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Impact of drip fertigation on growth, yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) cultivar Camarosa

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Abstract
The experiment was executed at Mata Gujri College in the experimental field in Fatehgarh Sahib (Punjab) in the academic year 2018–2019 to examine the influence of drip fertigation on strawberry (*Fragaria* × *ananassa* Duch.) cultivar Camarosa. A RBD and five treatments were used in the study. (T_1) the recommended NPK dose through soil; (T_2) the 70% recommended NPK dose through drip; (T_3) 90% the recommended NPK dose through drip; (T_4) 100% the recommended NPK dose through drip; and (T_5) 110% the recommended NPK dose through drip at 10 day intervals in 11 doses with five replications. According to the study, treatment T_5 produced the greatest incremental plant height (26.16 cm), leaf area (148.94 cm2), leaf number per plant (26.16), and leaf area index (4.89). The fruit attributing characteristics of T_4 were higher: average weight of berry (23.92 gram), length of berry (48.92 millimetre), breadth of berry (34.47 millimetre), yield of fruit (174.70 gram), and biochemical attributes: total sugars i.e. 7.52%, reducing sugars i.e. 4.80%, non-reducing sugars i.e. 2.72%, anthocyanin content (0.235 at OD 530 nm), firmness of berries (1.82), and titratable acidity was 0.63% and also discovered that the T_5 has the highest level of ascorbic acid (57.42 mg/100 g). In addition to receiving recommended NPK soil application and fertigation, the plants utilizing treatment (T_4) exhibited increased net return, gross income and B: C ratio. Consequently, when yield and quality metrics are taken into account, the T_4 treatment, which consists of a drip-fed 100% dose of the necessary NPK, has shown to produce the best results.

Keywords: Camarosa, fruit quality, fertigation, *Fragaria* × *ananassa* Duch., strawberry, TSS, yield

Introduction
Garden strawberry is another name for the strawberry. It is modest, globally-grown, and incredibly delicious impeccably. The strawberry, which is a member of the Rosaceae subfamily of the Rosoideae family, has chromosome number 2n=56. Cultivated varieties of Strawberries are octaploid. The first time Strawberries were cultivated in Brittney, France (1750). It is a hybrid between the male *Fragaria virginiana* and the female *Fragaria chiloensis*. In India, strawberries are mostly grown in the country's temperate zones, although they are also becoming more and more prevalent in subtropical areas. Strawberry production was approximately 5000 MT, with a 1000 hectare area under cultivation (Anonymous, 2018). According to Karkara and Dwivedi (2002) [13], it is an excellent source of potassium, proteins (0.67 gm), lipids (0.3 gm), carbs (7.68 gm), vitamin C (58.8 mg/100 gm), and various other dietary minerals. All age groups can benefit from it as it is rich in antioxidants, antibiotics, and anticarcinogenic compounds (Wang and associates, 1996) [25]. Camarosa is a short-day (June bearing) cultivar that resembles {Chandler}, but it produces larger, firmer fruit earlier in the growing season and has a more vigorous plant. According to Deshmukh and Hardaha (2014) [5], fertilization is a technique that uses drip irrigation to distribute fertilizers in a regulated manner that allows plants to receive a consistent supply of nutrients and regulates fertilizer and water inputs. When fertilizers are applied by broadcast, the plants do not use them very effectively. Conversely, fertilization enables precise and even nutrient administrations to the wet region where majority of roots are concentrated and actively growing (Jat *et al.,* 2011 together with Kachwaya *et al.,* 2015) [10, 12]. In regions with insufficient rainfall, fertigation is the best and occasionally the only—means of guaranteeing that nutrients reach the root zone (Goud *et al.,* 2017) [8].

Fertigation is a contemporary agricultural practice that offers a great chance to enhance production while minimizing environmental contamination by using irrigation to apply both fertilizer and water simultaneously. (Thanari *et al.,* 2018) [24].

