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Influence of INM on soil physical and chemical property before and after harvesting of strawberry cv. sweet Charlie

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Abstract
A field experiment was carried out during 2013-14 and 2014-15 to see "the Influence of INM on soil Physical and chemical property before and after harvesting of Strawberry cv. Sweet Charlie" with 21 treatments with different combinations of organic and microbial sources of nutrients (Compost, Poultry manure, Vermicompost, FYM, *Azotobacter* and PSB) replicated thrice with 18 plants per replication in Randomized Block Design. Observations were recorded for vegetative growth, fruit yield, and chemical properties of soil. In different combinations (organic manure+ biofertilizers and organic manure) the treatment T_{15} (Vermicompost (5 tonnes) + Poultry manure (2.5 tonnes) + PSB+ *Azotobacter*) recorded highest plant height, plant spread, and leaf area. Plant supplied with T_{15} (Vermicomopost (5 tonnes) + Poultry manure (2.5 tonnes)+ PSB+ *Azotobacter*) registered earliest flowering. The maximum fruit weight, number of fruits per plant and yield were recorded with plants treated with a T_{15} (Vermicompost (5 tonnes)+ Poultry manure (2.5 tonnes)+PSB +*Azotobacter*) followed by T_{18} (Poultry manure (2.5 tonnes/ha)+ FYM (5 tonnes/ha)+ PSB +*Azotobacter*). The application of T_{15} (Vermicompost (5 tonnes/ha) + Poultry manure (2.5 tonnes/ha) +PSB + *Azotobacter*) was found to more effective in decreasing the Electrical conductivity and pH of soil. The maximum residual organic carbon, available nitrogen, phosphorus and potassium was found in T_{15} (Vermicompost (5 tonnes/ha) + Poultry manure (2.5 tonnes/ha) +PSB + *Azotobacter*). The highest yield and best quality fruit were recorded in the combination of T_{15} (Vermicompost (5 tonnes/ha) + Poultry manure (2.5 tonnes/ha) + PSB+ *Azotobacter*).

Keywords: strawberry, organic manure, biofertilizers, vegetative growth, soil properties

Introduction
The modern cultivated strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious, refreshing and nutritious soft fruit of the world (Vaishnav *et al*., 2017) [1]. Increasing need for enhanced crop productivity due to ever increasing population necessitates adequate amount of plant nutrition. It is cultivated to a limited extent is plains and sub mountainous areas of Himachal Pradesh, Uttarakhand, Uttar Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Madhya Pradesh, wherever, irrigation facilities are available in India.

Since fertilizers constitute a major costly production input, exploitation of yield potentiality of crops depend on how effectively and efficiently this input is managed. Moreover high fertility levels not only put a heavy financial burden to the basic system of production, on the other hand, the large scale use of only chemical fertilizers as a source of nutrients has less fertilizer use efficiency (Pandey *et al*., 2017) [2]. Fruit and vegetables have high toxic residues if chemical fertilizers, insecticides are spread on them to save them from pest attack and when human beings eat such fruits and vegetables they have serious health problems (Kumari *et al*., 2015). Plants can absorb only 5% of food elements from the chemical fertilizers. The acidic and alkaline elements of the remaining chemical fertilizers react with soil and forms thick layers of rocks in the soil and leaves. This rocky layer makes the land infertile. Many of these fertilizers are acidic hence long term use increases the acidity of the soil which reduces the beneficial soil organisms thus degrades ecosystem and accelerate the process of soil erosion (Kumari *et al*., 2016) [3]. To combat this problem, use of organic manures and bio fertilizers are probably the best way to maintain a sustained fruit production pattern.

Integrated Nutrient Management involves judicious use of organic, inorganic and microbial sources in such a way that it sustains optimum yield, improves and maintains the soil physical, chemical and biological properties, which can bring about an equilibrium between degenerative and restorative activates in the soil environment (verma and rao 2013) [5].

