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Shubha AS
Research Scholar, Department of Vegetable Science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Srinivasa V
Professor and Head, Department of vegetable science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Devaraju
Assistant Professor, Department of vegetable science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Shivaprasad M
Associate Director of Research, ZAHRS, Mudigere, Karnataka, India

Nandish MS
Assistant Professor, Department of Agricultural Microbiology, College of Agriculture, Shivamogga, Karnataka, India

Yogaraju M
Department of Vegetable Science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Shanvaz A
Department of Vegetable Science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Correspondence
Srinivasa V
Professor and Head, Department of Vegetable Science, College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India

Effect of integrated nutrient management on microbial density, yield and quality attributes in potato under hill zone of Karnataka

Shubha AS, Srinivasa V, Devaraju, Shivaprasad M, Nandish MS, Yogaraju M and Shanwaz A

Abstract
In order to know the effect of INM on microbial content, yield and quality parameters, the study was undertaken at College of Horticulture, Mudigere by adopting RCBD design with 3 replications and 14 treatments. The results revealed the combination of 75 % RDF + *Azotobacter* + PSB + KSB + $MgSO_4$ + Micronutrient mixture recorded the maximum bacterial count (231.67 and 229 cfu/ g count of soil at 10^{-5} and 10^{-6} dilutions, respectively), PSB (13 and 12.67 at 10^{-5} and 10^{-6} dilutions, respectively) and KSB (6.43 and 6.26 at 10^{-5} and 10^{-6} dilutions, respectively). Yield attributes like number of tubers per plant (2.97), and plot (10.50 Kg/plot) marketable yield per plant (171.03 g/plot) and plot (6.83 Kg/plot) were also high in the same treatment. Quality attributes like total sugar (2.34 %), reducing sugar (1.27 %) and starch (18.47 %) were also found high in the same treatment.

Keywords: Potato, PSB, KSB, *Azotobacter*, actinomycetes, fungus

Introduction
The potato (*Solanum tuberosum* L.) believed to be the gift of Incas of South America to the people of the world. It is the world's major food crop ranking fourth after rice, wheat and maize in its consumption. It is a native of the high Andean region of South America, belongs to the family Solanaceae and genus *Solanum*. Potato is one of the main source of carbohydrates in human diet providing the cheapest source of energy. It provides high quality food within a relatively short period. 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 [1].

Integrated supply of nutrients through organic, inorganic and bio fertilizers is the need of the hour for sustainable productivity and to maintain better soil health [2]. There are many organic sources of nitrogen, phosphorus and potassium among them Farm Yard Manure (FYM) is most popular. To increase the production and quality of potato, judicious combination of organic sources of nutrients along with inorganic and biofertilizers (*Azotobactor* and phosphobacteria) receive the good response [3]. Besides the major nutrients, micronutrients also have a good role in plant growth. Micronutrients like iron, zinc and boron are necessary for plant development and metabolism. Foliar spray of micronutrients facilitates efficient consumption of nutrients straightly through leaves, the effect of which can show its importance soon [4]. 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.

Material and Methods
The experiment was conducted at department of vegetable science in College of Horticulture, Mudigere. The experiment was conducted in RCBD design with 14 set of treatments replicated thrice. The treatment details is as follows: T_1 – control (RDF: 125: 100:125 Kg/ha + FYM 25 t/ha), T_2-75% RDF + Vermicompost (2.5 t/ha), T_3-75% RDF + Vermicompost + *Azotobacter,* T_4- 100% RDF + *Azotobacter,* T_5- 75% N + RD of P and K +*Azotobacter* T_6-100% RDF

+PSB, T_7- 75% P+ RD of N and K + PSB, T_8- 100% RDF +KSB, T_9- 75% K + RD of N and P + KSB, T_{10}-50% RDF+ VC+ *Azotobacter* +PSB +KSB, T_{11}- T_{10}+$MgSO_4$ + Micronutrient mixture, T_{12}- 75% RDF + *Azotobacter*+ PSB + KSB, T_{13}- T_{12}+ $MgSO_4$+ Micronutrient mixture, T_{14}- RDF +$MgSO_4$ + Micronutrient mixture.

Enumeration of soil microorganisms was done by preparing media such as Nutrient Agar (NA) for Bacteria, Martin's Rose Bengal Agar (MRBA) for Fungi and Kuster's Agar (KA) for Actinomycetes. Quality parameters were estimated as per the formulas [5].

