Changes in quality parameters of strawberry fruit through drip irrigation under protected cultivation

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Abstract
The present study was conducted at experimental farm of CSK HPKV, Palampur (Himachal Pradesh), during the year 2015-16 with the objectives of evaluating the effects of drip irrigation and NK fertigation levels on growth and quality of strawberry under protected condition. The treatments comprised of three drip irrigation levels (DI0, DI6 and DI12), three NK fertigation levels (NK50, NK75 and NK100) and Control (C). The results indicated that DI12 treatment due to favourable soil moisture regimes led to higher TSS content while vitamin C was higher in DI0. In case of different NK fertigation treatment, NK100 and NK75 had higher fruit length, breadth, weight and TSS content as compared to NK50 treatment.

Keywords: Drip irrigation, strawberry, TSS, Vit. C

1. Introduction
Strawberry (Fragaria × ananassa), one of the most economically important fresh and processed fruits, is cultivated in all arable regions of the globe from the Arctic to the Tropics. It is well known that consumers now pay much more attention to food quality. As a regular part of the diets of millions of people, strawberry is consumed for both its unique flavour and nutrient content through-out the world (Zorrilla-Fontanesi et al., 2011) [25]. Strawberry flavour is decided in part by the balance between soluble solids content (SSC) and titratable acid content in ripe fruits. Now, consumers usually prefer sweet strawberries, while sweetness is positively correlated to SSC. Decreasing SSC in strawberries results in lower consumer acceptance of fruits (Keutgen and Pawelzik, 2007) [11], so the SSC value of strawberry fruits is demanded by both consumers and growers.

Strawberries are a good choice among food stuffs containing plentiful amounts of several essential components such as vitamin C, potassium, calcium and magnesium. Cultivation, variety, fertilization, region and weather conditions as well as sampling time and degree of ripeness considerably affect the nutritive value of strawberries (May & Pritts 1990; Tahvonen 1993; Albrechts & Howard 1978; Albrechts & Howard 1980; May Pritts & Kelly 1994; Kidmose, Andersen and Yang-Petersen 1996; Haffner, Vestrheim, Jeksrud, & Tengesdal 1998) [17, 24, 1, 2, 12, 18, 6]. Strawberries need moderate fertilization and irrigation and nearly neutral (6–6.5) soil pH. (Hakala et al, 2003) [7].

Culture system and cultural practices such as planting time, groundcover, manuring and irrigation have a great impact on variation of SSC in strawberries (Correia et al., 2011; Jouquand et al. 2008; Kirnak et al. 2003; and Moshiur Rahman et al. 2014) [5, 9, 13, 19]. Fertilizers are extremely important factors in determining strawberry yield and quality. Sufficient nitrogen (N) is essential for normal plant development of strawberry (Papadopoulos, 1987), but high N level can reduced SSC in strawberry fruits (Cantliffe et al., 2007) [4].

Potassium (K) is needed in relatively high amounts by strawberries, and high K treatments often increased significantly SSC in strawberry fruits (Hammad et al., 2014) [8].

Keeping in view the quality and physical parameters of strawberry in Himachal Pradesh, the present study was conducted to evaluate the performance of strawberry cv. Chandler under varying fertigation and drip irrigation levels grown in naturally ventilated polyhouse during October 2015 – May 2016 season.
2. Materials and Methods

An experiment was conducted during 2015-16 with strawberry as a test crop in naturally ventilated polyhouse to study the “Effect of drip irrigation and fertigation on yield and quality of strawberry under protected cultivation” at the experimental farm of CSK HIMACHAL PRADESH KRISHI VISHVAVIDYALAYA, Palampur. The average values of physical-chemical, OC and chemical properties of pH of the surface soil (0-0.15 m) were pH 5.67 and organic carbon 12.20 g kg⁻¹. The soil was low in available N (212.0 kg ha⁻¹), high in available P (41.65 kg ha⁻¹) and medium in available K (180.9 kg ha⁻¹).

