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Economic Impact of Fertigation on Strawberry (*Fragaria × ananassa*) cv. Camarosa

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ABSTRACT: Strawberry (*Fragaria × ananassa*) is a popular fruit crop globally, with the variety Caramosa gaining significant attention due to its unique flavor and superior characteristics. As the demand for high-quality strawberries increases, growers are constantly seeking innovative techniques to enhance crop productivity, fruit quality, and overall economic profitability. Fertigation, the precise application of fertilizers through irrigation systems, has emerged as a promising practice in modern agriculture. This study aims to assess the economic effects of fertigation on the cultivation of strawberry cv. Caramosa. The study involves a comprehensive analysis of the cost-effectiveness and financial viability of fertigation in comparison to conventional fertilizer application methods. The highest soil pH (7.51) and electrical conductivity (0.349 dSm^{-1}) was recorded in Treatment T2 (120% of the recommended NPK dose through drip irrigation). The highest levels of available nitrogen, phosphorous and potassium in the soil (310.18 kg/ha, 15.33 kg/ha, and 176.08 kg/ha, respectively) was found in T2. Berry plants treated with T3 (100 % of recommended dose of NPK through drip) demonstrated superior performance, producing the maximum number of fruits, yield per plant (170.20 g) and yield per hectare (6.13 t/ha). Economic analysis revealed T3 as the most profitable, with the highest net return (Rs. 11,04,180) and benefit-to-cost ratio (B:C ratio) (2.58), emphasizing the significance of NPK dosage and application method in optimizing soil health, berry yield, and economic outcomes.

Keywords: Strawberry, Fertigation, NPK, Net return, B:C ratio.

INTRODUCTION

In India, strawberries (*Fragaria × ananassa* Duch.) were first introduced by the NBPGR Regional Research Station, Shimla (Himachal Pradesh), in the early sixties. But the early efforts to popularize its cultivation in Himachal Pradesh and Uttar Pradesh had received set back on account of the poor adaptability of the cultivars, low returns per unit area and lack of technical know-how (Sharma and Singh 1999). In India it is being widely cultivated in the states of Punjab, Haryana, Maharashtra, Himachal Pradesh, Jammu and Kashmir besides some hilly regions of Uttar Pradesh with Maharashtra as a leading state in its production (Baba *et al*., 2018). In India, present status of strawberry occupies an area is 500 hectare and production 3800 MT (Anonymous 2018). The nutrition status of strawberry plays a vital role in determining the growth, yield and quality since it is a very sensitive plant to nutritional balance (Mohamed *et al*., 2011). An optimal fertilization is conducive in obtaining high yield of good quality and high biological value. It is a profitable fruit crop in the shortest possible time as compared to the other fruits. It is the most popular and early paying back fruit in the world. Strawberry is rich source of vitamins and minerals with delicate flavour, the red colour of the fruit is mainly due to the presence of the anthocyanin, pelarogonidin, 3-monoglucoside and traces of cyaniding (Pathak and Singh 1971). The most important aroma compounds are ethyl hexanoate, ethyl heptanoate, ethyl butanoate, furanone and linalool. Essential oils can extracted from leaves. The major constituents of oil are linalool and nonanal (Khanizadeh and Belanger 1993) Strawberry is used as fresh fruit being rich in vitamin C and ellagic acid, which has anti cancerous property. Fruits are attractive with distinct pleasant aroma and flavour, consumed as dessert and also have a special demand by the fruit processing units for the preparation of jams, ice cream, syrups etc. (Singh *et al.*, 2015). Camarosa strawberry is an early short day variety that produces large to very large, firm, deep red fruit. It has great productivity with substantially greater early productivity and self-pollinating. Fruit ripens in February to June. Right combination of water and nutrients is the key for high yield and quality of produce. Fertigation ensures the application of fertilizers directly to the plant roots and is gaining popularity in all the horticultural crops. Fertigation of NPK gave significantly higher fruit yield as compared to soil fertilization in strawberry cv. Chandler (Kachwaya and Chandel 2015). Fertigation

ensures higher fruit yield by 50-75 % along with saving of water and fertilizers by 40-50 % besides reducing soil loss up to 20 % under fruit based land use systems and save time and labour, which makes fertigation economically viable (Sharda, 2011). Keeping this into consideration, the present investigation was conducted to determine the effects of fertigation on the economics of strawberry cv. Camarosa.

