

Impact of integrated nutrient management on growth, yield and quality of strawberry (*Fragaria x annanassa* Duch.) cultivation in India

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Abstract: Modern agricultural practices are mostly directed toward high application of commercial fertilizers to achieve high yield. It is widely recognized that application of fertilizer (especially nitrogen) can cause ground water pollution by nitrate leaching through the soil profile. A new approach to farming is often referred to as sustainable agriculture and it seeks to introduce friendlier agricultural practices to the environment and maintains the long term ecological balance of the soil ecosystem. Hence investigations were carried out to develop nutrient management for strawberry cultivar Sweet Charley subjected to various treatment combinations of organic and inorganic fertilizers. Traits such as plant growth characteristics (leaves/plant and plant spread), yield characteristics (flower buds, fruits per plant and fruit yield tons/ha) and quality characteristics (juice content, total sugar content, vitamin C and specific gravity) were observed. The runners of strawberry cv. Sweet Charley were planted in the first week of November with a spacing of (30x60cm). The investigations was laid out in a randomized block design with five treatment combinations replicated thrice. The data regarding the different growth parameters observed at 30, 45, 60, 90, 105, 120 days after planting, yield parameters at 45, 60, 90, 120, 135, 150 days after planting and their quality parameters clearly indicate that the application of integrated sources of nutrients significantly affect the vegetative, reproductive and yield characteristics of the strawberry plant. However the manure fertilizer combination under treatment T4 (75% Organic Fertilizers + 25% inorganic Fertilizers) was found to be the best treatment with regard to integrated and combined application of nutrient resources for strawberry cultivation in India.

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1. Introduction

The Strawberry (*Fragaria X annanassa* Duch.), a member of the rose family, is not really a berry but a false fruit and consists of many tiny individual fruits embedded in a fleshy scarlet receptacle. The brownish or whitish specks, commonly considered seeds, are the true fruits known as achenes. Strawberries are an excellent source of vitamin C, a good source of folate and potassium, and are relatively low in calories. 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 (Sharma and Sharma, 2003). Initially grown in temperate zones of India, its cultivation has now become possible in the sub-tropical zones as well with the introduction of day neutral cultivars (Asrey and Singh, 2004). Strawberry offers quicker returns on capital outlay than any other fruit crop since under special methods of cultivation a crop can be picked as early as the first summer after planting. The fruit is the first of the home-grown supplies to reach the market. Strawberry is one of the most important high value cash crops around the world. In India, it is cultivated

commercially in Hamachal Pradesh, Utter Pradesh, Maharashtra, West Bengal, Nilgiri Hills, Delhi, Haryana, Punjab, Rajasthan and Jammu and Kashmir. Its cultivation can be extended successfully to other suitable areas of the world where irrigation and transportation facilities can be assured. Strawberry is an attractive, luscious, tasty and nutritious fruit with a distinct and pleasant aroma and flavor. It has a unique place among cultivated berry fruits in world. Rich in vitamin C and iron, the principal demand for cultivated strawberry is from the processing and baking industries around the world as suggested by Childers (1980) that the strawberry is a delectable fruit that is highly prized by almost everyone.

Among the various factors which contribute towards the growth, yield and quality of strawberry, nutrition is the most important and it has direct bearing on crop production (Umar *et al.*, 2008). 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. It is widely reported that the extensive use of chemical fertilizers adversely affects soil health and results in decreased crop productivity and quality (Macit *et al.*, 2007). Even with the application of recommended doses, yield potential of strawberry cropping systems has reduced to a plateau because soil health has deteriorated drastically and especially its organic matter content has depleted significantly. 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 organic and inorganic nutrient sources 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. Bio-organic nutrition also improves the yield and quality of product. Organically produced fruit fetches higher prices compared to products grown using inorganic fertilization. The practical approach will be organic farming to the most responsive fruit crops and to encourage integrated nutrient supply for tapping the potential yield of crops. As reported by Hennion *et al.* (1999), "strawberry cultivation is highly nutrition responsive" and therefore the present experiment was undertaken to manage the growth, yield and quality of strawberry through an integrated approach.

2. Materials and Methods

The present investigation was carried out at experimental fields of the horticulture department SHIATS, Allahabad during spring season 2009-10.