Materials and Methods

The investigation was carried out at the research farm of the Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India during year 2013-14 and 2014-15. The strawberry runners of uniform size were transplanted 2-5 cm depth at a spacing of 60×30 cm. in first week of November. Un-inoculated runners were transplanted first then the inoculated runners were planted. FYM, Compost, Vermicompost and Poultry Manure were applied in the concerned plots as per the treatment. NPK were applied in the control treatment. Slurry of 200 ml of the lignite based culture of PSB and *Azotobacter* were prepared in 15 L of water individually and combinations of both 100 ml *Azotobacter* and 100 ml PSB culture were prepared in 15 L of water. Four months old strawberry runners were dipped in the slurry for 30 min and then transplanted. The various combinations of organic manures and biofertilizers were: T0- Recommended dose of nutrients through chemical fertilizers, T1- compost, T2- Poultry Manure, T3- vermicompost, T4- FYM, T5- Vermicopost + Poultry manure, T6- Poultry manure + Compost, T7- FYM + Vermicompost, T8- Poultry manure + FYM, T9- Vermicompost + compost, T10- Compost + FYM, T11- Compost + *Azotobacter* + PSB, T12- Poultry Manure+ *Azotobacter* + PSB, T13- Vermicompost+ *Azotobacter* + PSB, T14- FYM+ *Azotobacter* + PSB, T15- vermicompost+ Poultry manure+ PSB+ *Azotobacter*, T16- Poultry manure + Compost+ *Azotobacter* + PSB, T17- FYM + Vermicompost+ *Azotobacter* + PSB, T18- Poultry manure + FYM+ *Azotobacter* + PSB, T19- Vermicompost + compost+ *Azotobacter* + PSB, T20- Compost + FYM+ *Azotobacter* + PSB. Paddy straw mulch was applied after 60 days of planting. Mulch usually applied on the surface of soil to protect the fruit in the direct contact of soil.

Result and Discussion

Plant height, plant spread, and leaf area were significantly increased by different treatments of organic manures and bio fertilizers at all successive stage of growth. Maximum Plant height (16.19 cm), plant spread (24.68 cm), and leaf area (77.26 cm^2) were recorded in T_{15} (Vermicompost (5Tonnes/ha) + Poultry manure (2.5Tonnes/ha) + *Azotobacter* + PSB) and minimum Plant height (12.34 cm), plant spread (20.56), and leaf area (69.72 cm^2) were observed with T_0 (Recommended dose of nutrients of chemical fertilizers).

Number of fruit $plant^{-1}$, fruit yield, fruit weight, fruit diameter, fruit length and specific gravity were significantly increased by different treatments of organic manures and bio fertilizers at all successive stage of yield attributes. Maximum Number of fruit $plant^{-1}$ (11.78), fruit yield (112.63g), fruit weight (12.26 g), fruit diameter (2.99 cm) and fruit length (5.25 cm) were recorded in T_{15} (Vermicompost (5Tonnes/ha) + Poultry manure (2.5Tonnes/ha) + *Azotobacter* + PSB) and specific gravity (1.86) was recorded in T_{17} (FYM (5Tonnes/ha) + Vermicompost (2.5Tonnes/ha) + *Azotobacter* + PSB) and minimum Number of fruit $plant^{-1}$ (8.34), fruit yield (51.61g), fruit weight (7.94), fruit diameter (2.42 cm), fruit length (3.08 cm) and specific gravity (1.13) were recorded in T_0. Similar findings also reported by (Pandey *et al.*, 2017) [2] on Dahlia, (Kumari *et al*., 2015; 2016; 2017) [2, 3, 4] on Paddy, Legumes and cole crops, Yadav *et al.*, (2010) [7], Umar *et al*., (2009) [8], Singh *et al*., (2008), Rana and Chandel (2003) [11], Zargar *et al.*, (2008) [9], Umar *et al*., (2010) Ahmad and Mohammad (2012) and Jitendra and Rao (2013) in strawberry.