MATERIAL AND METHODS

The experiment was conducted at the Agriculture Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab. The climatic condition of Fatehgarh Sahib is sub-tropical with three distinct seasons *i.e.* winter, summer and rainy. During the winter month (December-January), temperature fall 7-10 ℃ or even low, while in summer month (May-June) it reaches as high as 42-45 ℃ occasional spell of frost and precipitation may be during winters. Most of rainfall is received in the middle of July to end of September after which the intensity of rainfall decreases. The mean annual rainfall about 67 cm. The samples of soil from experimental field were taken randomly from 10-15 cm depth before planting the strawberry runners. A composite soil sample was taken by quartering method and analysed for chemical properties by adopting standard methods in the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib. The result recorded of soil pH, EC and organic carbon 7.2, 0.30 and 0.49 respectively. The one-year-old healthy and disease-free runners of Camarosa variety was procured from strawberry grower Virender Verma, Kanog, Sirmour (Himachal Pradesh). The strawberry runners having cut the 2/3rd portion of leaves were planted on raised bed of 18 m × 1 m size at 40 cm × 30 cm distance on the last week of October. The experiment was laid out in RBD with five replications and comprising of 5 treatments, *viz*., T_1, Recommended dose of NPK (@ 150: 100: 120 kg/ha) through soil; T_2, 120 % of recommended dose of NPK through drip; T_3, 100 % of recommended dose of NPK through drip; T_4, 80 % of recommended dose of NPK through drip; T_5, 60 % of recommended dose of NPK through drip. Each treatment has 12 number of plant and 11 number of split doses of fertilizers. Fertigation was done through venturi, which works on the principle of a differential pressure that forms a vaccum. Observations were recorded on soil parameters (Soil pH, EC, organic carbon, available N, P, K), yield attributes (Total number of fruit per plant, fruit yield per plant and yield per hectare) and economics of the crop (cost of cultivation, gross income, net returns and B:C ratio). An observation on organic carbon in soil was determined by Walkley and Black's method. Available nitrogen was estimated by Alkaline Potassium Permagnate Method (Subbjah and Asija 1956). Available Phosphorus content was analysed with Olsen method (Olsen *et al.* 1954). Available potassium was determined in the neutral normal ammonium acetate extract of soil through flame photometer (Jackson 1973). Cost of cultivation per hectare was calculated on the basis of expenditure on various inputs, cultural and managerial aspects. This expenditure was subtracted from the gross calculated income based on prevailing market selling rate, which gave net profit per hectare. Benefit-cost ratio was calculated by dividing net return to cost of cultivation.

RESULTS AND DISCUSSION

The maximum soil pH and soil EC (7.51 and 0.349 dSm^{-1}) were recorded in treatment T_2 (120 % of recommended dose of NPK through drip), maximum organic carbon of soil (0.61 %) was recorded in treatment T_3 (100 % of recommended dose of NPK through drip). The maximum available nitrogen, phosphorous and potassium content of soil 310.18 kg/ha, 15.33 kg/ha and 176.08 kg/ha were recorded in treatment T_2 (120 % of recommended dose of NPK through drip), respectively. Which were statistically at par with 305.98 kg/ha, 15.28 kg/ha and 175.94 kg/ha respectively, in treatment T_3 (100 % of recommended dose of NPK through drip) while, minimum available nitrogen, phosphorous and potassium content of soil 269.86 kg/ha, 13.26 kg/ha and 172.75 kg/ha were recorded in treatment T_1 (Recommended dose of NPK through soil) respectively (Table 1). Fertigation reduced the nutrient leaching below the root zone when compared to conventional method of fertilizer application. The lesser leaching losses occurred under drip system might have due to the fact that NPK fertilizers were applied in small doses through eleven split applications. The increase in soil EC and nutrient status might be due to the fact that the Nitrogen possesses the ability of formation of enzyme complex. Organic carbon content was not much influenced by different treatments. Uptake of NPK kg n ha^{-1} and kg t^{-1} was reduced with reduced level of fertilizer dose. However, uptake of nutrients was increased in the fertigation treatments as compared to the conventional method of fertilizer application Bhalerao *et al*. (2010). These results are in conformity with those of Weijun *et al*. (2011), who reported that fertigation treatments had higher soil available nutrient concentration than conventional soil fertilization in apricot.

Plants treated with treatment T_3 (100 % of recommended dose of NPK through drip) produced maximum number of fruit, yield per plant and yield per hectare (17.26, 170.20 g and 6.13t/ha), respectively, which were statistically at par by T_2 (120 % of recommended dose of NPK through drip) with the value of 17.06 number of berries per plant, 168.50g yield per plant and 6.04t/ha yield per hectare while, minimum number of fruits, yield per plant and yield per hectare (13.20, 142.46g and 5.07t/ha) were recorded in T_1 (Recommended dose of NPK through soil), respectively (Table 2). The favorable influence on the carbohydrate metabolism and increased synthesis of protein might have resulted in better C:N ratio leading to more number of fruits (Kotoky *et al*., 2005). The increased yield under drip fertigation might have resulted due to better water utilization and higher uptake of nutrients.