The experimental field is located at an elevation of 78 m above sea level and latitude 81.15° E and longitude 28.87° N. The soil of the experimental field was sandy loam in texture, poor in nitrogen (0.24%), comparatively richer in potassium (0.57%) and phosphorus (0.62%) and slightly acidic (pH=6.60) in nature.

The strawberry (cv. Sweet Charley) was procured from Wimco seedling Ltd, Baghwale Rudrapur (U.S.N) Uttar Pradesh, India. The experiment was comprised of the following five treatment combinations:

The manures used in this experiment were farmyard manure and forest litter. The experiment was laid out in a Randomized Block Design with four replications. The observations recorded were on growth parameters (leaves/plant and plant spread), yield characteristics (flower buds, fruits per plant and fruit yield tons/ha) and quality characteristics (juice content, total sugar content, total soluble solids, vitamin C, pH and specific gravity).

3. Results and Discussion

All the treatments in the present investigation had significant impact for all observed traits. However, treatments differed significantly from one another at various time intervals (see Tables 1 and 2; figures 1-8). The highest vegetative growth (15.25 mean leaves/plant and 21.50 cm mean plant spread) was recorded for treatment T4. Observations revealed that plant spread and leaves/plant coincided with peak flower buds/plant, which within one month produced the highest fruits/plant. Afterwards production declined drastically and fewer fruits/plant were produced towards the lag end of growth (i.e. mid April).

Table 1 - Impact of integrated nutrient management on growth and development of strawberry cv. Sweet Charley in India

Treatments	Average leaf size/plant					Average plant spread (cm)					Average flower buds per plant					Average fruits per plant				
	Days after transplanting					Days after transplanting					Days after transplanting					Days after transplanting				
	30	45	60	90	120	30	45	60	90	105	45	60	90	120	135	60	90	120	135	150
T ₁	3.25	3.50	4.25	6.75	10.75	9.25	11.25	11.75	14.75	14.25	1.0	2.00	2.25	3.25	3.25	1.25	3.00	3.75	4.5	5.25
T ₂	3.75	4.25	4.50	7.25	11.25	09.5	11.25	12.00	15.25	15.00	0.75	2.00	2.50	4.00	4.0	1.00	3.50	4.50	5.25	5.75
T ₃	4.25	4.50	5.00	7.50	11.75	10.0	11.75	12.50	15.75	15.50	1.0	2.00	2.00	4.50	4.5	1.00	3.75	5.25	5.75	6.50
T ₄	5.75	6.00	7.75	11.2	15.25	11.0	13.0	16.25	21.50	20.75	1.25	3.00	3.75	5.25	5.25	1.75	4.00	8.00	9.0	9.50
T ₅	3.00	3.50	4.00	6.50	10.75	09.0	11.25	11.50	14.75	14.50	1.0	2.25	1.75	3.75	3.75	0.50	3.25	3.75	4.0	6.25
SE±	0.97	0.91	1.36	1.73	1.69	0.70	0.67	1.89	2.57	2.41	0.37	0.40	0.69	0.55	0.68	0.63	0.35	1.57	1.75	1.48
C.D at 5%	0.66	0.39	0.78	0.55	0.55	0.48	0.77	0.50	0.57	0.57	0.55	0.55	0.10	1.52	0.71	0.67	0.98	1.14	2.43	2.15

Table 2 - Impact of integrated nutrient management on yield and quality characteristics of strawberry cv. Sweet Charley in India

Treatments	Length/diameter ratio of fruits	Total fruits/plant	Fruit yield tones /ha	Juice content (%)	Acidity content (%)	TSS °B	Total sugar (%)	Ascorbic acid content (mg/100 g)	pH	Specific gravity
T ₁	1.25	23.75	21.13	82.10	0.16	9.00	13.50	35.55	3.01	0.80
T ₂	1.30	25.25	22.53	84.50	0.15	10.00	14.25	38.56	2.96	1.00
T ₃	1.35	27.75	24.93	89.10	0.14	11.00	14.95	42.74	2.91	1.10
T ₄	1.43	29.50	26.81	93.20	0.12	13.00	15.00	49.78	2.87	1.30
T ₅	1.26	24.50	19.55	91.40	0.11	14.00	15.25	53.60	2.81	0.90
SE±	0.06	2.14	2.60	4.16	0.019	1.85	0.63	6.75	0.06	0.17
C.D at 5%	1.17	5.55	9.08	19.54	0.48	7.40	4.09	7.32	1.01	0.84

