STUDIES ON WATER AND NUTRIENT MANAGEMENT IN MANGO (*Mangifera indica* L.) CULTIVAR DASHEHARI UNDER JAMMU SUB-TROPICS

By

Simrandeep Kour
(J-15-D-247-A)

Thesis submitted to Faculty of Postgraduate Studies
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STUDIES ON WATER AND NUTRIENT MANAGEMENT IN MANGO (*Mangifera indica* L.) CULTIVAR DASHEHARI UNDER JAMMU SUB-TROPICS

Simrandeep Kour

2021

CERTIFICATE-I

This is to certify that the thesis entitled **"Studies on water and nutrient management in mango (*Mangifera indica* L.) cultivar Dashehari under Jammu sub-tropics"** submitted in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Horticulture (Fruit Science)** to the Faculty of Post Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, is a record of bonafide research, carried out by **Mrs Simrandeep Kour**, Registration No. **J-15-D-247-A**, under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.

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Place : Jammu

Dated: 12-1-2021

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ABSTRACT

Title of the Thesis	**:**	**"Studies on water and nutrient management in mango (*Mangifera indica* L.) cultivar Dashehari under Jammu sub-tropics"**
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ABSTRACT

The present investigation entitled "Studies on water and nutrient management in mango (*Mangifera indica* L.) cv. Dashehari under Jammu subtropics" was carried out at Farmer's Field in Akhnoor on twelve years old mango orchard of cv. Dashehari, during the years 2017 and 2018 to study the effect of regulated deficit irrigation (RDI), partial root zone drying (PRD) and fertigation on growth, yield, quality and shelf life of mango. The plants which were treated with PRD $_{75\%\ ETc}$ + F (T_7) recorded advanced date of appearance of panicle, date of full bloom, date of maximum fruit set, date of harvest and maximum duration of flowering as compared to other treatments, in both the years. The maximum panicle length (26.57 and 25.18 cm) and breadth of panicle (13.53 and 12.27 cm) was found in treatment PRD 75% ETc + F (T_7) while minimum length (18.52 and 17.37 cm) and breadth (10.88 and 9.52 cm) of panicle was observed in treatment (T_{10}) no irrigation in both years 2017 and 2018, respectively. Maximum tree height (5.97 m and 6.18 m), tree spread from east to west (4.91 m and 5.22 m), and from north to south (4.64 m and 4.93 m), scion stock ratio (0.941and 0.954), stock girth (63.53 cm and 65.72 cm), scion girth (59.81cm and 62.70 cm) were recorded in T_1 100% ETc. The maximum fruit weight (206.45 and 208.29 gram), fruit length (10.37 and 10.40 cm), fruit breadth (6.31 and 6.33 cm), fruit volume (213.87 and 216.56 cm^3) and specific gravity (1.03 and 1.04 g/cc) were recorded in T_7 (PRD 75% ETc + F) during both the years 2017 and 2018, respectively. Mango trees treated with PRD 50% ETc and fertigation recorded maximum TSS (20.42 and 20.50 ^{0}Brix), titrable acidity (0.22 and 0.22 %), total sugars (15.25 and 15.30 %), reducing sugars (3.71 and 3.73 %), non reducing sugars (10.96 and 10.99 %) and sugar acid ratio (92.81 and 93.18) in 2017 and 2018, respectively. The maximum leaf potassium (0.28 and 0.30%), calcium (1.79 and 1.81%), and boron (19.84 and 20.16 ppm) content were observed in treatment T_7 i.e PRD 75% ETc coupled with fertigation in the years 2017 and 2018, respectively. Whereas, minimum leaf potassium (0.20 and 0.21%), calcium (1.70 and 1.72%), and boron (13.83 and 13.94 ppm) content were observed in treatment T_{10} i.e.no irrigation in the years 2017 and 2018, respectively. The proline content and Pectin methyl esterase (PME) activity was found maximum in treatment T_{10} i.e no irrigation (36.01 and 36.23μg g^{-1} FW) and (185.2 and 179.2 μg min^{-1} $\cdot g^{-1}$ FW) in 2017 and 2018, respectively. The application of PRD 75% ETc + F resulted in maximum number of fruits (227 and 466), fruit set (0.96 and 0.98 %) and yield (47.02 and 97.11 kg/tree) compared to all other treatments and maximum fruit drop percent was found in treatment (T_{10}) 86.24 and 87.13 %. The maximum water use efficiency was recorded in PRD $_{50\%\ ETc}$ + F (T_9). Soil moisture content was recorded maximum in treatment T_1(100% ETc) whereas, soil potential and leaf temperature were recorded maximum under T_{10} (no irrigation) during both the years.

During storage maximum fruit firmness (27.33 lb/inch^2 and 28.12 lb/inch^2) was recorded in treatment PRD $_{50\%\ ETc}$ + F (T_9) and minimum firmness was recorded under treatment T_{10} (no irrigation)with 20.97 lb/inch and 21.62 lb/inch at 0 day and 6.52 lb/inch^2 and 7.14 lb/inch^2 during both the years 2017 and 2018 respectively. Physiological loss in weight (21.06 % and 21.10 %), decay loss (51.00% and 52.20%) and carotenoids (8.42 and 8.44 mg/100 gram pulp) were observed to be maximum in treatment no irrigation (T_{10}) in both the years during 2017 and 2018 respectively. Maximum fruit moisture (77.46% and 77.72%) was recorded in treatment PRD $_{75\%\ ETc}$ + F (T_7) during 2017 and 2018, respectively. Maximum total soluble solids (17.41 and17.43 ^{0}Brix), total sugars (16.01 and 16.05%), reducing sugars (6.39% and 6.41%) and non reducing sugars (9.14 and 9.16%) and pectin content (0.294 and 0.296 %) was found in treatment (T_9) in both the years during 2017 and 2018 respectively. During storage maximum fruit potassium content (0.74 and 0.75 %), calcium content (0.045 and 0.046 %) and boron content (12.13 and 12.15 ppm) was found in treatment (T_7) which is PRD $_{75\ \%ETc}$ along with fertigation in both years (2017 and 2018) respectively, and showed non significant change with increase in storage period. Economics of water and nutrient management in mango cultivar Dashehari was worked out and highest benefit cost ratio (1: 2.30 and 1:4.19) per hectare was obtained in treatment (T_7) PRD $_{75\ \%\ ETc}$ +F during both the years i.e 2017 and 2018, respectively. From the present investigation, it can be concluded that for improving the growth, yield, quality and shelf life of mango cv. Dashehari under rainfed conditions of Jammu where water is scarce, trees should be irrigated at PRD $_{75\%\ ETc}$ + Fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%) (PRD $_{50\%\ ETc}$ + F).