Results and Discussion

The data regarding total microbial population in the soil which is recorded after the harvest of the crop is presented in Table 1. The bacterial, fungal, actinomycetes, PSB and KSB population varied significantly due to different treatments. The higher bacterial population of 231.67 and 229 cfu/gram of soil at 10^{-5} and 10^{-6} dilution, fungal of 67 and 66 cfu per gram of soil at was observed 10^{-3} and 10^{-4} dilution, actinomycetes 16 cfu per gram of soil at 10^{-2} and 10^{-3} dilution, PSB of 14.00 and 13.67 cfu/gram of soil at 10^{-5} and 10^{-6} dilution, KSB of 7.00 and 6.50 cfu/gram of soil at 10^{-5} and 10^{-6} dilution under *Azotobacter* + PSB + KSB + 75 % RDF + $MgSO_4$ + Micronutrient mixture (T_{13}). The increase in bacterial biomass under this treatment might be due to increased microbial activity and multiplication as it was inoculated with the microbial consortium. These results get support from the findings of [6] in elephant foot yam.

The highest number of tubers per plant (2.97), yield per plant and plot (263.12 g, 10.50 Kg), marketable yield per plant and plot (171.03 g/plant, 6.83 Kg/plot respectively) (fig 1 and table 2) was recorded with the combination of *Azotobacter* + PSB + KSB + $MgSO_4$ + Micro nutrient mixture + 75 % RDF (T_{13}) which was statistically on par with T_{11}, T_{14}, T_{12}, T_6 and T_7. The increase in number of tubers per plant and plot could be attributed to increased vegetative growth observed due to balanced nutrient levels, which stimulated initiation of more stolons, thus increasing the number of tubers per plant, which in turn increases yield and marketable per plant as well as plot. These findings are in line with the findings of [7, 8, 9] also reported that positive effect of the application of nutrients from organic and inorganic source influenced the production of number of tubers and tuber yield of potato. [10] also revealed that the integrated application of 50 % of NPK through inorganic sources recorded the highest tuber yield (22.73 t/ha) and [11] observed similar results.

Total, reducing, non-reducing sugar and starch were significantly higher for the plants supplied with *Azotobacter* + PSB + KSB + $MgSO_4$ + Micro nutrient mixture + 75 % RDF which recorded the maximum reducing and non reducing sugar content (2.34 %, 1.27 %, 1.07 % and 18.47 %, respectively) and the lowest was recorded in the control (Table 3 and fig 2) and these were on par with T_{11}, T_{14} and T_{12}. The higher accumulation of sugars in the tubers could be due to better availability of nutrients and synthesis of sugars when plants received combined chemical fertilizers, organic manure and bio-fertilizers. It is also related to the application of biofertilizers especially *Azotobacter* that helped in fixation of atmospheric nitrogen while the applied FYM improve the soil physical and chemical properties which aided in the accumulation of more sugars. The higher sugar content under integrated use of inorganics + organics and vermicompost + bio-fertilizer probably reflects the greater nutrients availability under this treatment. The supply of nutrients to potato crop through inorganic sources of nutrients provide higher amount of plant available nutrients during different growth and development stages and if the potassium availability remains optimum or high, then it resulted, in reduction of reducing sugar in potato. The results were in conformity with the findings of [12] and [13].