The nine treatment combinations were imposed in a completely randomized design replicated three times. An additional treatment of control was also kept as an independent module for general comparison of results. The treatments comprised of, (a) Three drip irrigation levels, DI₀.₆ (Daily drip irrigation at 60 per cent of open pan evaporation), DI₀.₈ (Daily drip irrigation at 80 per cent of open pan evaporation) and DI₁.₀ (Daily drip irrigation at 100 per cent of open pan evaporation), (b) Three NK fertigation levels viz., NK₅₀ (50% of RDF of which 25% applied as basal and rest 75% through fertigation at weekly interval), NK₇₅ (75% of RDF of which 25% applied as basal and rest 75% through fertigation at weekly interval) and NK₁₀₀ (100% of RDF of which 25% applied as basal and rest 75% through fertigation at weekly interval) and (c) Control (C)- 100% RDF applied through conventional method (1/2 N and full PK as basal and remaining 1/2 N in equal split at monthly intervals) with drip irrigation at 1.0 PE.

The FYM @ 2.5 kg m⁻² was applied to all the treatments. In conventional method, urea, single super phosphate and mureate of potash were used whereas, in fertigation treatments, water soluble fertilizers such as 0:0:50 and urea were applied through drip irrigation system.

Physical parameters of fruit such as Length (cm), breadth (cm) and weight (g), of strawberry fruit were calculated by Kachwaya and Chandel (2015) [3] and Vitamin C (Ascorbic acid) content was calculated by the titration method with standard dye (2, 6-dichlorophenol-indophenol + sodium bicarbonate) as given by Ranganna (2012) [21].

3. Results and Discussion

3.1 Physical parameters of fruit

The data pertaining to the effects of drip irrigation and NK fertigation levels on fruit length, breadth and weight are given in Table 1.

The fruit length was non-significant under different irrigation schedules. The fruit length values under different NK fertigation levels were 2.7cm, 2.8cm and 3.0 in NK₅₀, NK₇₅ and NK₁₀₀ respectively. The data showed that NK₁₀₀ was statistically at par with NK₁₀₀. Similar results were reported by Singh et al. (2013) [23] and Kachwaya and Chandel (2015) [10] where fertigation with RDF of NPK gave maximum fruit length. The result was non-significant under ‘control’ vs. ‘others’. The interaction between irrigation and NK fertigation levels was also non-significant.

The fruit breadth was non-significant under different irrigation schedules. Among different NK fertigation levels, the fruit breadth was 2.2 cm in NK₅₀, 2.5 in NK₇₅ and 2.5 in NK₁₀₀. The data showed that fruit breadth was significantly higher in NK₇₅ and NK₁₀₀ and both were statistically at par. Similar results were reported by Kachwaya and Chandel (2015) [10] where fertigation with RDF of NPK gave maximum fruit breadth. The fruit breadth was non-significant under ‘control’ vs. ‘others’. The interaction between irrigation and NK fertigation levels was also non-significant.

The fruit weight values were non-significant under different irrigation schedules. The fruit weight values under different NK fertigation levels were 6.4g, 6.8g and 7.0 in NK₅₀, NK₇₅ and NK₁₀₀ respectively. The data showed that NK₇₅ was statistically at par with NK₁₀₀. Similar results were reported by Singh et al. (2013) [23] and Kachwaya and Chandel (2015) [10] where fertigation with RDF of NPK gave maximum fruit weight. Fruit weight was non-significant under ‘control’ vs. ‘others’.

Table 1: Effect of drip irrigation and fertigation on physical parameters at harvest of strawberry

| Treatments          | Fruit length (cm) | Fruit breadth(cm) | Fruit weight (g) |
|---------------------|-------------------|-------------------|-----------------|
| Drip irrigation     |                   |                   |                 |
| DI₀.₆               | 2.9               | 2.4               | 6.6             |
| DI₀.₈               | 2.7               | 2.3               | 6.9             |
| DI₁.₀               | 2.8               | 2.5               | 6.7             |
| LSD (P=0.05)        | NS                | NS                | NS              |
| Fertigation treatments |                 |                   |                 |
| NK₅₀                | 2.7               | 2.2               | 6.4             |
| NK₇₅                | 2.8               | 2.5               | 6.8             |
| NK₁₀₀               | 3.0               | 2.5               | 7.0             |
| LSD (P=0.05)        | 0.2               | 0.2               | 0.3             |
| Control vs. others  |                   |                   |                 |
| Control             | 2.7               | 2.4               | 7.0             |
| Others              | 2.8               | 2.4               | 6.7             |
| LSD(P=0.05)         | NS                | NS                | NS              |

The data on interaction between drip irrigation and NK fertigation levels showed that DI₀.₆ NK₅₀, DI₀.₈ NK₇₅, DI₁.₀ NK₇₅ and DI₁.₀ NK₁₀₀ were statistically at par with DI₀.₆ NK₁₀₀.