Keywords: *Regulated deficit irrigation, partial root zone drying, water use efficiency*

Signature of Major Advisor **Signature of Student**

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Chapter-1

Introduction

CHAPTER-1

INTRODUCTION

The mango (*Mangifera indica* L.) belonging to family Anacardiaceae is the most important commercially grown fruit crop of India. It is called as king of the fruits and is said to have originated in the Indo-Burma region. The number of species in the genus Mangifera is controversial. Mukherjee (1985) described 35 species, while Bompard (1993) reported the existence of 69 species, with *Mangifera indica* as the most commercially important. The tree is hardy in nature and requires comparatively low maintenance costs. The chromosome number of *M. indica* is n=20 and 2n=40. The tree is large, spreading, evergreen with a dense rounded or globular crown. The trunk is erect and thick. Branches are numerous, the lower ones spreading horizontally to a great extent, the upper ones gradually ascending till they become nearly in centre, branches are rather thick and robust, yellowish green when young with slightly prominent scars of the fallen leaves. Flowers are small, polygamous, monoecious, male and bisexual on the same panicle. The fruit is drupe, having a skin or the epicarp, the flesh or the mesocarp and the hard covering of the seed or stone known as the endocarp.

Mango flowering is polygamous, generally of the terminal type, however, lateral buds may also emerge (Campbell and Mallo, 1974), with the number of flowers varying from 500 to 4,000 per panicle. Mango fruit is utilised at all stages of its development both in its immature and mature state. Raw fruits are used for making chutney, pickles and juices. The ripe fruits besides being used for preparing several products like squashes, syrups, nectars, jams and jellies. Given the multiple products which can be made, it is therefore a potential source of foreign exchange for a developing country as well as a potential source of employment for a considerable seasonal labour force. Although grown widely, mango prefers a warm, frost-free climate with a well defined winter dry season. Rain and high humidity during flowering and fruit development reduces fruit yields. Mango trees are usually between 3 and 10 m (10–33 feet) tall but can reach up to 30 m (100 ft) in some forest situations and have evergreen canopy with a generally spreading habit. In India, it is grown in Uttar Pradesh, Maharashtra, Gujrat, Madhya Pradesh, Harayana, Andhra Pradesh, West Bengal, Karnataka, Bihar, Uttarakhand and Jammu Kashmir. The current area and production of mango in India is 2288 thousand hectares and production 21253 thousand million tones (Anonymous, 2018) whereas, in Jammu province of J&K union territory, the total area under mango cultivation is 13037 hawith the total production of 30478 metric tones, respectively (Anonymous, 2019). In India, mangoes are mainly grown in tropical and sub-tropical regions from sea level to an altitude of 1,500 m.

Available water resources for agriculture have been decreasing in recent years with the increased demands for irrigation and other non agricultural water uses. Irrigation management for the mango crop must follow technical criteria, so that water is applied at the right time and in right amount. Mango fruit development takes place during the dry season and irrigation is necessary to ensure stable yields of high quality. Meanwhile, climate change and expanding land use in horticulture have increased the pressure on water resources. Climate variability has been and continues to be, the principal source of fluctuations in global food production in developing countries. The earth's climate has warmed by approximately 0.6^0 C over the past 100 years with two main periods of warming, between 1910 and 1945 and from 1976 onwards and is greater than any other time during the last 1000 years. Undoubtedly, horticultural production is going to be affected due to its consequences and the magnitude of which on crop yields will vary locally due to regional differences in both natural and anthropogenic factors that control plant responses (Wei *et al.*, 2011). Coupled with resource scarcity of land, water, energy, and nutrients, declining soil quality, increased greenhouse gas emissions and surface water eutrophication, climate change will affect crop production in a great deal (Fan *et al.*, 2011; Tripathi *et al.*, 2016). Water availability becomes major constraint to crop production in almost all regions of world and climate change is expected to exacerbate this situation by increasing potential evapotranspiration, decreasing rainfall and increasing the frequency and intensity of droughts (Niang *et al.*, 2014). In Jammu region, agriculture is mainly dependent on underground water and surface water since the rainfall is erratic and not well distributed throughout the year, thus pressure is increasing on available water resources. Under limited water conditions, it is therefore imperative that water is used judiciously and in a manner to minimize evaporative and other losses and thus improving water use efficiency. On the other hand, the area under mango production is increasing due to higher economic return from this crop compared with others. Under such situations, orchardists often receive water allocations below the maximum crop evapotranspiration needs (ETc) and they either have to concentrate on the supply of water over a smaller land area or have to irrigate the total area with levels below full ETc (Fereres and Soriano, 2007). For sustainable water use in agriculture, crop-specific and water-saving irrigation techniques that do not negatively affect crop productivity must be developed. Worldwide, successful attempts have been documented regarding the use of deficit irrigation methods, namely regulated deficit irrigation (RDI) and partial rootzone drying (PRD) to improve water use efficiency (WUE) in various tree crop species (Arzani *et al.,* 2000 in apricot; Hutton, 2000 in citrus; Kang *et al*., 2002 in pear; Grant *et al.,* 2004 in raspberries; Romero *et al.,* 2004 in almond; Van Hooijdonk *et al*., 2004 in apple; Cifre *et al.,* 2005 in grapvines and Tognetti *et al.,* 2005 in olive). Deficit irrigation strategies present an interesting alternative to common irrigation practices for increasing water use efficiency (WUE), wherever water is a limiting factor to production. Therefore, some regions have been adopting strategies of irrigation management that favor the rational utilization of water resources. In this context, irrigation techniques with controlled deficit, such as Drip irrigation, Regulated Deficit Irrigation (RDI) and Partial Rootzone Drying (PRD) are worth mentioning. In drip irrigation, the drippers operate at a slow rate; usually the discharge matches the soil infiltration rate which neither allows surface flooding nor the runoff making water losses minimal. Fertilizers and nutrients are also applied through this system and their losses made minimal by localised application and reduced percolation. The RDI technique was originally employed in peach (*Prunus persica* L.) and pear (*Pyrus* spp. L.) orchards, in order to control vegetative and reproductive growth, by means of imposing water stresses during important phases of fruit development (McCarthy, 2000). The RDI technique consists of delivering irrigation water with deficits at developmental stages when plant growth and fruit quality present low sensitivity to water stress; in other words, when it is possible to reduce water and energy consumption without compromising fruit quality and orchard yield. Partial rootzone drying (PRD) is an innovative irrigation technique which is thought to reduce plants water consumption based on the induction of changes in the plants hormonal balance and chemical signaling of roots in the drying soil (Davies *et al*. 2000, 2002). To stimulate these responses, under PRD one side of the root system is well watered, while the other falls dry. In the drying part of the roots increased amounts of abscisic acid (ABA) are produced which make the plant reduce its water consumption. Through the wet side of the root system it is still well enough supplied to maintain fruit growth, while vegetative growth is reduced (Dry *et al*., 2000). Thereby, fruit yield is widely unaffected or only slightly reduced and so water-use efficiency can be increased massively. This has been described for a variety of tree crops, such as grape-wine (Dry *et al*., 2000), pear (Kang *et al*., 2002), citrus (Hutton, 2000), raspberries (Grant *et al*., 2004) and olives (Wahbi *et al*., 2005). The timing and rate of irrigation should be adjusted to correspond to the plants water demand with an ambition to produce good yields of prime quality. Compared to furrow irrigation, drip irrigation provides better water use efficiency (Hoppula and Salo, 2007). Scheduling water application is very critical to make the most efficient use of drip irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and hence reduces production. An optimal use of irrigation can be characterized as the supply of sufficient water according to plant needs in the rooting area and at the same time avoiding the leaching of nutrients into deeper soil levels (Kruger *et al.*, 1999). High frequency water management by drip irrigation minimizes soil as a storage reservoir for water, provides at least daily requirements of water to a portion of the root zone of each plant and maintains a high soil matric potential to reduce plant water stress (Yuan *et al*., 2004).