Table 1: Effect of INM total microbial count in potato after harvest

Treatments	Total bacteria (cfu/g of soil)		Total fungi (cfu/g of soil)		Total actinomycetes (cfu/g of soil)		Total PSB (cfu/g of soil)		Total KSB (cfu/g of soil)	
	10^{-5}	10^{-6}	10^{-3}	10^{-5}	10^{-6}	10^{-5}	10^{-6}	10^{-4}	10^{-2}	10^{-3}
T_1	36.33	21.33	16.00	2.32	1.61	1.27	1.13	15.33	5.7	7.0
T_2	55.33	51.00	24.00	2.60	2.44	2.10	1.93	27.00	9.7	7.0
T_3	60.78	58.33	21.00	2.44	2.23	3.43	3.27	22.33	7.7	6.7
T_4	124.67	119.33	21.33	4.51	4.08	3.37	3.27	22.33	14.0	5.7
T_5	103.00	93.33	21.00	3.00	2.67	3.00	2.83	22.00	11.0	7.7
T_6	114.78	109.67	42.00	7.27	6.93	4.83	4.67	38.33	14.0	7.0
T_7	103.59	94.67	37.67	5.37	4.93	4.67	4.50	40.67	4.0	5.0
T_8	117.33	107.67	20.67	7.00	6.67	5.00	4.83	19.67	11.7	6.0
T_9	108.07	110.33	17.67	6.93	6.67	4.67	4.33	16.00	6.0	4.3
T_{10}	130.67	121.00	32.00	10.33	9.67	5.33	4.90	34.00	15.3	12.0
T_{11}	226.33	224.67	64.67	13.67	13.33	6.77	6.43	64.33	15.0	15.3
T_{12}	222.00	220.33	63.33	13.00	12.67	6.43	6.26	62.33	9.0	13.7
T_{13}	231.67	229.00	67.00	14.00	13.67	7.00	6.50	66.00	16.0	16.0
T_{14}	223.33	224.33	64.33	13.33	13.00	6.60	6.27	63.33	10.0	14.0
S. E m±	8.37	8.60	2.25	0.65	0.72	0.55	0.49	1.60	1.11	1.06
CD @ 5%	24.32	25.00	6.54	1.88	2.08	1.60	1.42	4.65	3.24	3.07

Table 2: Effect of INM on yield and marketable yield per plant and plot in potato

Treatments	Yield per plant (g)	Yield per plot (Kg)	Marketable yield/plant (g)	Marketable yield/plot (Kg)
T_1	161.57	6.45	80.78	3.23
T_2	170.88	6.83	88.86	3.55
T_3	182.25	7.25	96.59	3.84
T_4	196.28	7.83	109.92	4.38
T_5	184.19	7.36	101.30	4.05
T_6	204.10	8.19	116.34	4.67
T_7	202.97	8.12	113.67	4.55
T_8	187.97	7.52	101.51	4.06
T_9	179.68	7.18	95.23	3.81
T_{10}	196.39	7.85	117.83	4.71
T_{11}	245.57	9.82	157.17	6.28
T_{12}	238.36	9.53	147.78	5.91
T_{13}	263.12	10.50	171.03	6.83
T_{14}	242.21	9.68	152.59	6.10
S. E m±	14.47	0.57	8.35	0.33
CD @5%	42.06	1.65	24.27	0.96

Table 3: Effect of INM on quality parameters in potato

Treatments	TSS (° Brix)	Chlorophyll (mg/g)	Number of eyes	Reducing sugar (%)	Non reducing sugar (%)	Starch (%)
T_1	5.00	1.01	6.33	0.79	0.77	16.05
T_2	5.31	1.05	6.87	0.81	0.80	16.25
T_3	5.45	1.11	7.07	0.85	0.81	16.28
T_4	5.72	1.20	8.13	0.86	0.88	16.50
T_5	5.71	1.15	7.73	0.83	0.83	16.35
T_6	5.75	1.16	7.87	0.84	0.85	16.48
T_7	5.74	1.14	7.37	0.82	0.84	16.43
T_8	5.70	1.14	7.19	0.92	0.91	17.00
T_9	5.69	1.12	7.00	0.90	0.87	16.93
T_{10}	5.76	1.21	8.67	1.06	0.95	17.85
T_{11}	5.87	1.27	10.50	1.22	1.05	18.37
T_{12}	5.81	1.25	10.27	1.20	1.02	18.00
T_{13}	5.95	1.29	10.97	1.27	1.07	18.47
T_{14}	5.82	1.26	10.33	1.21	1.04	18.20
S. E m±	0.08	0.05	0.50	0.02	0.018	0.12
CD @5%	0.24	0.14	1.44	0.07	0.052	0.34

