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Original Research Paper

Integrated nutrient management and its impact on growth, yield and quality of strawberry

Handique K.[1*], Barua P.C.[2], Saroj N.L.[3], Devi N.S.[4], Kotoky U.[5], Dutta S.[6], Das K.[7] and Saikia H.[8]

[1,2,3,4,5]Department of Horticulture, [6]Department of Soil Science, [7]Department of Crop Physiology,
[8]Department of Agricultural Statistics
Assam Agricultural University, Jorhat - 785 013, India
*Corresponding author Email: karobihandiquekh@gmail.com

ABSTRACT

The present investigation was carried out to study the effect of integrated nutrient management on growth, yield and quality of strawberry, with 16 treatments replicated thrice under randomized block design, during 2020 to 2022. The results revealed that maximum plant height (20.07 cm), plant spread (25.71 cm), number of crowns (4.77) and flowers (48.20) were recorded in the treatment T_{10} (100% RDF + vermicompost 2.5 t/ha+0.5% $ZnSO_4$+0.4% B spray+lime+microbial consortium). Likewise, yield attributes *viz*., maximum number of fruits per plant (41.22), fruit diameter (4.57 cm), fruit weight (39.86 g) and fruit yield per plant (1.58 kg), were noted significantly higher in the same treatment *i.e.* T_{10}. Similarly, the quality parameters *viz*., highest TSS (10.87°B), sugar acid ratio (15.70), ascorbic acid (58.07 mg 100 g^{-1}), anthocyanin (38.24 mg 100 g^{-1}), potassium (3.42 mg 100g^{-1}) and minimum titratable acidity (0.63 %) were also observed in the T_{10}.

Keywords: FYM, integrated nutrient management, microbial consortium, strawberry, vermicompost

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duchense.) is one of the most popular and important soft fruits in the world. The monoecious octaploid strawberry (*Fragaria* × *ananassa* Duch.) is a hybrid of two mostly dioecious octaploid species, *Fragaria virginiana* and *Fragaria chiloensis*. It belongs to the Rosaceae family having chromosome number 2n=56. The strawberry is widely grown in the Indian states of Tamil Nadu, Uttar Pradesh, Kerala, Madhya Pradesh, Himachal Pradesh, Mizoram, Meghalaya, and Haryana. An average production of 25,000 MT was recorded from a 4000-hectare area in India (Anon., 2025). The fruits of strawberry have a characteristic flavour, attractive red colour, juicy texture, and sweetness. These fruits are packed with essential nutrients and vitamins, making them ideal for consumption as part of a healthy diet. They also have low calorie carbohydrate content with 90 % water as a major constituent. They are also rich in minerals including calcium, iron, potassium, phosphorus, and niacin. Vitamin C, minerals, folates, and a few other crucial phytonutrients are among the micronutrients found naturally in strawberries. Strawberries are high in carotenoids, flavonoids, phenols, glutathione, and vitamin A (60 IU/100 g of edible portion), vitamin C (30–120 mg/100 g of edible portion), fiber, and pectin (0.55%) (Singh et al., 2023).

Strawberries can be grown in many types of soil, from light sand to heavy clay. They are highly sensitive to nutrient fluctuations and proper nutritional management is essential as it affects vegetative growth and yield. Nutrient management that maintains soil fertility is essential for improving strawberry yield and fruit quality. Appropriate application of organic and inorganic nutrients together with biofertilizers can improve plant growth, yield, and strawberry quality and keep the soil healthy. Therefore, considering economy, environmental friendliness, and maintenance of better soil health, plant nutrients should be effectively used by adopting integrated nutrient management practices. The rationale behind this research is to provide both chemical and organic fertilizers together with biofertilizers in the most efficient way for sustainable crop production. In view of above facts, the present study was carried out to study the effect of integrated nutrient management on growth, yield and quality of strawberry under Assam condition.