Applying fertilizers through an efficient irrigation system, termed as fertigation, offers a vast potential for more accurate and timely crop nutrition. Fertilizers applied through broadcasting are not efficiently utilized by the plant, whereas, fertigation allows an accurate and uniform application of nutrients to the wetted area, where the active roots are concentrated. Fertigation increases the efficiency in the application of the fertilizers, which also allows reducing the amount of applied fertilizers. This not only reduces the production cost but also lessens the potential of ground water pollution caused by the fertilizer leaching. Fertigation allows to adopt the amount and concentration of the applied nutrients in order to meet the actual nutritional requirement of the crop throughout the growing season (Raina, 2002, Raina *et al.,* 2005 and Kachwaya, 2018). Therefore it seemed to be essential to evaluate both strategies according to their water-saving effectiveness and their impact on fruit quality of mango. Keeping in view the above facts present investigation was undertaken with following objectives:-

1. To determine the effect of Regulated deficit irrigation (RDI) and Partial root zone drying (PRD) on growth (vegetative and reproductive) and shelf life of mango.
2. To study the effect of RDI, PRD and fertigation with Potassium, Boron and Calcium on shelf life of mango.
3. To standardize irrigation scheduling for mango.

Chapter-2

Review of Literature

CHAPTER-2

REVIEW OF LITERATURE

The water and nutrient management are most important factors that influence the growth and development of fruit, which in turn have direct effect on its qualitative and quantitative parameters. The overall irrigation efficiency in conventional furrow and flood methods is low and there is a great scope in saving large quantities of water with the adoption of efficient methods of irrigation. Drip or trickle irrigation system in fruit crops has shown an inbuilt capacity to save water and increase production. Among various methods of irrigation, drip irrigation is the most efficient method as it supplies the exact amount of water required by the plant at right time and near to root surface (Gupta, 1997). It saves 50-70 per cent of water, 75-80 percent of power and 30-40 per cent of fertilizers (Sivanappan, 1998). Nevertheless, it has become essential to manage the water as the amount of water throughout the world for agricultural use is decreasing day by day. For sustainable water use in agriculture, crop-specific and water-saving irrigation techniques that do not negatively affect crop productivity must be developed. Worldwide, successful attempts have been documented regarding the use of deficit irrigation methods, namely regulated deficit irrigation (RDI) and partial rootzone drying (PRD) to improve water use efficiency (WUE) in various tree crop species have been reported by several workers (Arzani *et al.*, 2000; Hutton, 2000; Kang *et al.*, 2002; Grant *et al.*, 2004; Romero *et al.*, 2004; Van Hooijdonk *et al.*, 2004; Cifre *et al.*, 2005 and Tognetti *et al.*, 2005).

Deficit irrigation strategies present an interesting alternative to common irrigation practices for increasing water use efficiency (WUE), wherever water is a limiting factor to production. Therefore, some regions have been adopting strategies of irrigation management that favor the rational utilization of water resources. In this context, irrigation techniques with controlled deficit, such as Drip irrigation, Regulated Deficit Irrigation (RDI) and Partial Rootzone Drying (PRD) are worth mentioning. The RDI technique was originally employed in peach (*Prunus persica* L.) and pear (*Pyrus* spp. L.) orchards, in order to control vegetative and reproductive growth, by means of imposing water stresses during important phases of fruit development (McCarthy, 2000). The RDI technique consists of delivering irrigation water with deficits at developmental stages when plant growth and fruit quality present low sensitivity to water stress; in other words, when it is possible to reduce water and energy consumption without compromising fruit quality and orchard yield. Partial rootzone drying (PRD) is an innovative irrigation technique which is thought to reduce plants water consumption based on the induction of changes in the plants hormonal balance and chemical signaling of roots in the drying soil (Davies *et al*. 2000, 2002). To stimulate these responses, under PRD one side of the root system is well watered, while the other falls dry. In the drying part of the roots increased amounts of abscisic acid (ABA) is produced which make the plant reduce its water consumption. Through the wet side of the root system it is still well enough supplied to maintain fruit growth, while vegetative growth is reduced (Dry *et al*., 2000). Although mango grows well even in poor soils because of its deep root system but keeping in view the vegetative growth it has to attain and removal of nutrients through the harvest, it needs some amount of fertilizers. Applying fertilizers through an efficient irrigation system, termed as fertigation, offers a vast potential for more accurate and timely crop nutrition. Fertilizers applied through broadcasting are not efficiently utilized by the plant, whereas, fertigation allows an accurate and uniform application of nutrients to the wetted area, where the active roots are concentrated. Fertigation increases the efficiency in the application of the fertilizers, which also allows reducing the amount of applied fertilizers. This not only reduces the production cost but also lessens the potential of ground water pollution caused by the fertilizer leaching. Fertigation allows to adopt the amount and concentration of the applied nutrients in order to meet the actual nutritional requirement of the crop throughout the growing season (Raina, 2002, Raina *et al*., 2005 and Kachwaya, 2018). Therefore it seemed to be essential to evaluate both strategies according to their water-saving effectiveness and their impact on fruit quality of mango. A lot of work on irrigation methods have been done in fruit crops. An attempt has been made in this chapter to review the relevant literature on water and nutrient management in fruit crops in general and mango in particular under appropriate heads.

2.1 Irrigation scheduling of mango

2.1.1 Irrigation scheduling based on weather parameters

2.1.2 Irrigation scheduling based on soil moisture content

2.1.3 Irrigation scheduling based on leaf temperature

2.2 Water use efficiency

2.3 Effect of deficit irrigation on phenological characteristics of mango

2.3.1 Time and period of flowering

2.3.2 Inflorescence characteristics

2.4 Effect of deficit irrigation on tree growth characteristics of mango

2.5 Effect of deficit irrigation on physiochemical characteristics of mango

2.5.1 Physical characteristics

2.5.1.1 Fruit weight

2.5.1.2 Fruit size

2.5.1.3 Fruit volume

2.5.2 Biochemical characteristics

2.5.2.1 Total soluble solids

2.5.2.2 Titrable Acidity

2.5.2.3 Sugars

2.5.2.4 Proline

2.5.2.5 Pectin methylesterase(PME)

2.6 Effect of deficit irrigation on fruiting characteristics of mango

2.6.1 Fruit set and Fruit drop

2.6.2 Yield

2.6.3 Number of Fruits per tree

2.7 Economics

2.8 Effect of fertigation on growth, yield and quality parameters

2.8.1 Effect of fertigation on leaf nutrients

2.8.2 Effect of fertigation on growth and yield

2.8.3 Effect of fertigation on fruit quality

2.9 Effect of different deficit irrigation regimes and fertigation on shelf life on mango

2.1 Irrigation scheduling of mango

Irrigation is done to supplement the deficit in soil water storage. The major aspects to be conducted relate to time, quantum and methods of irrigation. The proper scheduling of irrigation water is important to achieve maximum productivity. This involves the soil, plant and climatologically parameters. Developing irrigation regimes require knowledge of both the timing and amount of water to be applied in order to replenish evapo-transpiration (ET) losses. Irrigation scheduling consists of two main parts: (1) applying the appropriate amount of water and (2) at the correct time. For these two variables, when one increases then the other automatically decreases, since they are inversely related. So a prime management choice that irrigators need to make is whether to focus on the amount of water per application or the time interval between irrigations. The procedures used to schedule irrigation in orchards may be classified into those using soil or plant measurements to determine irrigation timing and those based on water budget to estimate both depth of application and timing (Goldhamer and Snyder 1989). Mango fruit mostly matures in month of April, during the fruit growth period irrigation facilities are limiting hence appropriate irrigation scheduling is required to minimize plant water deficit throughout the crop life cycle. In orchards there are many situations where irrigation applications are insufficient to meet the tree demand, either due to limited water supply or because of management imposed water deficits at certain growth stages.