1. 100% recommended dose of inorganic fertilizers +0% recommended dose of manures (T₁);
2. 75% recommended dose of inorganic fertilizers + 25% recommended dose of manures (T₂);
3. 50% recommended dose of inorganic fertilizers + 50% recommended dose of manures (T₃);
4. 25% recommended dose of inorganic fertilizers +75% recommended dose of manures (T₄);
5. 0% Recommended dose of inorganic fertilizers + 100% recommended dose of manures (T₅).

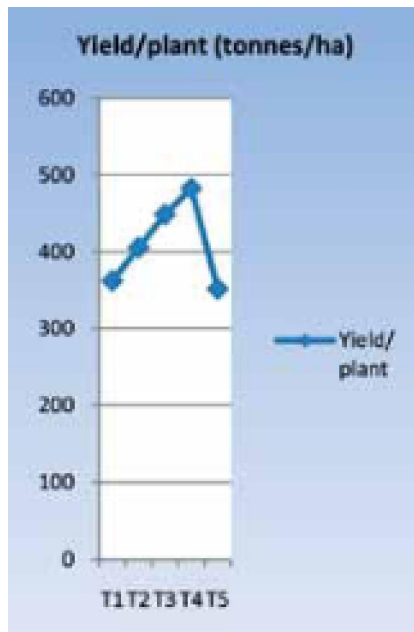


Fig. 1 - Effect of different integrated nutrient management on yield (tons/ha) of strawberry cv. Sweet Charley in India.

Overall, treatment T4 which contained a greater amount of organic manures and less inorganic fertilizers was judged superior to the other treatments. This treatment showed 45.61% superiority over treatments T5 and T1 (control) in average leaves/plant and 61.53% superiority over T1 in average plant spread/plant. Recently it was revealed that available NPK and micronutrients increased significantly with organic sources of nutrients either alone or in combination with inorganic fertilizers over inorganic fertilizers used alone, thus improving vegetative growth. Similar results were also reported by Klaas (2000), Funt and Blerman (2000), Prasad *et al.* (2002), Gajbhiye *et al.* (2003), Arancon *et al.* (2004) and Singh and Dwivedi (2011). Hence, taking these findings as reference, strawberry cv. Sweet Charley responded positively to the manure and fertilizer combination applied in treatment T4.

Eight pickings were carried out starting from 60 days after planting to 150 days after planting (i.e. from end of December to mid April). Treatment T4 produced 2.5 mean flower buds/plant more than T1 (control) whereas in the number of fruits/plant, treatment T4 produced 5.75 average number of fruits more than treatment T1 with greater.

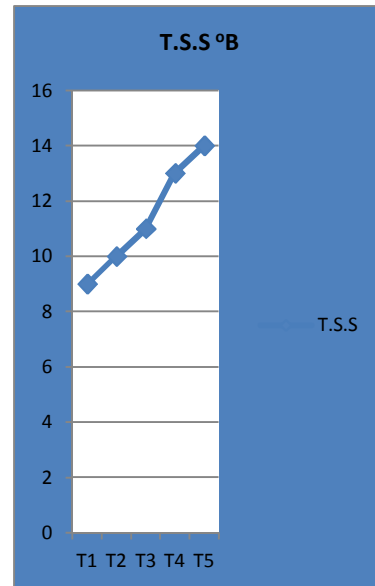


Fig. 2 - Effect of different integrated nutrient management on T.S.S. (°B) of strawberry cv. Sweet Charley in India.

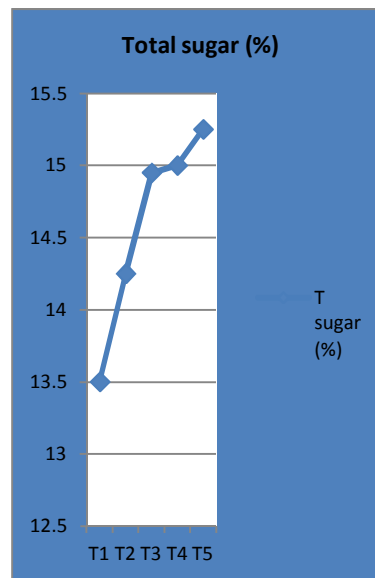


Fig. 3 - Effect of different integrated nutrient management on total sugar (%) of strawberry cv. Sweet Charley in India.