In the physico- chemical properties of soil residual available nitrogen, residual available phosphorus, residual available potash and organic carbon were significantly increased by different treatments of organic manures and bio fertilizers at all successive stage. In first year data maximum available nitrogen (288.49 kg ha^{-1}), available phosphorus (75.08 kg ha^{-1}), available potash (289.14 kg ha^{-1}) and organic carbon (1.28%) and in second year data available nitrogen (370.19 kg ha^{-1}), available phosphorus (135.16 kg ha^{-1}), available potash (350.72 kg ha^{-1}) and organic carbon (1.30%) were recorded in T_{15} (Vermicompost (5Tonnes/ha) + Poultry manure (2.5Tonnes/ha) + *Azotobacter* + PSB). In first year minimum available nitrogen (260.25 kg ha^{-1}), available phosphorus (63.31 kg ha^{-1}), available potash (270.84 kg ha^{-1}) and organic carbon (0.71%) and in second year available nitrogen (318.63 kg ha^{-1}), available phosphorus (105 kg ha^{-1}), available potash (321.96 kg ha^{-1}), and organic carbon (0.95) were recorded in T_0.

In the physico- chemical properties of soil, soil pH and electrical conductivity showed decreasing trend. In first year minimum soil pH (6.55) and electrical conductivity (0.20dsm-1) and in second year soil pH (6.39) and electrical conductivity (0.18 dsm^{-1}) were recorded in T_{15} (Vermicompost (5Tonnes/ha) + Poultry manure (2.5Tonnes/ha) + *Azotobacter* + PSB). In first year maximum soil pH (7.24) and electrical conductivity (0.34 dsm^{-1}) were recorded in T_0. Similar finding were found in strawberry Jitendra and Rao (2013), and Baba *et al*., 2008 [9].

Table 1: Effect of Integrated Nutrient Management on growth, yield and quality of strawberry cv. Sweet Charlie

Treatment combinations	Plant height (cm)	Plant spread (cm)	Number of fruit $plant^{-1}$	Fruit yield $plant^{-1}$	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Specific gravity
T0	12.34	20.56	8.34	51.61	7.94	2.42	3.08	1.13
T1	13.54	22.96	8.91	67.70	8.97	2.54	3.58	1.23
T2	13.85	21.02	9.08	70.33	9.18	2.47	3.37	1.48
T3	12.70	22.52	9.17	80.88	10.63	2.75	3.84	1.43
T4	12.82	22.59	9.27	66.25	9.89	2.54	3.57	1.38
T5	15.44	24.14	10.36	100.7	11.71	2.89	4.55	1.81
T6	15.03	22.74	10.70	97.87	11.59	2.76	3.92	1.60
T7	15.32	23.00	11.50	105.3	11.94	2.89	3.89	1.70
T8	14.56	23.19	9.78	92.45	11.28	2.83	4.27	1.66
T9	14.25	22.33	9.69	86.11	11.28	2.73	3.67	1.67
T10	14.36	21.37	9.18	77.52	10.84	2.77	3.35	1.45
T11	14.39	21.99	9.57	77.03	10.38	2.53	3.62	1.54
T12	14.14	22.76	9.22	79.36	10.40	2.76	3.66	1.76
T13	14.65	22.54	9.61	81.24	10.51	2.80	3.73	1.59
T14	14.57	21.24	9.72	81.40	10.50	2.75	3.71	1.59

T15	16.19	24.68	11.78	112.6	12.26	2.99	5.25	1.84
T16	14.77	21.85	11.07	98.65	11.89	2.77	3.72	1.53
T17	15.95	23.87	11.71	109.5	12.23	2.98	4.61	1.86
T18	15.86	23.57	11.70	105.4	12.11	2.94	4.14	1.80
T19	13.95	23.66	10.77	88.29	11.37	2.85	3.83	1.74
T20	14.67	22.32	9.71	87.81	11.67	2.83	3.50	1.75
F-test	**S**	S	S	**S**	**S**	**S**	**S**	**S**
SE.d (±)	0.295	0.632	0.437	1.817	0.076	0.053	0.285	0.220
CD t 0.5%	0.596	1.278	0.883	3.673	0.153	0.107	0.576	0.445

