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Yield, quality and relative economics of strawberry (*Fragaria* x *ananassa* Duch.) as influenced by different integrated nutrient management practices cv. Shimla delicious under hilly conditions of Uttarakhand

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Abstract
The present investigation entitled "Yield, quality and relative economics of strawberry (*Fragaria* x *ananassa* Duch.) as influenced by different integrated nutrient management practices cv. Shimla Delicious under hilly conditions of Uttarakhand" was carried out at the Fruit Block, College of Horticulture, VCSG UUHF, Bharsar, Pauri Garhwal during the month of July 2017 to May 2018. The experiment was performed to find out the most suitable treatment combination for better yield, quality and highest economics of strawberry under hilly conditions of Uttarakhand. The experiment was laid out in a Randomized Complete Block Design with nine treatments and three replications. The treatments comprise of different doses of organic manures with combination with inorganic Fertilizers. Maximum fruit yield per plot, fruit length(cm), fruit breadth(cm), fruit size(g), TSS (^{0}B), reducing sugar(%), non reducing sugar(%), total sugar(%), ascorbic acid (mg/100g), total anthocyanin content (mg/100g) and highest cost benefit ratio was found under the treatment combinations 75% Organic Manure FYM+ Inorganic Fertilizer NPK (RDF) (T_8). However the maximum acidity of fruit juice (0.72%) was observed in treatment 25% Organic Manure (FYM) + 75% Inorganic Fertilizer RDF (T_6).

Keywords: Farm yard manure, (RDF) recommended dose of fertilizer, strawberry, yield and quality

Introduction
The Strawberry is not really a berry, but is a false fruit and consists of many tiny individual fruits embedded in a fleshy scarlet receptacle which belongs to family Rosaceae having 56 chromosomes where as somatic number is 7 due to octaploid in nature. The brownish or whitish specks, commonly considered seeds, are the true fruit known as achene. Nutritionally, strawberry is a low calorie carbohydrate fruit. Its edible part is succulent thalamus rich in good amount of vitamin C (30-100 mg/100 g of fruit) and vitamin A (60 I.U. / 100 g of fruit), minerals such as potassium (164 mg), calcium (21 mg), and phosphorus (21 mg). The total carbohydrate in the fruit is 8.5-9.2g, protein 0.7g, fat 0.5g and fibre 1.1%. Water is a major constituent (90%) of strawberry fruit. Strawberry is one of the most widely appreciated fruits and it has attained a premier position in the fresh fruit market and processing industries of the world.

Integrated nutrient management includes the use of inorganic and organic sources of nutrients to ensure balanced nutrient proportions by enhancing nutrient response efficiency and maximizing crop productivity of desired quality. It also helps to minimize the existing gap between nutrient removal through continuous use of chemical fertilizers and supply through slow release of fertilizers. As intensive agriculture is becoming more and more necessary to meet the needs of the population, the soil nutrient balance is becoming increasingly negative and thus requiring appropriate supplement through integrated nutrient management. The use of fertilizers and manures not only helps to increase crop yields but also helps to storehouse nutrients for successive crops in addition to improving the physical condition of the soil. Hence application of organic manures like FYM to soil not only improve soil physical properties, pH, water holding capacity but also add important nutrients to the soil, thus increase the nutrient availability and its ultimate absorption by plant and enhance the quality and yield of strawberry fruit.