Length/diameter ratio of 1.43, compared to 1.25 for treatment T1. Thus, treatment T4 showed 61.53%, 80.95% and 14.4% superiority over treatment T1 in average flower buds/plant, average number of fruits per plant and length/diameter ratio of fruits, respectively. Also fruit yield per plant was highest (482.6 g/plant=26.81 tons/ha) with treatment T4 and lowest with treatment T5 (351.5 g/plant=19.55 tons/ha); treatment T4 showed 37.14% superiority over treatment T5 in fruit yield tons/ha. Kopanski and Kawecki (1994).

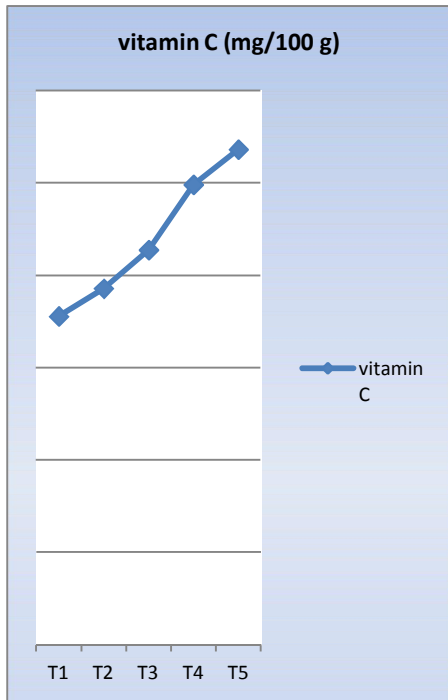


Fig. 4 - Effect of different integrated nutrient management on vitamin C(mg/100 g) of strawberry cv. Sweet Charley in India.

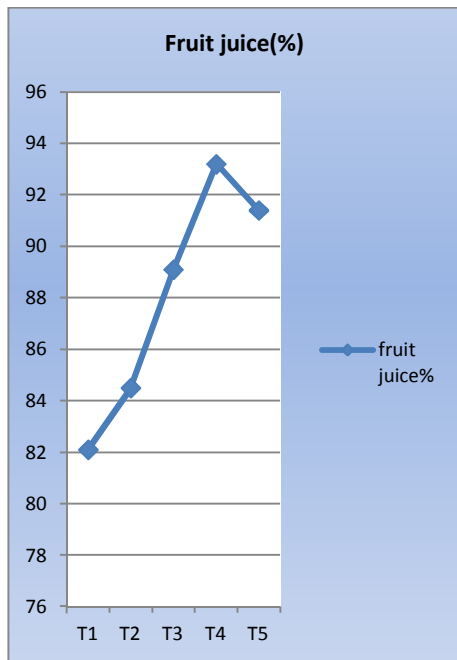


Fig. 5 - Effect of different integrated nutrient management on fruit juice (%) of strawberry cv. Sweet Charley in India.

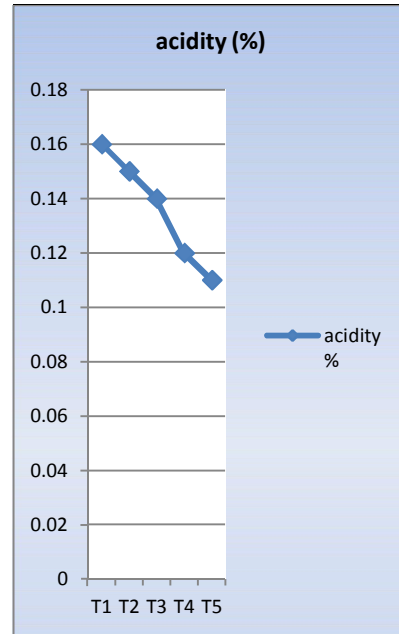


Fig. 6 - Effect of different integrated nutrient management on acidity (%) of strawberry cv. Sweet Charley in India