Table 2: Effect of Integrated Nutrient Management on Physico-chemical properties of strawberry before and after harvesting cv. Sweet Charlie

Treatment	Nitrogen (kg ha^{-1})				Phosphorus (Kg ha^{-1})				Potash (Kg ha^{-1})			
	2013-14		2014-15		2013-2014		2014-2015		2013-2014		2014-2015	
	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting
T_0	207.56	260.25	260.25	318.63	15.36	63.31	63.31	105.00	219.00	270.84	270.84	321.96
T_1	207.56	262.55	262.55	332.74	15.36	65.61	65.61	115.83	219.00	276.17	276.17	330.02
T_2	207.56	264.25	264.25	339.66	15.36	66.40	66.40	121.40	219.00	278.85	278.85	335.11
T_3	207.56	271.05	271.05	342.73	15.36	68.41	68.41	125.51	219.00	281.71	281.71	334.53
T_4	207.56	262.81	262.81	340.73	15.36	63.55	63.55	126.66	219.00	277.79	277.79	328.83
T_5	207.56	274.37	274.37	351.63	15.36	73.82	73.82	131.70	219.00	284.56	284.56	337.63
T_6	207.56	271.79	271.79	346.93	15.36	66.22	66.22	129.48	219.00	281.74	281.74	339.13
T_7	207.56	271.33	271.33	347.93	15.36	69.87	69.87	130.20	219.00	282.01	282.01	335.19
T_8	207.56	271.92	271.92	349.83	15.36	66.12	66.12	128.58	219.00	282.47	282.47	328.45
T_9	207.56	265.29	265.29	345.94	15.36	70.74	70.74	130.44	219.00	282.26	282.26	330.39
T_{10}	207.56	270.61	270.61	374.16	15.36	70.59	70.59	130.55	219.00	277.66	277.66	329.99
T_{11}	207.56	268.10	268.10	338.83	15.36	65.30	65.30	125.56	219.00	279.40	279.40	338.17
T_{12}	207.56	271.48	271.48	342.73	15.36	67.21	67.21	128.93	219.00	280.35	280.35	334.50
T_{13}	207.56	276.02	276.02	346.93	15.36	67.73	67.73	130.08	219.00	281.65	281.65	331.77
T_{14}	207.56	274.22	274.22	343.83	15.36	64.06	64.06	130.37	219.00	280.75	280.75	329.10
T_{15}	207.56	288.49	288.49	370.13	15.36	75.08	75.08	135.16	219.00	289.14	289.14	350.72
T_{16}	207.56	278.92	278.92	358.03	15.36	72.93	72.93	134.85	219.00	284.69	284.69	337.79
T_{17}	207.56	285.40	285.40	367.13	15.36	74.44	74.44	134.87	219.00	287.33	287.33	341.63
T_{18}	207.56	281.79	281.79	366.32	15.36	72.59	72.59	134.91	219.00	287.06	287.06	339.59
T_{19}	207.56	277.56	277.56	361.63	15.36	72.22	72.22	128.92	219.00	283.56	283.56	334.87
T_{20}	207.56	279.11	279.11	360.63	15.36	72.87	72.87	129.09	219.00	282.20	282.20	335.19
F-test	NS	S	S	S	NS	S	S	S	NS	S	S	S
SE.d (±)	0.00	1.624	1.624	9.361	0.003	1.505	1.505	1.281	0.007	0.513	0.513	5.062
CD(0.5%)	0.00	3.282	3.282	18.919	0.006	3.042	3.042	2.588	0.015	1.037	1.037	10.231

Table 3: Effect of Integrated Nutrient Management on Physico-chemical properties of strawberry before and after harvesting cv. Sweet Charlie