Materials and Methods

The investigation was executed at the Agriculture Department's Research Farm at Mata Gujri College in Fatehgarh Sahib, Punjab. The experimental area is located at a mean elevation of 279 m above sea level in 2018–2019, between latitudes of 30° 56' 11.90"N and longitudes of 76° 18' 13.18"E. The soil's pH was 7.2, its organic carbon content was 0.60 percent, and its accessible nitrogen, phosphorus, and potassium contents were 250, 11.2, and 173 kg/ha, respectively. The study employed a RBD design and five treatments: (T_1) the recommended NPK dose through soil (150,100,120 kg/ha); (T_2) the recommended NPK dose through drip (105,70,84 kg/ha); (T_3) the recommended NPK dose through drip (135,90,108 kg/ha); (T_4) the recommended NPK dose through drip (100,100,120 kg/ha); and (T_5) the recommended NPK dose through drip (165,110,132 kg/ha) at 10-day intervals. Five repetitions were made for each treatment. The healthy runners of Camarosa variety that are one year old were planted. Before planting, the roots of runners were treated with Bavistin solution (1 g / litre of water). The Roots were soaked in this solution for 1-2 minutes. In the last week of October 2018, strawberry runners that had had two-thirds of their leaves chopped were sown on a raised bed measuring 3 × 0.80 meter, spaced 60 x 30 cm apart, with the assistance of khurpi. Each treatment was maintained in five beds, each containing sixty plants. Full doses of K_2O and P_2O_5 were added during soil fertilization as the planting beds were being prepared. The nitrogen was supplied in two separate dosages; half was applied in February, just before the blossoming stage After two months of planting, the NPK fertilizer was split into 11 equal doses based on the treatments and applied by drip irrigation at interval of 10 days. All of the experimental beds had irrigation administered at 100% ETC during the trial. Plant height is expressed in centimeters and is measured with a measuring scale from the crown to the main leaf on the apex leaf.

A random count of the leaves on each plant in each condition was conducted and be available as a typical plant's leaf count. The leaf area was measured using a leaf area meter, and the total leaf area was represented in square centimeters. The index of leaf area was calculated as per formula proposed by Watson (1947) [26].

$$\text{Leaf area index} = \frac{\text{Total leaf area of plant}}{\text{Ground area occupied by plant (spacing)}}$$

After each harvesting, the diameter and length of the fruit were measured using digital Vernier callipers. Five berries from each replicate were placed on top pan balance to determine the weight of berries, which was then reported in grams. Based on the average production per plant and the overall weight of fruits taken from ten randomly chosen plants from each treatment, the yield of strawberry from different treatments was measured. Using an Erma-hand rafractometer, the juice's T.S.S. was calculated. A penetrometer was used to measure the berry's fruit firmness. Fruits were chemically analyzed using the AOAC (1980) [1] standard technique. The method described by Harborne (1973) [9] was used to determine the anthocyanin content of the berry. Based on the produce's market price, gross income for each treatment was computed. The overall cost of cultivation was then subtracted from gross income to calculate net returns. The net profits were divided by the total cost of manufacturing to get the cost benefit ratio. The collected data were statistically analysed using the methodology given by Gomez and Gomez, 1984 [6].

Results and Discussion

Vegetative growth

Based on recorded data, it was shown that various fertigation treatments had a substantial impact on vegetative development metrics (Table 1). T_5 (110% dose of recommended NPK through drip) had the highest height of plant (26.14cm), no. of leaves (26.16 plant^{-1}), leaf area (148.94cm^2), and LAI (4.89). This was statistically comparable to T_4 (100% dose of recommended NPK through drip), which had height of plant (25.56cm), no. of leaves (25.65 plant^{-1}), leaf area (147.75), and LAI (4.38). The increasing nutrient content under these fertigation treatments may have improved numerous physiological and metabolic processes in the plant, which may improve the vegetative growth characteristics. Supressing flowering and promoting vegetative development are established outcomes of providing enough supply of nitrogen along with chances for carbohydrate synthesis. During the crucial growth phases of the plant, the fertigation treatments' continuous nutrient supply which involved applying fertilizers in eleven divided doses probably made it easier for the plant to get the nutrients it needed. Goud *et al.* (2017) [8] found that Nagpur Mandarin grew at the highest rate after receiving a 115% NPK fertigation treatment; these results are consistent with their findings. In addition, Kachwaya *et al.* (2015) [12] and Ramniwas *et al*. (2012) [20] noticed that compared to the prescribed NPK dose through soil fertilization, fertigation of NPK through drip considerably increased vegetative growth.