Material and Methods

The experiment was conducted at the Fruit Block, College of Horticulture, VCSG UUHF, Bharsar during the month of July 2017 to May 2018. The soil of experimental site was sandy loam with a pH of 5.79. The experimental site received average rainfall of 96.28 mm (July 2017-May 2018) with average minimum and maximum temperature of 8.5 ^{0}C and 11.4 ^{0}C, respectively during the period of investigation. The experiment was laid out in Randomized Complete Block Design with nine treatments replicated three times having plot size0.9× 1.5 m^2 accommodating 15 plants in each plot at a spacing of 30 cm x 30 cm. The nine treatments consisted of T_1 control (FYM + NPK RDF), T_2 (25% Poultry Manure + 75% Inorganic Fertilizer RDF), T_3 (25% Poultry Manure +50% Inorganic Fertilizer RDF), T_4 (75% Poultry Manure +25% Inorganic Fertilizer RDF), T_5 (100% Poultry Manure), T_6 (25% FYM + 75% Inorganic Fertilizer RDF), T_7 (50% FYM + 50% Inorganic Fertilizer RDF), T_8 (75% FYM + 25% Inorganic Fertilizer RDF) and T_9 (100% FYM). All the doses of organic manures with combination with inorganic fertilizer were applied at the time of planting and during flowering initiation and observations were recorded on fruit yield per plot, fruit length (cm), fruit breadth (cm), fruit size (g), TSS (^{0}B), reducing sugar (%), non reducing sugar (%), total sugar (%), ascorbic acid (mg/100g), total anthocyanin content (mg/100g) and highest cost benefit ratio.

Results and Discussion

Yield parameters

Yield parameters were influenced by different doses of organic manures with combination of inorganic fertilizers. The maximum fruit yield per plot (6.58kg/plot) was obtained in the treatment (T_8) that contain75% Organic Fertilizer FYM + 25% Inorganic Fertilizer (RDF) while the minimum fruit yield per plot (1.2 kg) was found under the treatment combination i.e. (T_1) control FYM + NPK (RDF). The superiority of treatment T_8 in producing a maximum yield may be due to a greater growth and reproductive capacity of plants as influenced by a mixture of manures and inorganic fertilizers applied in treatment. These results are in agreement with (Wani *et al*. 2017) (Table 1).

Quality Parameters

Physical Parameter

The results indicated that the growth parameters were influenced by different dozes of organic manures and inorganic fertilizers had a significant influence on the physical parameters of the fruit quality. However, the maximum fruit length (4.69cm), fruit breadth (2.40cm) and average fruit weight (16.61gm) was recorded in the treatment 75% Organic Fertilizer FYM + 25% Inorganic Fertilizer RDF (T_8). Odongo *et al*. 2008 [7] reported that FYM had a pronounced effect on berry size and weight compared to inorganic triple phosphate fertilizer. The increased fruit length, fruit diameter and fruit weight attributed to better fillings of fruits may be due to more balanced uptake of nutrients which may have led to better metabolic activities in the plant which ultimately led to high protein and carbohydrate synthesis (Ahmad and Mohammad 2012) [1] (Table 2).

Chemical parameters

Organic manures had a beneficial effect on chemical parameters. the maximum TSS of fruit (14.97^{0}B), minimum titrable acidity (0.50%), maximum reducing sugar (4.68%), maximum total sugar (9.01%), maximum anthocyanin content of fruit (76.26mg/100gm) and maximum ascorbic acid content in strawberry (36.43 mg/100gm) were recorded in 75% Organic Fertilizer FYM + 25% Inorganic Fertilizer RDF (T_8). Odongo *et al*. (2008) [7] reported that FYM enhanced the TSS content of strawberry fruits. Increase in total sugars, TSS and titrable acidity have arisen due to synergistic effect of differential combination of inorganic fertilizer and organic manures as reported by (El-Hamid *et al*. 2006) [6]. Absorption of nitrogen may have exerted regulatory role as an important constituent of endogenous factors in affecting the quality of fruit in which carbohydrate is important and during ripening of fruits, the carbohydrate reserves of the roots and stem are drawn upon heavily by fruits which might have resulted into higher TSS and sugar contents in fruits (Antipchuk *et al*. 1982) [4]. Ali *et al*. (2003) [3] found an increase in TSS with farm yard manure treatment. The sugars and acid contents in fruit are considered important for fruit quality attributes in strawberries Organic fertilizers are hydrophilic in nature and absorb moisture and nutrients which persist longer thus improving the soil structure and indirectly enhancing fruit quality and ascorbic acid contents. Hence these findings are in accordance with those of Wang and Lin (2002) [13], Arancon *et al*. (2004) [5], Singh *et al*. (2010) [10] (Table 3).