Gajbhiye *et al.* (2003), Asrey and Singh (2004), Umar *et al.* (2008), Singh and Singh (2009), Singh *et al.* (2010) and Yadav *et al.* (2010) all reported the superiority of organic manures compared to NPK inorganic fertilizers in producing higher yields. The superiority of treatment T4 in producing a maximum number of fruits/plant 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. As far as fruit quality parameters are concerned, treatment T4 showed overall significant superiority to treatments T1 and T5. The juice content of fruits increased with increasing manure content and decreasing NPK inorganic fertilizer content although reduced slightly when manures were used alone (Table 2; Figs. 1 and 5). The maximum juice content (93.2%) was recorded for treatment T4 and the minimum (82.10%) for treatment T1. The increase in juice content may be due to an interactional effect of mixture of manures and inorganic NPK applied through treatment T4 which might have improved cell elongation, cell thickening and fruit development, resulting in better ripening with more succulent fruits. Several reports have indicated that manure and fertilizer combinations in strawberry have led to the production of softer fruits (Neuweiler, 1997; Ghaderi and Talaie, 2008; Singh and Singh, 2009).

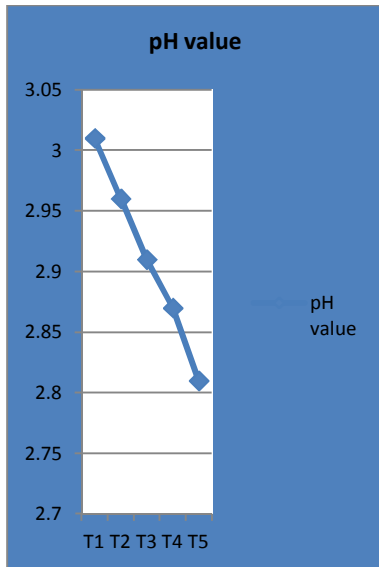


Fig. 7 - Effect of different integrated nutrient management on pH value of strawberry cv. Sweet Charley in India.

The maximum TSS (14%) was found in treatment T5 and the minimum (9%) in treatment T1, likewise total sugar and vitamin C content was highest in treatment T5 and lowest in treatment T1 (Table 2 and figure 2, 3, 4). On the other hand, both acidity (%) and pH were highest in treatment T1 and lowest in treatment T5 while treatment T4 exhibited the highest specific gravity of fruits and treatment T1 the lowest, as shown in Table 2 and figures 6, 7 and 8. Thus strawberry cv. Sweet Charley responded negatively to NPK inorganic fertilizers and positively to higher manure levels under the experimental conditions of this study.

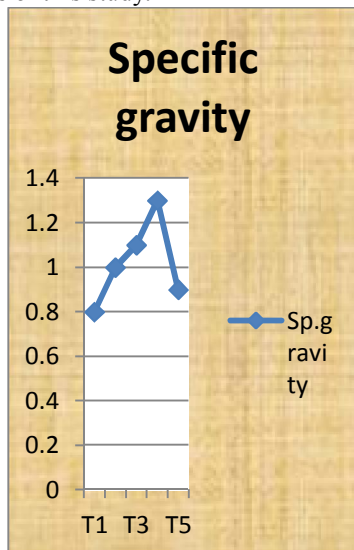


Fig. 8 - Effect of different integrated nutrient management on specific gravity of strawberry cv. Sweet Charley in India.

Present findings are in close conformity with the results presented by Dradi and Faedi (1995), Bergamaschi *et al.* (1995), Prasad *et al.* (2002), Nazir, *et al.* (2006) and Singhand Dwivedi (2011).

Effect of different integrated nutrient management on Fig. (1) Yield/plant, Fig. (2) Total sugar, Fig. (3) T.S.S., Fig. (4) Vitamin C, Fig. (5) Fruit Juice, Fig. (6) Acidity, Fig. (7) pH Value and Fig. (8) Specific gravity ($^{\circ}$ B) of strawberry Cv. Sweet Charley in India.

4. Conclusions

It can be concluded from the present study that an integrated nutrient management combination such as treatment T₄ (25% recommended dose of inorganic fertilizers +75% recommended dose of manures) is advisable for maximum returns from strawberry.

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