MATERIALS AND METHODS

The experiment was conducted in the Experimental Farm, Department of Horticulture, College of Agriculture, Jorhat (26° 47′ N, 94° 12′ E and altitude of 86.6 meters above mean sea level) during 2020-21 and 2021-22. The experimental site is subtropical humid region and hence humidity is generally high, *i.e.* above 80%. The maximum temperature range is 34°C-37°C during summer and minimum temperature range falls between 8°C-10°C during winter. The soil was acidic (pH 4.71), medium in available N (282.72 kg ha^{-1}), available P (42.56 kg ha^{-1}) and K (167.38 kg ha^{-1}). It contained 11.6 kg S ha-1 and 0.56 mg kg Zn. The experiment was laid out in randomized block design with three replications and sixteen treatments *viz.*, T_0: control (no manures and fertilizers), T_1: 100% RDF (NPK 80:40:40 kg/ha), T_2: 100% RDF+ vermicompost 2.5 t/ha, T_3: 100% RDF+FYM 10 t/ha, T_4: 100% RDF+vermicompost 2.5 t/ha+0.5% $ZnSO_4$+0.4% boron spray+lime, T_5: 100% RDF+ FYM 10 t/ha+0.5% $ZnSO_4$+0.4% boron spray+lime, T_6: 75% RDF+25% N through vermicompost+0.5% $ZnSO_4$+0.4% boron spray+lime, T_7: 75% RDF+25% N through FYM+0.5% $ZnSO_4$+0.4% boron spray+lime, T_8: 50% RDF+50% N through vermicompost+0.5% $ZnSO_4$+0.4% boron spray+lime, T_9: 50% RDF+50% N through FYM+0.5% $ZnSO_4$+0.4% boron spray+lime, T_{10}: T_4+microbial consortium, T_{11}: T_5+microbial consortium, T_{12}: T_6+microbial consortium, T_{13}: T_7+microbial consortium, T_{14}: T_8+microbial consortium and T_{15}: T_9+microbial consortium. The microbial consortiums consist of four species *viz*., Rhizobium, Azotobacter, Azospirillum and phosphate solubilising bacteria (PSB).

The healthy runners of strawberry var. Sweet Charlie having uniform crown and well-developed root system were planted in 15-20 cm raised beds with spacing of 30 cm x 60 cm. Depending on the treatments, half of N and full doses of P and K were applied with lime during land preparation, and the other half of nitrogen was applied by foliar spray before flowering. In contrast, FYM and vermicompost were applied one fortnight before planting. The microbial consortium was applied at the time of planting. Foliar applications of zinc sulphate and boric acid were done one month after planting at an interval of 15 days.

From each treatment five plants were selected randomly and the various growth and yield parameters like plant height (cm), plant spread (cm), number of crowns per plant, number of flowers per plant, number of fruits, yield per plant (g), fruit length (cm), fruit weight (g) and diameter (cm) etc. were recorded using different standard methods. While, the quality parameters like TSS (°B), acidity (%), sugar acid ratio, anthocyanin content (mg per 100 g), ascorbic acid content (mg per 100 g), phosphorus content (mg per 100 g) and potassium content (mg per 100 g) of the fruits were analyzed in the laboratory after harvesting the ripe fruits from the field. The TSS was recorded using hand refractometer (0-32 range) (Ranganna, 1977). The titratable acidity was determined by using standard method of AOAC (1980). Ascorbic acid was determined by using 2, 6-dichlorophenol-indophenol dye method (Freed, 1966). The anthocyanin content was determined by the method described by Srivastava & Kumar (2007). Ash (total mineral) content was determined as per the procedure of AOAC (2000). The phosphorus and potassium content of the fruits were determined by the method described by Jackson (1973). OPSTAT (Sheoran et al., 1998), a Windows-based computer program, was used to statistically evaluate the results. It determined the critical difference and standard error of the difference in mean (SEd) between the treatments at a 5% level of significance.