Detecting tree water deficit is now possible by combination of tree and soil water measurements.

Azevedo *et al.* (2003) estimated the crop coefficient values (Kc) for mango to estimate the water requirement of irrigated mango orchards in northeast Brazil, the accumulated mango orchard water consumption for the whole productive cycle was 551.6 and 555.1 mm by the soil water and Bowen ratio energy balance methods, respectively.

2.1.1 Irrigation scheduling based on weather parameters

Li-Gy *et al.* (2000) reported the water use of drip irrigated peach trees under full and regulated deficit irrigation (RDI). Peach trees grown on clay loam soil, were irrigated under two different treatments: 1) 80% of pan evaporation for all seasons (full irrigation) and 2) 20% of pan evaporation (RDI) during the slow fruit growth stage plus 80% of pan evaporation during rest of the period. RDI treatment saved 20% of water, kept yield almost the same and reduced shoot growth.

Ravishankar *et al.*, 2011 studied some aspects of weather dynamics influencing production and sustainability of mango (*Mangifera indica* L.) in Malihabd belt of Uttar Pradesh and reported that sudden increase in temperature (Tmax and Tmin) couples with reduction in RH and concomitant increase in bright sunshine hours, wind speed and pan evaporation during post flowering period severely impacted fruit set, fruit formation, fruit drop, fruit growth and development.

The most commonly used method for irrigation scheduling employ empirical estimation of plant water consumption by measurements of evaporation of free water or soil status. The so called class-A pan evaporimeter (U.S. weather Bereau Class A Evaporation Pan) is popular for scheduling irrigation because of the high association between water loss and actual evaporation is easy to monitor and necessary equipment is simple and easy to maintain (Jensen and Middleton, 1970; Doorenbos and Pruitt, 1977).

2.1.2 Irrigation scheduling based on soil moisture content

Soil moisture affects almost every aspect of plant growth and development by modifying morphological and biochemical characteristics of plant (Hsiao, 1973). The optimum moisture in the soil is maintained either through rainfall or supplemental irrigation has direct effect on vegetative growth of plant.

Yan and Chen (1980) found that vegetative growth and photosynthesis of potted mango trees were reduced when soil moisture content was below 40%. Under sub-tropical conditions, temperatures of 15ºC or below promotes mango flower induction (Lu and Chacko, 2000), while temperatures close to 20ºC promote vegetative growth (Davenport and Nunez-Elisea, 1997).

Higher soil moisture may result in higher evaporation and precipitation, and an accurate soil moisture representation can enhance precipitation predictability (Koster *et al.*, 2000).

Panigrahi and Srivastava (2011) found that soil moisture fluctuations under different irrigation regimes were negligibly affected at both 45 cm and 60 cm depths, suggesting the confinement of effective root zone of the citrus plants within top 30 cm soil profile. The fluctuation of soil moisture content at 0-30 cm depth in 100 % irrigation was relatively higher during April to June than November to March, indicating higher tree water consumption during April-June over November-March.

2.1.3 Irrigation scheduling based on leaf temperature

Leaf temperature was used to assess for water stress as lower transpiration rates can result in increased leaf temperatures due to stomatal closure and decreased energy dissipation. Leaf temperature (◦C) was measured on three occasions during the study encompassing various environmental conditions (ambient temperature range 19–30◦C). Leaf temperature was measured mid-afternoon (1300–1530 hours) on four dry fully-expanded sunlit leaves per plot using an infrared thermometer (Connell and Goodwin 2007).

Direct measurement of leaf temperature has been related to crop water stress based on the fact that under stress-free conditions the water transpired by the plants evaporates and cools the leaves. Conversely, in a water-deficit situation, little water is transpired and the leaf temperature increases. This is also the dominant mechanism when the canopy is considered as a whole (Idso and Baker 1967).

Massai *et al.* (2000) used leaf temperature measurement as stress indicator in peach tree growing under different climatic conditions. Single leaf temperature appeared to be a good indicator of water stress but showed poor correlation with pre-dawn and mid-day water potential.

2.2 Water use efficiency

Hedge and Srinivas (1990) recorded highest water use efficiency (64.4 kg/ha/mm water) under drip irrigation as compared to basin irrigated banana plants (53.7 kg/ha/mm water). Berad *et al.* (1998) observed 48 per cent of water saving in banana with drip irrigation as compared to surface irrigation. Similarly, Shelke *et al.*

(1998) reported 24 per cent of water saving in banana with drip irrigation as compared to other methods of irrigation. More *et al.* (1999) comprehended higher consumptive use of water in basin system of irrigation (3,104 mm) than drip irrigation (2,957 mm), whereas, water use efficiency was highest under drip irrigation in banana.

Drip irrigation in pomegranate resulted in a water saving of 45 to 94 per cent at various locations in India over basin irrigation method. Sivanappan (1994) reported 45 per cent of water saving in pomegranate with drip than conventional basin irrigation. Whereas, Magar (1985) reported water savings of 62 per cent with drip irrigation than basin irrigation.

Tekinel *et al*. (1989) studied the effect of drip and other conventional irrigation methods on the water use efficiency (WUE) in strawberry and recorded highest WUE under drip irrigation. Rolbiecki *et al.* (2004) reported that water use efficiency was significantly higher (178 kg/ha/mm) for drip irrigated strawberry plants when only half water rate was used as compared to drip irrigation with full water rate (78 kg/ha/mm) and micro sprinkler irrigation (61 kg/ha/mm). Water use efficiency decreased in strawberry as applied water increased by Kirschbaum *et al.* (2004).

According to Hutmacher *et al.* (1994), water use efficiency increased linearly with the decrease in the irrigation water amount. Palma and Novello (1998) reported that under dry conditions, irrigation upto 50 per cent ETc resulted in markedly higher water use efficiency. Futhermore, they concluded that the increase in water use efficiency was due to increased rate of leaf net CO_2 assimilation and low net transpiration rate.