Relative Economics

The application of T_8 (75% Organic Manure FYM + 25% Inorganic Fertilizer RDF) has resulted in maximum net return per hectare (Rs. 1,492,640) followed by (Rs.1,309,649) T_4 that contain75% Organic Fertilizer Poultry Manure + 25% Inorganic Fertilizer (RDF) respectively. Cost: benefit ratio is an important and ultimate factor which decides the optimum levels of input to be used for maximization of production and returns of any crop. The maximum cost: benefit ratio was also obtained highest under 75% Organic Fertilizer FYM + 25% Inorganic Fertilizer RDF (T_8). The least cost: benefit ratio in treatment T_1 (Recommended dose of nutrients through chemical fertilizers and inorganic manures) was found lower returns compared to cost of cultivation of strawberry. Many workers also reported the higher net return and cost: benefit ratio with the application of organic manures and inorganic fertilizers (Yadav *et al*. 2010) [14] (Table 4).

Table 1: Effect of different doses of manures and fertilizers on fruit yield per plot (kg) in strawberry (*Fragaria* x *ananassa* Duch.)

Treatment	Fruit yield per plot (kg) ±SE(m)
T_1 FYM + NPK (RDF)	0.897
T_2 25% Organic Manure (Poultry Manure) + 75% Inorganic Fertilizer (RDF)	1.44
T_3 25% Organic Manure (Poultry Manure) +50% Inorganic Fertilizer (RDF)	1.36
T_4 75% Organic Manure (Poultry Manure) +25% Inorganic Fertilizer (RDF)	4.36
T_5 100% Organic Manure (Poultry Manure)	3.08
T_6 25% Organic Manure (FYM) + 75% Inorganic Fertilizer (RDF)	1.19
T_7 50% Organic Manure (FYM) + 50% Inorganic Fertilizer (RDF)	2.26
T_8 75% Organic Manure (FYM) + 25% Inorganic Fertilizer (RDF)	6.58
T_9 100% Organic Manure (FYM)	1.96

SE(d)	0.697
C.D.$_{(0.05)}$	1.49

Table 2: Effect of different doses of manures and fertilizers on fruit length (cm), fruit breadth (cm) and average fruit weight (g) in strawberry (*Fragaria* x *ananassa* Duch.)

Treatment	Fruit length (cm) ±SE(m)	Fruit breadth (cm) ±SE(m)	Average fruit weight (gm) ±SE(m)
T_1 FYM + NPK (RDF)	2.46	1.63	4.20
T_2 25% Organic Manure (Poultry Manure) + 75% Inorganic Fertilizer (RDF)	3.42	1.74	7.79
T_3 25% Organic Manure (Poultry Manure) +50% Inorganic Fertilizer (RDF)	3.27	1.83	8.90
T_4 75% Organic Manure (Poultry Manure) +25% Inorganic Fertilizer (RDF)	4.30	2.34	15.72
T_5 100% Organic Manure (Poultry Manure)	3.60	1.75	7.96
T_6 25% Organic Manure (FYM) + 75% Inorganic Fertilizer (RDF)	3.66	1.95	9.05
T_7 50% Organic Manure (FYM) + 50% Inorganic Fertilizer (RDF)	3.48	2.30	8.18
T_8 75% Organic Manure (FYM) + 25% Inorganic Fertilizer (RDF)	4.69	2.40	16.10
T_9 100% Organic Manure (FYM)	3.66	1.84	7.22
SE(d)	0.091	0.125	0.415
C.D.$_{(0.05)}$	0.193	0.266	0.886

Table 3: Effect of different doses of manures and fertilizers on Total soluble solid (^{0}B), Titrable acidity (%), Ascorbic acid (mg/100g), Reducing Sugar (%), Non reducing sugar (%), Total sugar (%) and Total anthocyanin content (mg/100g) in strawberry(*Fragaria* x *ananassa* Duch.)