RESULTS AND DISCUSSION

The pooled data of both the years presented in the Table 1 revealed that the growth characters *viz*., maximum plant height (20.07 cm), plant spread (25.71 cm), number of crowns (4.77) and number of flowers (48.20) were recorded in the treatment T_{10}. The enhanced growth may be the result of improved nutrient intake, such as nitrogen, which is crucial for the production of proteins, enzymes, and chlorophyll, all of which promote vegetative development. In addition to this, organic amendments also improved vegetative growth characters by increasing soil enzyme activity and improving soil aeration, which improved the physiological activities of the plants. The other reason for increased plant growth may be due to the production of plant growth regulators by biofertilizers in the rhizosphere which are absorbed by the roots, as also reported by Subraya et al. (2017) and Singh et al. (2016).

Table 1 : Effect of INM on growth and yield parameters of strawberry

Treatment	Plant height (cm)	Plant spread (cm)	No. of crowns/ plant	No. of flowers/ plant	No. of fruits/ plant	Fruits weight (g/plant)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	B:C ratio
T_0	11.47	17.44	1.90	15.75	19.11	283.86	2.80	2.12	14.84	0.37
T_1	14.17	17.96	2.10	27.03	23.56	414.08	3.12	2.20	19.01	0.72
T_2	15.15	19.05	2.40	30.18	24.79	546.04	3.20	2.33	23.80	1.38
T_3	14.56	18.67	2.27	29.47	25.03	494.27	3.17	2.40	21.55	1.22
T_4	17.81	22.57	3.47	35.00	30.11	873.53	4.33	3.37	30.73	2.95
T_5	17.67	22.25	3.37	33.65	29.28	827.15	4.15	3.20	30.22	2.69
T_6	17.21	21.49	3.13	31.87	28.76	759.67	3.93	3.00	28.52	2.23
T_7	16.61	21.01	2.97	31.07	26.92	702.50	3.82	2.80	27.85	2.09
T_8	16.08	20.34	2.70	29.81	27.91	619.58	3.58	2.63	23.98	1.63
T_9	15.86	19.73	2.58	28.43	27.13	551.62	3.35	2.52	22.23	1.35
T_{10}	20.07	25.71	4.77	48.20	41.22	1580.85	5.75	4.57	39.86	4.54
T_{11}	19.95	25.30	4.70	46.66	40.08	1445.40	5.52	4.48	37.94	4.32
T_{12}	19.85	24.69	4.48	43.76	38.34	1265.60	4.95	4.25	34.65	4.23
T_{13}	19.11	24.13	4.32	42.49	36.73	1147.43	4.68	3.97	32.85	4.12
T_{14}	18.73	23.52	3.97	38.71	34.33	900.07	4.53	3.78	27.82	3.20
T_{15}	18.24	23.12	3.77	36.99	31.91	807.04	4.43	3.57	26.85	2.86
S.E.d(±)	0.10	0.13	0.07	1.48	1.10	45.06	0.15	0.05	1.26	-
C.D. (p=0.05)	0.20	0.27	0.15	3.03	2.25	92.47	0.31	0.10	2.58	-

The yield attributes *viz*., maximum number of fruits per plant (41.22), fruit length (5.75 cm), fruit diameter (4.57 cm) and fruit weight (39.86 g) were recorded significantly higher in the treatment T_{10}. The growth characteristics of the plant mostly determine the yield and yield-attributing traits. Increased dry matter buildup increased the capacity to produce larger yields. The combined application of recommended dose of fertilizers with organic manures and biofertilizers increased the vegetative growth in terms of leaf number and size, which worked as an efficient source of photosynthesis and produced high amount of carbohydrates required for reproductive growth of the plant which resulted in production of more number of flowers, increased fruit set and thus number of fruits. Similar findings were also reported by Yadav et al. (2010) and Verma & Rao (2013) in strawberry. The increase in length, weight and diameter might be due to more balanced uptake of nutrients which helped in better filling of fruits which may have lead to better metabolic activities in the plant ultimately lead to high protein and carbohydrate synthesis.

Application of organic and inorganic fertilizers might have balance the level of hormone and nitrogen fixers known for accumulation of dry matter and their translocation (Kachot et al., 2001) as well as synthesis of different growth regulators. Similar results were also obtained by Yadav et al. (2010) and Shukla et al. (2009) in tomato. In addition to this, the ability of microbial inoculants to release plant hormones particularly gibberellins might also helped in improvement in fruit size. Additionally, the application of micronutrients like zinc and boron may have contributed to the increased weight by facilitating the quick synthesis of protein and the translocation of carbohydrates.