In apple, Bhardwaj *et al.* (1995) found that water use with drip irrigation was 90.1 to 93.5 per cent less than furrow irrigation. The effect of drip irrigation on water use efficiency (WUE) of apple was investigated by Treder and Czynczyk (1997) and found higher water use efficiency (22.3%) in drip irrigated trees than unirrigated trees. Regulated deficit irrigation effects on growth and yield of plum tree was studied by Battilani, (2004) and he found that water use efficiency was highest in the rainfed plot and decreased by (4.5 kg m-3) in 50% ETc and further (5.8 kg m-3) in 100%

ETc. Bryla *et al*. (2003) observed higher water use efficiency under surface and subsurface drip irrigation than under furrow irrigation in peaches.

Shukla *et al.* (2000) reported water saving of 58 per cent with drip irrigation in mango compared to conventional basin irrigation (3720 mm). Srinivas (1996) registered a 50-60 per cent of water saving with drip method than furrow irrigation (3510 mm) in papaya. Sivanappan (1998) found 68 per cent savings in water with adoption of drip irrigation compared to basin irrigation (2280 mm). Agrawal *et al.* (2002) noticed highest water use efficiency (180.54 q/ha/mm) with drip irrigation than basin irrigation in papaya.

Chandel *et al.* (2004) found highest water use efficiency (2.91 q/ha/cm) under drip irrigation at 100% ETc, followed by drip irrigation at 80% ETc (2.76 q/ha/cm) in kiwifruit. Chauhan and Chandel (2010) studied the comparative performance of drip irrigation and conventional basin irrigation on water use efficiency in kiwifruit. They found highest WUE in drip irrigation with 0.6 'V' volume of water. Serman *et al*. (2004) studied the effect of trickle irrigation on grapes cv. Superior Seedless and found that water use efficiency (27.56 kg mm-1) was higher in trickle irrigation at 60% ETc, followed by 27.27 kg mm-1 in trickle irrigation at 70% ETc and minimum (20.72 kg mm-1) in trickle irrigation at 100 % ETc.

Sharma *et al.* (2005) reported that drip irrigation registered much higher water use efficiency as compared to surface irrigation. Also, the drip irrigation registers much higher water use efficiency as compared to surface irrigation in strawberry (Kumar *et al*; 2012).

Spreer *et al.* (2007) reported that PRD yielded less than the fully-irrigated control treatment, nearly doubling WUE, although the differences were not significant.

Perez-Pastor (2007) evaluated postharvest fruit quality of Apricot (*Prunus armeniaca* L. cv. Búlida) harvested from trees exposed to three different treatments: control treatment (100% of evapotranspiration); regulated deficit irrigation (RDI), which consists in fully irrigation during critical periods; and 50 per cent water regime compared to control. At harvest no differences were observed in weight, equatorial diameter and firmness of the fruit among the different treatments.

Increased water use efficiency (WUE) resulted in up to 50% irrigation water saving during the Deficit irrigation treatments as reported by Laajimi *et al.* (2009).

Yield and fruit development in mango (*Mangifera indica* L. cv. Chok Anan) under different irrigation regimes was investigated by Spreer *et al.* (2009) and found high water use efficiency in PRD (13.79 Kg/m^3) followed by RDI (11.01 Kg/m^3) and minimum under control (8.36 Kg/m^3).

Zuazo *et al.,* (2011) studied the impact of sustained-deficit irrigation on tree growth, mineral nutrition, fruit yield and quality of mango in Spain and found maximum water use efficiency at 50 % ETc (7.1 kg/ m^3) and minimum at 100 % ETc (3.1 kg/ m^3).

Carter *et al.,* (2013) studied the effect of deficit irrigation on water use and water use efficiency of alfalfa and observed that the WUE was as high as 3 kg m^{-3} and as low as 1.17 kg m^{-3} for the fully irrigated and the 25% irrigated treatments, respectively.

Highest IWUE (57.1 g/m3) was observed in case of drip irrigation having 20 % ETc level and irrigation starting from 1^{st}April. Deficit irrigation showed great potential to increase the irrigation water use efficiency of litchi production with slight deviation in potential yield as reported by Mali *et al.,* (2015).

Influence of irrigation during the growth stage on yield and quality in mango (*Mangifera indica L*) was investigated by Wei *et al.,* (2017) and found maximum WUE in T_5 63-66% (28.45 kg/m^3) and minimum in T_1 79-82% (13.54 kg/m^3). Partial root-zone drying saves 50 % of irrigation water and increases water use efficiency of banana cv. BRS Princesa crop by 78 % as reported by Coelho *et al.,* (2018).

Kachwaya *et al.* (2018) studied the performance of strawberry grown in open field conditions in relation to differential irrigation scheduling and the result revealed that highest water use efficiency (0.67 t ha-1 and 0.95 t ha-1) during 2010 and 2011, respectively was observed under treatment 60% ETc drip irrigation treatment. The minimum water use efficiency (0.48 t ha-1 and 0.63 t ha-1) was recorded in furrow irrigation with 'V' volume of water treatment, during the year 2010 and 2011, respectively. The increased WUE under drip irrigation is due to the fact that water was applied precisely and directly into the root zone without wetting the entire area consequently leading to lesser evaporation and downward losses of water compared to surface irrigation.

2.3 Effect of deficit irrigation on pheneological characteristics of mango

2.3.1 Time and period of flowering

The time of flowering in different regions is greatly influenced by local weather conditions. In many parts of North India, the mango flowers late in January or in the beginning of February or even late March in some submontane districts. Flowering in mango continues in two or three distinct flushes for a period of 6 to 8 weeks on different branches or trees and it takes about 5 months for the fruit to mature and ripen after flowering. Mango produces blossoms and bears fruit mostly from the terminal buds of its shoots and very rarely from the axillary buds. Dry weather stimulated flowering and cloudy weather or winter rains tend to retard it. Inspite of a favourable dry weather after the month of October, the tree may not flower and it may produce vegetative or leafy shoots only.

Biennial bearing or irregular cropping is a serious problem for the mango growers. The nature of flower production in mango is a very complex one related to the mechanism of controlling the balance between vegetative and reproductive development and of course, the climatic condition which play vital role in the condition growth and flowering. Phenomena of flowering in mango trees is especially challenging for physiologists, breeders and growers (Rani, 2018). KNO_3 has potential for inducing flowering in mango by stimulating activity of nitrate reductase and increasing the production of ethylene.

Basiouny, (1984) reported that peach tree showed advanced flowering, fruit set and fruit maturity with effluent treated irrigation water wherein flower production was 4 to 7 days earlier and fruit set was heavier and more regular in irrigated trees. The differences in duration and stage of harvest may be due to the difference in the cell wall plasticity or other characteristics that allowed a different rate of water and air space.

Gehrmann (1985) observed that strawberry fruit maturity was accelerated in water stressed plants. Deshmukh *et al.* (1988) advocated that a water stress period of 30-40 days was found sufficient for successful induction of ambia flowering in

Nagpur mandarin grown in medium deep black clay soils. However, it has been observed that even with adoption of most severe water stress, it was not possible to induce flowering in many orchards. In another study with the cv. Shamouti of orange where tensiometers were used with 35 per cent less applied water than fully irrigated trees, flowers per tree increased by 52 per cent but the flower abscission rate was high which resulted in 20 per cent lower yield but high sugar and acid content (Moreshet *et al.,* 1983).

