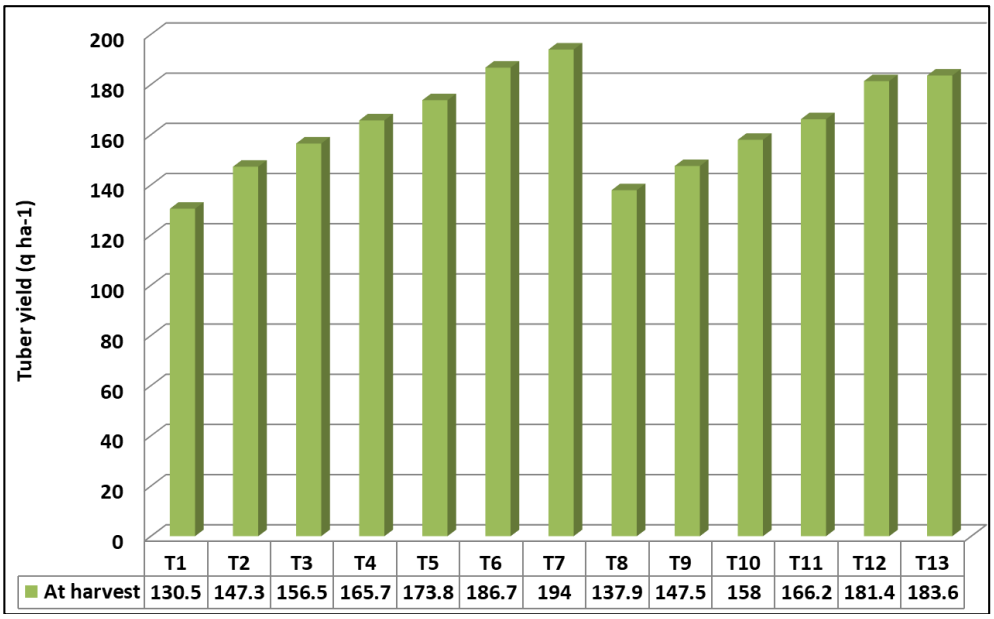
Fig 2: Response of integrated nutrient management on number of branches plant^{-1} at different growth stages of potato



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
30 DAS	12.7	13.5	14.96	15.68	17.46	19.67	20.81	13.42	14.71	15.64	16.93	17.75	18.22
60DAS	22.37	23.07	23.98	24.72	26.23	31.09	33.48	22.55	23.76	24.43	25.77	27.39	29.63
At harvest	35.05	36.04	37.18	37.87	39.04	41.08	43.17	35.87	36.22	37.28	38.12	39.14	40.43

Fig 3: Response of integrated nutrient management on Fresh weight plant^{-1} (g) at different growth stages of potato



	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
At harvest	130.5	147.3	156.5	165.7	173.8	186.7	194	137.9	147.5	158	166.2	181.4	183.6

Fig 4: Response of integrated nutrient management on tuber yield (q ha-1) of potato

Conclusion

On the basis of the results from the present investigation, the following conclusion has been drawn:

From the above study, I concluded that all growth parameters viz. plant height (cm), number of branches plant^{-1} and fresh weight plant^{-1} (g) were found to be significantly superior with the application of 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter*.

On the basis of results obtained from the present investigation, I concluded that tuber yield (q ha^{-1}) was found to be significantly best with the requisition of 100% RDF + 2t Poultry manure ha^{-1} + 20kg S ha^{-1} + 20kg $ZnSO_4$ ha^{-1} + 1t vermicompost ha^{-1} + *Azotobacter*. I also concluded that the use of INM improved productivity of potato as compare to inorganic fertilizers alone.

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