Fruit yield

The maximum yield (174.70 g/plant) was obtained from T_4 (100% dose of recommended NPK through drip), which was statistically comparable to the output of T_3 (90% dose of recommended NPK through drip), which record a yield (171.94 g per plant), which was higher than dose of recommended NPK through soil. Similarly, T_2 (70% dose of recommended NPK through drip) increased production more than soil fertilization. The boost in yield may result from larger berries in terms of width, length, and weight, as well as by the enhanced availability of major nutrients during the growth period of crop. This is likely caused by the increased application of split (11 equal split doses) nutrients through fertigation in comparatively smaller quantities, which also improved their translocation from root to flower. The Positive impact on carbohydrate metabolism and enhanced synthesis of protein may led to an improved C: N ratio, resulting in higher fruit yield reported by Kotoky *et al.* (2005) [14]. Drip fertigation may increase yield because it improves water usage efficiency and increases fertilizer uptake.

These results are consistent with Kachwaya and Chandel's (2015) [12] observation that, as compared to soil fertilization, utilizing the required NPK dose via fertigation resulted in a noticeably maximum no. of fruit sets and yield tonnes per

hectare. According to research by Mounashree *et al.*, 2018 [16], fertigation with 100% of the suggested fertilizer dose produced noticeably more fruit per plant in strawberries. According to Goud *et al.*, 2017 [8], 100% fertigation with RDF produced the greatest yield of fruits and number of fruits plant^{-1}. These results corroborate research by Deshmukh *et al*. (2014) [5] & Shedeed *et al*., 2019 [21] showing that the fertigation significantly boosted fruit yield when compared to conventional methods of applying soil fertilizer.

Physical characters

The application of T_4 (the 100% dose of recommended NPK through drip) showed the highest length of berry (48.92 mm), breadth of berry (34.47 mm) and weight of berry (23.92 g) in treated strawberry plants. These results were statistically comparable to T_3 (90% dose of recommended NPK through drip), which had slightly lower measurements with a length (48.26 mm), breadth (33.82 mm) and weight (22.92 g). In contrast, T_1 (dose of recommended NPK through soil) resulted in the lowest berry size outcomes. The final size and shape of the berry are effected by the number of achenes formed, which is affected by pollination and fertilization during the blooming stage. The potassium flow into fruits had a major impact on the circumference of the fruit, possibly due to increased osmosis-mediated water entry into cells, which in turn causes cell expansion and fruit circumference. The continuous supply of essential nutrients through fertigation until the fruit enlargement stage ensures a consistent distribution of nutrients. This, combined with confining the nutrients in the root zone under fertigation, helps maintain high nutrient availability throughout the crop growth. As a result, this practice promote better fruit size and weight.

Thanari *et al*. (2018) [24], they observed that maximum fruit size and weight was obtained with 100% fertigation in pomegranate cv. Bhagwa. According to Mounashree *et al.*, 2018 [16], the highest fruit weight, length, and diameter were produced when 100% of the prescribed amount of fertilizer (RDF) was applied through fertigation. Similarly, Kachwaya and Chandel (2015) [12] observed that the maximum fruit length was achieved with full recommended dose of NPK through fertigation.

Chemical characters

Fertigation has proven to boost the fruit quality in strawberries. The highest TSS (11.69 degree Brix), reducing sugar i.e. 4.80 percent, non-reducing sugar 2.72 percent, total sugar (7.52 percent), anthocyanin i.e. 0.235 at OD 530 nanometre) and firmness i.e. 1.82 content were obtained through the application of T_4 (100% dose of recommended NPK through drip). Similar outcomes showed with T_3 (90% dose of recommended NPK through drip), however, least results were obtained with the application of T_1 (dose of recommended NPK through soil).