Arzani *et al.* (2000) reported that Sundrop cultivar of apricot under regulated deficit irrigation applied in the first season had enhanced flowering, flower and fruit density, whereas fruit set and fruit number was enhanced during second year.

Early flowering under drip fertigation had been documented by Prabhakar *et al.* (2001), Meenakshi and Vadivel (2003) and Kavitha (2005) in tomato. This indicated that nutrient availability at regular intervals in water soluble form and judicious water availability might have helped early flowering and harvesting of the crop.

Tahir *et al.* (2003) reported a significant reduction of emergence of vegetative flushes by 46% in stressed trees compared to non-stressed trees. Similar results were reported by Levin *et al.* (2015 a, b) where post-harvest (PH) vegetative growth in mango cv. Keitt under Israeli growing conditions was significantly reduced when water application during the PH period was reduced by 50% compared to the standard farm water application (control), mainly after low production years. Also, reduced water application during the final fruit development (FFG) period had a significant impact on PH vegetative growth, mainly under high crop loads, even though all the trees received the same amount of water during PH (Levin *et al.,* 2015b).

Cuevas *et al.* (2007) observed that loquat trees under water stress advanced full bloom date by 13 and 18 days, while water cut of 50 per cent brought an anticipation of full bloom of only 12 and 10 days, depending on the year under regulated deficit irrigation. Similarly in mango, water stress also advance bloom date (Núñez-Elisea and Davenport, 1994; Lu and Chacko, 2000).

Hueso and Cuevas (2008) examined Algerie cultivar of loquat tree under post harvest regulated deficit irrigation (RDI) and reported that trees showed full bloom advancement by 10-20 days depending on the season as compared to continuous regulated deficit irrigation. They further reported that average harvest date was advanced by 5 to 9 days depending on the season in RDI, whereas advancement of harvest date in CDI was three days in first year and five days in second year.

Perez-Perez *et al.* (2008) observed that deficit irrigation affected the flowering, fruit set, abscission and fruit growth process in sweet orange cv. Lane late grafted on Carrizo than on Cleopatra and the tress on Cleopatra, deficit irrigation did not alter the flowering or fruit set in either year, however, in deficit irrigation tree on Carrizo, flowering and fruit set were delayed by seven days with respect to control tree in first year, whereas in second year the time of flowering and fruit set were similar on both rootstocks. Sidhu and Bal (2009) reported that ber plants irrigated at stress condition (cumulative Epan 150 mm) were first to flower, attained full bloom and first to complete flowering phase as compared to the plants which were irrigated at 50, 75, 100 and 125 pan cumulative evaporation.

Goodwin and Bruce (2011) reported that under post harvest deficit irrigation, peach flowering commenced earlier and lasted longer in the 50, 80 and 100 per cent evaporation level and at midpoint of the flowering period they were close to a twofold difference in the number of open flowers in the 50, 80 and 100 per cent levels as compared to 150 and 190 per cent evaporation levels.

Sharma *et al.* (2015) studied the effect of deficit irrigation on growth and yield of tomato under drip irrigation in shade net house and found that under water stress condition the initiation of flowering is earlier and this might be due to accumulation of maximum photosynthates favouring fast growth in tomato.

Rao *et al.* (2017) studied the influence of growth, yield and quality of guava (*Psidium guajava L*.) by drip irrigation and fertigation and found that the maximum plant height, Periphery of rootstock were higher under D1F1 (100 % irrigation with 100 % fertigation) followed by D2F1 (80 % irrigation with 100 % fertigation) and minimum under D3F2 (60 % irrigation with 75 % fertigation).

2.3.2 Inflorescence characteristics

Menzel and Simpson 1991studied the effects of temperature and leaf water stress on panicle and flower development of litchi *(Litchi chinensis* Sonn.) and found that temperature and water conditions after panicle emergence have strong effects on reproductive development and sex ratio in litchi.

Sarker and Rahim (2013) studied the effect of irrigation on harvesting time and yield in mango (*Mangifera indica* L.) and found that there were significant differences in terms of terminal shoot length, number of leaves per terminal shoot, leaf area, length and breadth of panicle and number of secondary branches per panicle as influenced by different irrigation treatments and this might be due to the uptake of sufficient nutrient elements from the soil.

Deficit irrigation practices have reduced vegetative growth in a number of tree crops (Romero *et al.,* 2004; Romero *et al*., 2006; Cui *et al.,* 2008). These effects may be viewed positively in crops such as pear, where severe and moderate water deficit at bud-burst to leafing and flowering to fruit set decreased new shoot length, new shoot diameter and panicle length (Cui *et al.,* 2008). Such levels of water deficit during these periods also reduced leaf area index (LAI) and pruning, however, they enhanced water use efficiency at the yield level (WUEY, defined as ratio of fruit yield to total water use) by 17.3 - 41.4%.

2.4 Effect of deficit irrigation on tree growth characteristics of mango

Li *et al.* (1989) reported that shoot growth and limb diameter were limited whenever water supply was restricted in Merrill Sundance cultivar of peach. Water stress significantly reduces trunk growth and shoot extension growth of peach tree. The maximum trunk girth and shoot extension growth was attained by plants irrigated at 40 mm potential ET level, whereas minimum trunk girth and shoot extension growth was observed under rainfed condition (Berman and Dejong, 1997). Similarly shoot growth and limb diameter in peach were limited whenever water supply was restricted (Li *et al.,* 1989). While studying the effect of irrigation on pistachio, Monastra *et al.* (1995) concluded that trials receiving the greatest amount of irrigation achieved significantly greater growth. Furthermore, it was noticed that irrigation equal to 50 per cent of evaporative demand could support trunk growth equal to that in the fully irrigated treatment. It was also observed that the highest volumes of water caused a statistically significant increase in the average number of vegetative buds but did not greatly influence the average number of floral buds.

Peach tree had a reduced trunk radial growth and canopy shaded area when no irrigation was provided to the trees as compared to irrigated ones (Johnson *et al.*, 1992).

In apricot and plum trees, Malik *et al.* (1992) evaluated different irrigation treatments *i.e.* flood irrigation, water applied to maintain soil moisture at field capacity, water applied to 25 per cent depletion of FC and water applied equivalent to evapotranspiration through drip method of irrigation. They concluded that drip irrigation at 25 per cent depletion of FC had highest trunk girth and shoot length. Barua *et al*. (2000) found that canopy diameter and number of fruits per plant of lemon were significantly better with full rate of drip irrigation (‘V’ volume).

Bonany and Camps (1998) conducted a study on effect of five irrigation levels (50, 75, 100, 125 and 150 per cent ETc) on Golden Delicious apple. They observed that the trees irrigated with 125 and 150 per cent ETc with drip method attained highest tree height and trunk circumference. Sabagh and Aggag (2003) reported that apple trees attained significantly more vegetative growth under drip irrigation, when applied at 100 per cent and 135 per cent of crop evapotranspiration as compared to 65 per cent of crop evapotranspiration.

A significant increase in canopy volume was reported by Kumar *et al*. (2008) in mango due to daily drip irrigation at 75 per cent pan evaporation replenishment.