Treatment	Total soluble solid (^{0}B) ± SE(m)	Titrable acidity (%) ± SE(m)	Ascorbic acid (mg/100gm)± SE(m)	Reducing sugar (%) ± SE(m)	Non reducing sugar (%) ± SE(m)	Total sugar (%) ± SE(m)	Total anthocyanin (mg/100gm) ± SE(m)
T_1 FYM + NPK (RDF)	9.86	0.71	14.87	2.20	2.11	4.49	33.60
T_2 25% Organic Manure (Poultry Manure) + 75% Inorganic Fertilizer (RDF)	12.18	0.52	24.77	2.92	2.16	5.14	43.66
T_3 25% Organic Manure (Poultry Manure) +50% Inorganic Fertilizer (RDF)	12.87	0.67	24.08	2.47	2.17	4.78	44.20
T_4 75% Organic Manure (Poultry Manure) +25% Inorganic Fertilizer (RDF)	14.05	0.64	34.48	3.52	4.24	8.10	71.26
T_5 100% Organic Manure (Poultry Manure)	13.07	0.61	22.37	2.54	2.28	4.92	42.60
T_6 25% Organic Manure (FYM) + 75% Inorganic Fertilizer (RDF)	13.10	0.72	22.90	3.37	1.76	5.46	45.00
T_7 50% Organic Manure (FYM) + 50% Inorganic Fertilizer (RDF)	11.58	0.54	21.78	3.16	3.62	6.94	44.60
T_8 75% Organic Manure (FYM) + 25% Inorganic Fertilizer (RDF)	14.97	0.50	36.43	4.68	4.37	9.01	76.26
T_9 100% Organic Manure (FYM)	12.58	0.61	23.70	2.27	4.01	6.80	40.93
SE(d)	0.195	0.028	1.164	0.245	0.099	0.188	1.412
C.D.$_{(0.05)}$	0.417	0.060	2.464	0.116	0.209	0.398	2.990

Table 4: Effect of different doses of manures and fertilizers on Relative Economics of strawberry (*Fragaria* x *ananassa* Duch.)

Treatment	Yield t/ha	Total cost of cultivation (Rs/ha)	Gross Income (Rs./ha)	Net return (Rs./ha)	C:B Ratio
T_1 FYM + NPK (RDF)	649.99	508,898	649,999.35	141,101.35	1:0.27
T_2 25% Organic Manure (Poultry Manure) + 75% Inorganic Fertilizer(RDF)	1024.99	526,220	1,024,998.975	498,778.975	1:0.94
T_3 25% Organic Manure (Poultry Manure) +50% Inorganic Fertilizer (RDF)	874.99	526,736	874,999.125	348,263.125	1:0.66
T_4 75% Organic Manure (Poultry Manure) +25% Inorganic Fertilizer (RDF)	1883.33	573,682	1,883,331.45	1,309,649.45	1:2.2
T_5 100% Organic Manure (Poultry Manure)	1366.66	595,644	1,366,665.3	771,021.3	1:1.2
T_6 25% Organic Manure (FYM) + 75% Inorganic Fertilizer (RDF)	1476.08	506,720	1,476,081.857	969,361.857	1:1.9
T_7 50% Organic Manure (FYM) + 50% Inorganic Fertilizer (RDF)	1362.49	506,996	1,362,498.638	855,502.638	1:2.6
T_8 75% Organic Manure (FYM) + 25% Inorganic Fertilizer (RDF)	1999.99	507,358	1,999,998	1,492,640	1:2.9
T_9 100% Organic Manure (FYM)	1108.33	507,694	1108,332.225	600,638.225	1:1.1

Conclusion

Results obtained from the present investigation revealed that organic manures in combination with inorganic fertilizers have a lot of benefits, apart from the increased yield and returns. Organic manures improves the soil structure and texture, reduces soil pollution due to reduced inorganic fertilizer application which is also beneficial for the present problems i.e. high cost of fertilizers and environmental pollution. Among the different treatments applied the best growth, yield and quality parameters were found from the plants grown in the plots applied with treatment T_8 (75% Organic Manure FYM + 25% Inorganic Fertilizer RDF). It can be clearly noted that appropriate application of 75% Organic Manure FYM + 25% Inorganic Fertilizer (RDF) can increase yield and ensuring profitable returns to strawberry growers.

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