Table 1: Influence of soil fertilization & fertigation on the growth and physical characteristics of the Camarosa strawberry variety

Treatments	Plant height (centimeter)	No. of leaves per plant	Leaf area (centimeter Square)	Leaf area index (LAI)	Berry length (millimeter)	Berry breadth (millimeter)	Berry weight (gram)
T_1- dose of recommended NPK through soil	21.85	23.13	144.70	3.12	44.64	30.55	24.97
T_2- 70% dose of recommended NPK through drip.	24.50	24.60	146.22	3.86	45.80	31.33	26.31
T_3- 90% dose of recommended NPK through drip.	24.72	24.82	147.18	3.93	48.26	33.42	27.92
T_4- 100% dose of recommended NPK through drip.	25.56	25.65	147.75	4.38	48.92	33.67	28.72
T_5- 110% dose of recommended NPK through drip.	26.14	26.16	148.94	4.89	47.40	32.38	27.27
CD (0.05)	1.40	1.07	1.42	0.53	0.90	0.80	0.78

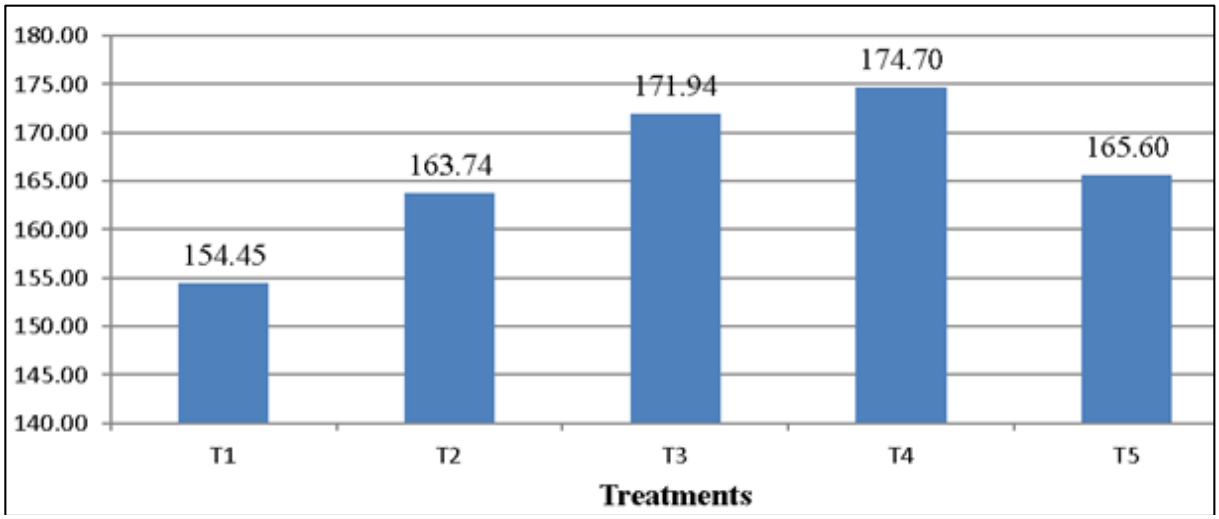

Fig 1: Yield per plant(g)

Table 2: Influence of soil fertilization and fertigation on the chemical characteristics of the Camarosa strawberry cultivar

Treatments	TSS (Degree Brix)	Titratable acidity (percent)	Ascorbic acid (milligram/100 gram)	Total Sugar (Percent)	Reducing Sugar (Percent)	Non-Reducing Sugar (Percent)	Anthocyanin (at 530 nanometer)	Firmness
T_1 - Dose of recommended NPK through soil	9.41	0.73	45.20	5.58	3.40	2.18	0.156	1.00
T_2- 70% dose of recommended NPK through drip.	10.47	0.71	48.70	6.53	4.12	2.41	0.187	1.23
T_3- 90% dose of recommended NPK through drip.	11.37	0.66	54.73	7.00	4.32	2.68	0.217	1.70
T_4- 100% dose of recommended NPK through drip.	11.69	0.63	56.78	7.52	4.80	2.72	0.235	1.82
T_5- 110% dose of recommended NPK through drip.	10.70	0.70	57.42	6.52	4.15	2.37	0.193	1.61
CD (0.05)	0.73	0.05	2.36	0.76	0.64	0.40	0.03	0.18