Panigrahi *et al.* (2008) studied on the effect of drip irrigation and plastic mulch on the performance of Nagpur mandarin (*Citrus reticulate* Blanco) and reported that the annual increase in tree height (0.45-0.62 m) responded significantly to different drip irrigation levels with the maximum value at 60% Ecp with plastic mulch over tree height (0.43 m) under basin irrigation method. They further reported that treatments have no significant influence on stock girth, whereas significant increase in the scion girth (38-459 mm) and canopy volume (0.503-0.988 m^3) was observed in response to drip irrigation treatment with plastic mulch in comparison to basin irrigation (32 mm scion girth; 0.451 m^3 canopy volume) and the maximum scion girth diameter and tree canopy volume were recorded under drip irrigation at 60% Ecp with plastic mulch, followed by drip irrigation at 80% Ecp with plastic mulch.

Bhardwaj *et al.* (2010) reported that apple tree had increased 12 per cent trunk girth and 92 per cent shoot growth under drip irrigation, whereas in basin irrigation trunk girth increased up to 6 per cent and shoot growth up to 32 per cent as compared to plant grown under rainfed conditions.

Regulated deficit irrigation applied at stage II as well as combined regulated irrigation at stage II and postharvest stage reduced length of the shoots (>75 cm) inside the canopy in clingstone peaches (Sotiropoulos, 2010).

Panigrahi *et al.* (2014b) compared sensing tree of citrus for yield forecasting under different irrigation and reported that the plant vegetative growth parameter (plant height, stock girth, canopy diameter and canopy volume) were significantly affected by irrigation treatments and observed that the highest growth of the plants were with full irrigation at 100% ETc, followed by deficit irrigation strategy 75% ETc.

Dolkar *et al.* (2017) studied the effect of deficit irrigation scheduling on yield and quality of kinnow mandarin fruits and reported maximum plant height, stock girth, scion girth and plant volume were recorded under plants supplied with RDI at 100% ETc in early and final fruit growth period (T_9) followed by plants treated with RDI at 100% ETc at early and 50% ETc in final fruit growth period (T_8) whereas, the minimum value were with plants treated with no irrigation (T_1) and this might be due to the plants grown under rainfed conditions or water stress conditions might have might have saturated the root zone, thereby reduced the oxygen level and respiration rate resulting into low uptake of nutrients and inhibited proper growth and vigour of plants. The similar type of observations were also recorded in the earlier studies on irrigation scheduling in Nagpur mandarin (Shirgure *et al.,* 2014), kinnow mandarin by Panigrahi *et al.,* (2014) and Nagpur mandarin by Shirgure *et al.,* (2016).

In another study by Kour *et al.* (2016) who stated that low chill peach tree response to various irrigation levels in terms of trunk girth and showed positive relationship during the study while the trunk girth reduced in plants grown under rainfed condition.

Vijaya *et al.,* (2017) studied the influence of different level of water and fertilizer application through drip system on growth and yield of kinnow mandarin (*Citrus reticulata* Blanco) and observed maximum plant height (48.8 cm), stem girth

(6.24 cm) and plant spread (40.1 cm) with the combined application of drip irrigation at 1.0 volume of water and 120% RDF through fertigation.

2.5 Effect of deficit irrigation on physiochemical characteristics of mango

2.5.1 Physical characteristics

2.5.1.1 Fruit weight

Larson and Schaffer (1989) reported that Tommy Atkins cv. of mango had largest fruit in trees irrigated at 7 days interval as well as fruit harvested from trees with no irrigation.

Behboubian and Lawes (1994) reported that reduction in fruit weight of Nijisseiki Asian pear was observed in late stress conditions compared to the well watered tree however the highest fruit weight under optimum irrigation and light water stress was reported in Big-Top cv. of peach and lowest average soluble solids percentages under water stress. When light water stress was applied; soluble solids percentages appeared to slightly decrease while peach weight remained relatively constant (Besset *et al.,* 2001).

Gurovich (2002) observed that irrigation at 75 per cent ETc maintained throughout the season under drip irrigation had a positive effect on cluster weight, berry weight, berry diameter, total soluble solids and pH of grapes.

Singh *et al.* (2006) observed that Ganesh cultivar of pomegranate had minimum average fruit weight and volume under surface irrigation. Cheng *et al*., 2008 found that there was a significant difference recorded as single fruit weight and single fruit volume were reduced under the DI and PRD treatments.

Ojeda *et al.* (2012) observed that pineapple fruit weight increased with irrigation volumes of 0.2, 0.3 and 0.4 Epan, while irrigation volumes affected polar and equatorial diameter of pineapple fruits with smallest fruit diameters in 0.1 Epan (8.07 and 5.15 cm respectively).

Panigrahi *et al.* (2012) evaluated the effect of drip and basin irrigation on fruit quality of Nagpur mandarin and recorded significantly higher fruit weight in drip irrigation with 80% Ecp (Cumulative Pan Evaporation) compared with basin irrigation. Similarly, Tejero *et al*. (2010) found positive impact of irrigation on fruit quality of citrus and recorded significantly higher fruit weight (316.9 g) at 100% ETc and lowest (279.3 g) at severe deficit irrigation at 50 % ETc.

Mali *et al.* 2015 studied the effect of water application method and deficit irrigation on yield, quality and irrigation water use efficiency of litchi (*Litchi Chinensis* Sonn.) cv Shahi and drip irrigation system recorded highest fruit weight (22.6 g) at 60 % ETc and irrigation starting from 1stMarch.

Subbaiah *et al.* (2017) studied the effect of different irrigation levels on yield and physiological-biochemical characteristics of mango cv. Banganpalli and revealed that the maximum fruit weight (379.0g and 360.0g), were observed in I2 (RDI at 100 % Ep) during both the seasons.

The fruit weight, fruit size (length and diameter) were recorded highest under plants receiving irrigation schedule with RDI at 100% ETc at early and 50% ETc in final fruit growth period (T8) the results were reported by Dolkar *et al.* (2017) and this might be due to larger number of cells and the positive effect of water availability on the cell division rather than cell expansion.

2.5.1.2 Fruit size

Werenfels *et al.* (1967) observed that fruit diameter in cherries increased by 0.5 mm in irrigated trees as compared with fruits from unirrigated trees. Rumayor-Rodriguez and Bravo-Lozano (1991) observed that Golden delicious and Top Red Delicious cultivars of apple trees under limited irrigation and flooding negatively affected yield and fruit size more than the pressurized system irrigation. They reported that the apple fruit from flooding and limited irrigation levels of all systems tended to be smaller, and had higher soluble solids than those from proper irrigation and other two systems tried i.e. micro sprinkler and drip irrigation.

Goldhamer *et al.* (1986) showed a general decrease in nut quality parameters of pistachio subjected to water stress. Although kernel-filling process did not affect by water stress but in other nut crops like almond water deficit affect the kernel filling and reducing the nut quality.

The beneficial effect of K in enhancing the fruit volume was reported by Opazo and Razeto (2001) in oranges and Ruiz (2000) in table grapes. This effect is attributed to enhanced water entry into cells by osmotic processes and an increase in cell expansion and fruit size.

Spreer *et al.* (2009) observed that under regulated deficit irrigation, bigger average fruit size and a more favourable fruit size distribution in Chok Anan cultivar of mango was recorded.