3.2 Quality parameters

The data pertaining to the effects of drip irrigation and NK fertigation levels on TSS content and vitamin C content at harvest are given in Table 3.

The TSS content under different irrigation levels was significantly higher under DI₁.₀ (10.0° B) followed by DI₀.₆ (8.5° B) and lowest in DI₀.₆ (7.9° B). This may be due to better root and shoot growth leading to more uptake of nutrients and water that resulted in high TSS content. Similar results were reported by Kumar et al. (2012) [14] where TSS (7.981%) content was higher under I₁ (IW/CPE=1) treatment than other irrigation levels. The TSS values under different NK fertigation levels were 8.0° B, 9.3° B and 9.1° B in NK₅₀, NK₇₅ and NK₁₀₀ respectively.
Table 3: Effect of drip irrigation and NK fertigation on TSS and vitamin C content

| Treatments | TSS (g B) | Vitamin C (mg 100 g⁻¹) |
|------------|-----------|------------------------|
| D₁₀.₆      | 7.9       | 67.1                   |
| D₁₀.₈      | 8.5       | 64.5                   |
| D₁₀.₅      | 10.0      | 51.1                   |
| LSD (P=0.05)| 1.0       | 3.2                    |

Fertilization treatments

|          | TSS (g B) | Vitamin C (mg 100 g⁻¹) |
|----------|-----------|------------------------|
| NK₅₀     | 8.0       | 60.2                   |
| NK₇₅     | 9.3       | 61.8                   |
| NK₁₀₀    | 9.1       | 60.7                   |
| LSD (P=0.05) | 0.7 | NS                     |

Control vs. others

|          | TSS (g B) | Vitamin C (mg 100 g⁻¹) |
|----------|-----------|------------------------|
| Control  | 8.3       | 41.6                   |
| Others   | 8.8       | 60.9                   |
| LSD (P=0.5) | NS    | 3.4                    |

The data further, showed that NK₁₀₀ was statistically at par with NK₇₅. Similar results were reported by Kachwaya and Chandel (2015) [10] where fertigation with 100% RDF of NPK gave highest TSS. The TSS values were non-significant in ‘control’ vs. ‘others’. The interaction between irrigation and NK fertigation levels except D₁₀.₈NK₅₀, D₁₀.₆NK₁₀₀ and D₁₀.₅NK₅₀ was statistically at par with D₁₀.₆NK₁₀₀. Vitamin C content determined under different irrigation levels was 67.1 mg 100 g⁻¹ in D₁₀.₆, 64.5 mg 100 g⁻¹ in D₁₀.₈ and 51.1 mg 100 g⁻¹ in D₁₀.₅. The data showed that vitamin C content in D₁₀.₈ was statistically at par with D₁₀.₆. Similar results were reported by Kumar et al. (2005) [16], Sharma et al. (2005) [22] and Kumar and Dey (2012) [15] where increased amount of irrigation water decreased the vitamin C content in fruit.

Vitamin C was non-significant under different NK fertigation levels. However, it was significantly higher in ‘others’ (60.9 mg100⁻¹ g⁻¹) compared to ‘control’ (41.6 mg 100⁻¹ g⁻¹). The interaction between irrigation and NK fertigation levels showed that D₁₀.₆NK₁₀₀ and D₁₀.₅NK₅₀ were statistically at par with D₁₀.₆NK₅₀.

Table 4: Interaction effect of drip irrigation and NK fertigation on TSS and vitamin C content

| Drip irrigation | TSS (g B) | Vitamin C (mg 100 g⁻¹) |
|-----------------|-----------|------------------------|
| NK₅₀            | NK₇₅      | NK₁₀₀                  |
| D₁₀.₆           | 7.7       | 9.1                    | 7.0                  | 59.4 | 71.7 | 70.1 |
| D₁₀.₈           | 6.5       | 8.9                    | 10.3                 | 68.1 | 64.9 | 60.6 |
| D₁₀.₅           | 9.9       | 10.0                   | 10.0                 | 53.3 | 48.7 | 51.3 |
| LSD (P=0.05)    | 1.4       | 4.5                    |

4. Conclusion
Based on the study, the following conclusion was drawn:

By increasing the irrigation levels from D₁₀.₆ to D₁₀.₅, there was improvement in TSS content. However, increased amount of irrigation water decreased the vitamin C content in fruits. Similarly, when the fertigation level increased from NK₅₀ to NK₁₀₀, there was also improvement in TSS content, fruit length, breadth and weight.

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