Fruits with maximum contents of TSS usually have lower titratable acidity. T_4 (100% dose of recommended NPK through drip) gave the lowest titratable acidity i.e. 0.63 percent while, Highest ascorbic acid i.e. 57.42 miliigram/100 gram were acquired with treatment T_5 (110% dose of recommended NPK through drip). The rise in these parameters by the NPK might be the impact of increased photosynthetic efficiency and a possible enhancement in assimilates translocation. The higher Total Soluble Solids and total sugars might be linked to optimum nitrogen application received in the plants. Nitrogen absorption of might have played a regulatory role as a necessary constituent which affecting the quality of fruits. This could have led to fruits using carbohydrate reserves from roots and stem, resulting in higher TSS and sugar levels in fruits.

Titratable acidity may also have decreased due to the ripening process using acids as a source of respiration and potassium in tissues neutralizing organic acids. The maximum content of Vitamin C or ascorbic acid with increased nitrogen levels could be linked to increased production & catalytic activity of different enzymes and co-enzymes which are required in vitamin C or synthesis of ascorbic acid. Jeyakumar & colleagues (2010) [11] also noted that papaya fruits harvested under drip irrigation with a 100% dose of prescribed N and K_2O had a greater level of total sugar. Fertigation enhanced the fruit quality as compared to soil fertilization were also noticed by Shirgure and Srivastava, 2013 [22], Kachwaya and Chandel, 2015 [12], Mounashree *et al*., 2018 [16], Kuchanwar *et al*., 2017 [15] and Shedeed *et al*., 2019 [21].

Table 3: The Economic effects of soil fertilization and fertigation on Strawberry cv. Camarosa

Treatments	Total cost of cultivation (Rs per ha)	Gross income (Rs per ha)	Net return (Rs per ha)	B : C ratio
T_1 - dose of recommended NPK through soil	4,13,320	13,50,000	9,36,680	2.26
T_2- 70% dose of recommended NPK through drip.	4,10,880	14,32,500	10,21,620	2.48
T_3- 90% dose of recommended NPK through drip.	4,22,507	15,02,500	10,79,993	2.55
T_4- 100% dose of recommended NPK through drip.	4,28,320	15,27,500	10,99,180	2.56
T_5- 110% dose of recommended NPK through drip.	4,34,134	14,48,000	10,13,866	2.33

Economics

The evaluation of the economic aspects of cultivation under various fertigation treatments abundantly evident that these treatments were preferable than soil fertilization. The fertigation treatments had the highest gross income, net returns, and benefit cost ratios. Treatment T_5, which administered a 110% dose of recommended NPK through drip, had the highest cultivation costs, whereas treatment T_1, which administered a dose of recommended NPK through soil, had the lowest cultivation costs. Gross income (15, 27,500 Rupees per ha), net return (10, 99,180 Rupees per ha), and benefit cost ratio (2.56) were all highest in treatment T_4 (100% dose of prescribed NPK through drip); in contrast, treatment T_1 (100% dose of required NPK through soil) had the lowest gross income, net return, and B: C. These findings are consistent with those of Patel *et al.* (2010) [19], and Neena Chauhan and Chandel (2008) [17]. According to their research, fertigation greatly improved the financial aspects as compared to the conventional method of applying nutrients through the soil.

Conclusion

The investigation's results led to the conclusion that, in comparison to other treatments and the prescribed NPK dose through soil, plants treated with T_5 (110% dose of NPK through drip) had a much higher rate of vegetative development. T_4 (100% of the recommended NPK dose through drip) had the best overall fruit quality observed. Moreover, the best B: C ratio, the highest yield per plant, gross income, and the maximum net profit produced by T_4 (100% dose of advised NPK through drip).

Authors' Contribution

Conceptualization of research (GK, DSK and SK); Designing of the experiments (GK and DSK); Contribution of experimental materials (GK and DSK), Execution of field/lab experiments and data collection (GK and SK); Analysis of data (GK and DSK) Preparation of the manuscript (GK).

Declaration

The authors declare that they do not have any disagreement of interest.

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