The pooled data on biochemical parameters revealed that T_{10} (100% RDF + vermicompost 2.5 t/ha+0.5% $ZnSO_4$+0.4% boron spray+lime+microbial consortium) *viz*., high content of TSS (10.87°B), sugar acid ratio (15.70), ascorbic acid (58.07 mg 100 g^{-1}), anthocyanin (38.24 mg 100 g^{-1}), phosphorus (1.47 mg 100 g^{-1}) and potassium (3.42 mg 100 g^{-1}) and minimum titratable acidity (0.63%) were observed in the T_{10} which was statistically similar with T_{11}.

The improvement in quality parameters like TSS might be attributed to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits. EI-Hamid et al. (2006) reported that the

Table 2 : Effect of integrated nutrient management on quality parameters of strawberry

Treatment	TSS (°Brix)	Acidity (%)	Sugar acid ratio	Anthocyanin content (mg/100 g)	Ascorbic acid (mg/100 g)	Phosphorus content (mg/100 g)	Potassium content (mg/100 g)
T_0	7.27	0.90	8.84	20.70	46.57	1.11	2.57
T_1	7.75	0.84	9.70	21.85	47.79	1.15	2.75
T_2	8.48	0.82	10.18	24.10	49.02	1.18	2.87
T_3	8.25	0.84	9.87	22.06	49.83	1.16	2.84
T_4	9.57	0.75	12.32	32.48	53.48	1.32	3.23
T_5	9.42	0.76	11.99	29.98	52.94	1.29	3.17
T_6	9.05	0.77	11.61	27.71	52.73	1.26	3.11
T_7	8.93	0.78	11.33	27.33	52.09	1.24	3.09
T_8	8.75	0.80	10.97	26.07	51.78	1.22	3.03
T_9	8.53	0.81	10.57	24.32	50.98	1.17	2.94
T_{10}	10.87	0.63	15.70	38.24	58.07	1.47	3.42
T_{11}	10.72	0.68	13.88	37.90	58.00	1.43	3.38
T_{12}	10.42	0.69	14.35	36.56	55.65	1.39	3.31
T_{13}	10.13	0.70	13.59	35.79	55.01	1.37	3.28
T_{14}	9.92	0.72	13.07	35.17	54.41	1.34	3.25
T_{15}	9.80	0.73	12.66	33.98	53.82	1.32	3.25
S.E.d(±)	0.04	0.02	0.24	0.09	0.11	0.15	0.05
C.D. (p=0.05)	0.09	0.04	0.49	0.19	0.22	NS	0.09

application of PSB on strawberry resulted increase in TSS. Singh et al. (2008) reported that fruit harvested from vermicompost treated plants recorded high TSS and ascorbic acid but low acidity. The reduction in titratable acidity may be attributed to the conversion of the organic acids and photosynthates into sugar during fruit ripening by applying biofertilizers and further utilization of acids as a substrate for respiration during ripening and neutralization of organic acids due to potassium in tissues. These findings are in close conformity with the results of Umar et al. (2009) in strawberry. The increase in ascorbic acid content might also be due to secretion of growth promoting substances which accelerated the physiological process like carbohydrates synthesis etc. The increase in ascorbic acid content might be due to rapid increase in total sugar as the fruit synthesizes ascorbic acid from hexose sugar (Jana et al., 2009) in guava.

CONCLUSION

The present investigation revealed that integrated nutrient management has the great potential in improving the growth, yield and quality of strawberry fruits. On the basis of present study, the treatment T_{10} *i.e.* 100% RDF+vermicompost 2.5 t ha^{-1}+0.5% $ZnSO_4$+0.4% boron spray+lime+microbial consortium was found to be the best integrated nutrient practice followed by T_{11} (100% RDF+FYM 10 t/ha+0.5% $ZnSO_4$+0.4% boron spray+lime+microbial consortium) which showed at par results with treatment T_{10}.

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