Treatment	Soil pH				Electric conductivity				Organic carbon			
	2013-14		2014-15		2013-2014		2014-2015		2013-2014		2014-2015	
	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting	Before planting	After harvesting
T_0	7.27	7.24	7.24	7.12	0.48	0.34	0.34	0.28	0.46	0.71	0.71	0.95
T_1	7.27	7.05	7.05	7.00	0.48	0.30	0.30	0.25	0.46	0.76	0.76	1.00
T_2	7.27	7.20	7.20	7.03	0.48	0.28	0.28	0.23	0.46	0.82	0.82	1.06
T_3	7.27	7.10	7.10	7.05	0.48	0.29	0.29	0.24	0.46	0.74	0.74	0.98
T_4	7.27	6.89	6.89	6.94	0.48	0.30	0.30	0.25	0.46	0.88	0.88	1.12
T_5	7.27	6.73	6.73	6.59	0.48	0.22	0.22	0.19	0.46	0.74	0.74	1.04
T_6	7.27	7.02	7.02	6.91	0.48	0.29	0.29	0.24	0.46	0.72	0.72	0.96
T_7	7.27	6.67	6.67	6.60	0.48	0.30	0.30	0.25	0.46	0.79	0.79	1.07
T_8	7.27	6.75	6.75	6.65	0.48	0.26	0.26	0.21	0.46	0.85	0.85	1.09
T_9	7.27	6.94	6.94	6.88	0.48	0.29	0.29	0.24	0.46	0.83	0.83	1.07
T_{10}	7.27	6.90	6.90	6.76	0.48	0.28	0.28	0.23	0.46	0.89	0.89	1.10
T_{11}	7.27	6.77	6.77	6.67	0.48	0.23	0.23	0.18	0.46	0.96	0.96	1.20
T_{12}	7.27	6.73	6.73	6.59	0.48	0.31	0.31	0.26	0.46	1.13	1.13	1.25
T_{13}	7.27	6.82	6.82	6.70	0.48	0.30	0.30	0.25	0.46	1.03	1.03	1.21
T_{14}	7.27	6.95	6.95	6.83	0.48	0.29	0.29	0.24	0.46	0.82	0.82	1.16
T_{15}	7.27	6.55	6.55	6.39	0.48	0.20	0.20	0.18	0.46	1.28	1.28	1.34
T_{16}	7.27	7.05	7.05	6.95	0.48	0.29	0.29	0.24	0.46	1.02	1.02	1.25
T_{17}	7.27	6.70	6.70	6.62	0.48	0.22	0.22	0.19	0.46	1.22	1.22	1.30
T_{18}	7.27	6.58	6.58	6.53	0.48	0.23	0.23	0.20	0.46	1.17	1.17	1.27
T_{19}	7.27	6.95	6.95	6.88	0.48	0.26	0.26	0.21	0.46	1.21	1.21	1.26
T_{20}	7.27	6.75	6.75	6.61	0.48	0.26	0.26	0.21	0.46	1.13	1.13	1.20
F-test	NS	S	S	S	NS	S	S	S	NS	S	S	S
SE.d (±)	0.002	0.068	0.068	0.102	0.004	0.026	0.026	0.026	0.002	0.098	0.098	0.062
CD(0.5%)	0.004	0.138	0.138	0.207	0.008	0.052	0.052	0.053	0.004	0.198	0.198	0.125

Conclusion

On the basis of present investigation 2013-14 and 2014-15, it is concluded that the treatment T_{15} (Poultry manure + Vermicompost + PSB+ *Azotobacter*) was found the best in terms of growth (plant height 16.19 cm, plant spread 24.68 cm, no. of leaves 15.79 and leaf area per plant 77.26 cm2), yield (112.63 g plant^{-1}) and also the Maximum residual organic carbon and N, P and K content were also found in T_{15} (Vermicompost (5Tonnes/ha) +Poultry manure (2.5Tonnes/ha) + PSB+ *Azotobacter*)

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