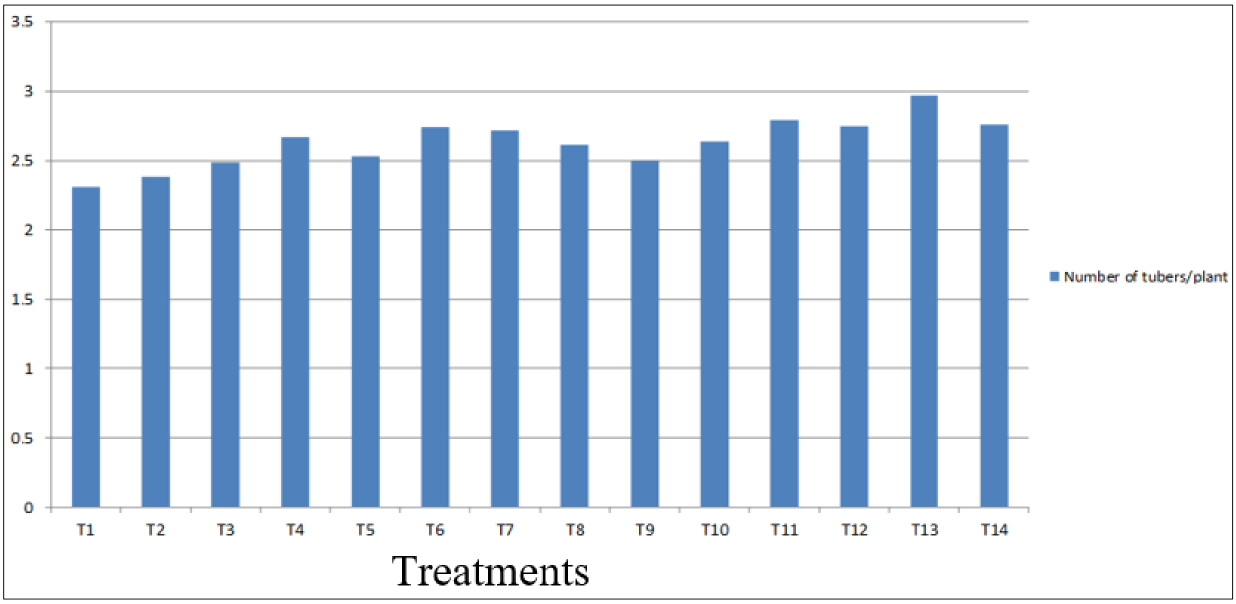

Fig 1: Effect of INM on number of tubers / plant in potato

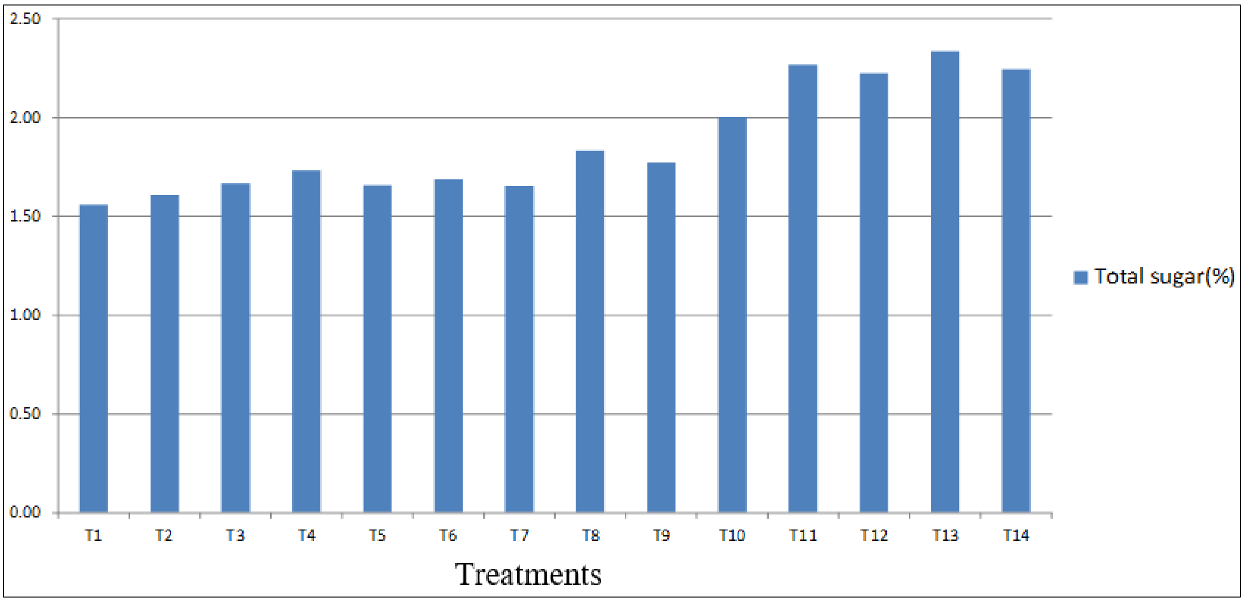

Fig 2: Effect of INM on total sugars in potato

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