These findings are similar with Kachwaya and Chandel (2015) reported that fertigation with recommended dose of NPK gave significantly higher number of fruit set and yield t/ha as compared to recommended dose of NPK through soil fertilization. Mounashree *et al*., (2018), they reported that the treatment 100 % recommended dose of fertilizer (RDF) through fertigation recorded significantly higher fruit yield per plant in strawberry. Goud *et al*. (2017), they reported that highest number of fruits plant^{-1}, fruit yield were recorded in 100 % fertigation with RDF which was at par with fertigation with 115 % and 85 % of recommended dose of fertilizers in Nagpur mandarin.

Maximum cost of cultivation (₹4,39,948) was calculated in treatment T_2 (120 % of recommended dose of NPK through drip). However, minimum (₹4,13,320) cost of cultivation was calculated in treatment T_1 (Recommended dose of NPK through soil). Maximum gross income (₹15,32,500) was calculated in the treatment T_3 (100 % of recommended dose of NPK through drip), while minimum (₹12,67,500) gross income was calculated in treatment T_1 (Recommended dose of NPK through soil). Maximum net return (₹11,04,180) was calculated in the treatment T_3 (100 % of recommended dose of NPK through drip). However, minimum (₹8,54,180) net return was calculated in treatment T_1 (Recommended dose of NPK through soil). Maximum B:C ratio (2.58) was calculated in the treatment T_3 (100 % of recommended dose of NPK through drip), whereas minimum (2.06) B:C ratio was calculated in treatment T_1 (Recommended dose of NPK through soil) (Table 3). These results are in agreement with the findings of Chauhan and Chandel (2008), Bhattacharya (2010), Patel *et al.* (2010) and Ramana *et al.* (2014) observed that fertigation significantly increased the economics as compare to application of fertilizers through soil.

Table 1: Fertigation and its effect on soil pH, soil EC, organic carbon and available nitrogen, phosphorous and potassium.

Treatments detail	Soil pH	Soil EC (dSm^{-1})	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorous (kg/ha)	Potassium (kg/ha)
T_1 (Recommended dose of NPK through soil)	7.20	0.275	0.51	269.86	13.26	172.75
T_2 (120 % of recommended dose of NPK through drip)	7.51	0.349	0.59	310.18	15.33	176.08
T_3 (100 % of recommended dose of NPK through drip)	7.42	0.335	0.61	305.98	15.28	175.94
T_4 (80 % of recommended dose of NPK through drip)	7.26	0.312	0.57	293.46	14.84	174.80
T_5 (60 % of recommended dose of NPK through drip)	7.22	0.299	0.53	275.12	14.27	174.61
SE(m)±	0.04	0.01	0.01	3.31	0.04	0.31
CD (0.05)	0.12	0.02	0.02	9.93	0.13	0.93

Table 2: Fertigation and its effect on number of berries per plant, yield per plant and yield per hectare of strawberry cv. Camarosa.

Treatments	Number of berries per plant	Yield per plant (g)	Yield per hectare (t/ha)
T_1 (Recommended dose of NPK through soil)	13.20	142.46	5.07
T_2 (120 % of recommended dose of NPK through drip)	17.06	168.50	6.04
T_3 (100 % of recommended dose of NPK through drip)	17.26	170.20	6.13
T_4 (80 % of recommended dose of NPK through drip)	15.82	156.31	5.39
T_5 (60 % of recommended dose of NPK through drip)	15.21	150.91	5.22
SE(m)±	0.08	0.57	0.04
CD (0.05)	0.25	1.72	0.13

Table 3: Fertigation and its effect on economics of strawberry cv. Camarosa.

Treatments	Total cost of cultivation (₹/ha)	Gross income (₹/ha)	Net return (₹/ha)	B:C ratio
T_1 (Recommended dose of NPK through soil)	4,13,320	12,67,500	8,54,180	2.06
T_2 (120 % of recommended dose of NPK through drip)	4,39,948	15,10,000	10,70,052	2.43
T_3 (100 % of recommended dose of NPK through drip)	4,28,320	15,32,500	11,04,180	2.58
T_4 (80 % of recommended dose of NPK through drip)	4,16,692	13,47,500	9,30,808	2.23
T_5 (60 % of recommended dose of NPK through drip)	4,05,064	13,05,000	8,99,936	2.22

CONCLUSIONS

This study highlights the positive economic impact of fertigation on the cultivation of strawberry cv. Caramosa. By optimizing nutrient management, fertigation proves to be a viable strategy for strawberry growers, offering higher yields, superior fruit quality and increased profitability. The findings provide valuable insights for farmers, agronomists, and policymakers, encouraging the adoption of fertigation techniques to enhance the economic viability of strawberry production while promoting sustainable agricultural practices. So far as the yield of strawberry fruits are concerned, maximum fruit plant, yield per plant, yield per hectare, highest net profit and B:C ratio also comes from T_3 (100 % of recommended dose of NPK through drip).

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Conflict of Interest. None.

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