The fruit size, shoot growth and yield were reduced on PRD and DI trees of apple compared to the fully watered (CI) trees reported by Connell and Goodwin 2007.

For apple under micro-irrigation, Einhorn and Caspari (2004); Caspari *et al*. (2004); Leib *et al*. (2005) and Lombardini *et al*. (2004) showed that PRD allowed for substantial water savings with minor to no impact on fruit size while potentially increasing fruit quality.

2.5.1.3 Fruit volume

Huslig *et al.* (1993) observed an increase in peach fruit size with irrigation compared to no irrigation. Shao Guang-Cheng *et al*., 2008 found that there was a significant difference recorded as single fruit volume were reduced under the DI and PRD treatments.

Al-Desouki *et al.* (2009) also observed that fig fruit volume increased about the double with supplement irrigations as compared with rainfed in both seasons of study.

2.5.2 Biochemical characteristics

2.5.2.1 Total soluble solids

Li *et al.* (1989) observed that peach fruit had higher total soluble solids under water stress condition during the final rapid phase of fruit growth. Castel and Buj (1990) observed that mature Satsuma trees grafted on sour orange rootstocks showed a good response on quality when irrigated with 60% of estimated ET loses from a class A pan and 80% of the control throughout the year. Lawand *et al.* (1992) studied the effect of irrigation with deviation during growth period on pomegranate and found that fruit had highest TSS under 0.4 irrigation water applied at cumulative pan evaporation (IW/CPE) ratio which decreased to 0.2 during November-December, while lowest TSS was recorded under 1.0 IW/CPE ratio which increased to 1.2 during flowering and fruit development.

Ebel *et al.* (1993) reported that apple fruit under regulated deficit irrigation had smaller fruits with higher soluble solid concentration. Crisosto *et al.* (1994) found that deficit irrigation increased total soluble solids at harvest in 'O' Henry peaches as compared to optimum or fully irrigated trees. In another study, similar effect was noticed by Crisosto *et al.* (1997), wherein deficit irrigation increased total soluble solids at harvest in 'O' Henry peaches.

Kobashi *et al.* (2000) observed that the levels of sucrose and total sugars increased under water stressed conditions in peach fruit.

Mpelasoka *et al*. (2001b) demonstrated that deficit irrigation (DI) has effects on fruit maturation and ripening depending on timing of application. All DI treatments increased fruit total soluble solids (TSS) and firmness regardless of maturity but had little or no effect on titratable acidity. According to the authors the DI fruit may be harvested over a longer period due to their earlier increased TSS and their higher firmness prior to harvest and for most of the storage period.

Increased level of total soluble (TSS) in Mihowase Satsuma under deficit irrigation compared to fruit grown under normal irrigation level with slight influence on peel color, titratable acidity (TA) and TSS/TA ratio was observed by Peng and Rabe (1998). Gurovich (2002) observed that irrigation at 75 per cent ETc maintained throughout the season under drip irrigation had a positive effect on cluster weight, berry weight, berry diameter, total soluble solids and pH of grapes.

Chandel *et al*. (2004) reported significant increase in fruit size, weight and quality of kiwifruit under drip irrigation at 100% ETc. Similarly, Chauhan and Chandel (2010) studied the comparative performance of drip irrigation and conventional basin irrigation on fruit quality in kiwifruit and found that total soluble solids and titratable acidity decreased with decrease in the volume of water applied. The maximum values for TSS (16.40^{o}B) and acidity (1.27%) were recorded in T_1 (drip irrigation with 'V' volume of water) treatment and the minimum TSS (13.54^{o}B) was observed in T_4 (basin irrigation at 80% of field capacity) and minimum acidity (1.12%) in T_3 (drip irrigation with 0.6 'V' volume of water) treatment. The maximum total sugars and reducing sugars (9.87 and 6.59% respectively) were recorded in T_3 (drip irrigation with 0.6 'V' volume of water) treatment and the minimum total sugars and reducing sugars (9.10 and 5.80%) were recorded in T_5 (basin irrigation with 'V' volume of water) treatment. Reducing sugars was maximum (3.31%) in fruits harvested from vines which was irrigated with 0.8 'V' volume of water through drip. The minimum reducing sugar (2.76%) were recorded in T_4 (basin irrigation at 80% of field capacity).

Gelly *et al.* (2004) reported that Andross cv. of peach had higher soluble solid content (12^0 Brix) under regulated deficit irrigation during stage II of fruit growth. Mercier *et al.* (2009) observed that total soluble solids in peach fruit increased under high water restriction as compared to control and light water restriction.

Perez-Pastor (2007) evaluated postharvest fruit quality of Apricot (*Prunus armeniaca* L. cv. Búlida) harvested from trees exposed to three different treatments: control treatment (100% of evapotranspiration); regulated deficit irrigation (RDI), which consists in fully irrigation during critical periods; and 50 per cent water regime compared to control and found that fruit from water stressed plants had higher values of total soluble solids (TSS) and titratable acidity (TA).

Perez-Perez *et al.* (2008) observed in mature Lane late sweet orange trees that the total soluble sugars and titratable acidity increased when a severe drought stress occurred only in phase III, however increased the peel/pulp ratio if severe drought stress occur in phase I, under deficit irrigation.

Shao Guang-Cheng *et al*. (2008) found that total soluble solids concentration of fruit harvested under the water-deficit treatments were higher compared to CI

Hassani *et al.* (2009) reported that highest TSS in fruit of red skin peach was obtained from irrigation levels of 50 per cent.

Total soluble solids in peach fruit increased under high water restriction as compared to control and light water restriction (Mercier *et al.,* 2009).

Garcia-Tejero (2010) determined the postharvest fruit quality of oranges (*Citrus sinensis* L. Osbeck, cv. Salustiano) exposed to RDI in commercial orchards at the semi-arid region of Andalusia- Spain, in the years 2005, 2006 and 2007. The experiment was composed by four different treatments: Control (irrigation replacing

100% of Evapotranspiration, ETc), low deficit irrigation (75% of ETc), moderate deficit irrigation (65% of ETc) and severe deficit irrigation (50% of ETc). As a result, fruit quality parameters as TSS and TA increased in all stressed treatments resulting better organoleptic parameters. Significant fruit size reduction was observed in the year 2005 only. In the years 2006 and 2007, a significant yield loss was not observed.

Perez Sarmiento *et al*. (2010) using nine year-old apricot-trees (*Prunus armeniaca* L. cv. 'Búlida') grafted on 'Real Fino' rootstock analyzed the effects of RDI on fruit quality. Two irrigation treatments were established. The first, a control treatment, was irrigated to fully satisfy the crop water requirements (100% ETc) during the critical periods (stage III of fruit growth and two months after harvest period), and the second, a RDI treatment, was subject to water shortage during the non-critical periods of crop development, by reducing the amount of applied irrigation water to: a) 40% of ETc from flowering until the end of the first stage of fruit growth; b) 60% of ETc during the second stage of fruit growth and c) 50% and 25% of ETc during the late postharvest period (that starts 60 days after harvesting), for the first 30 days and until the end of tree defoliation, respectively. They found that some qualitative characteristics such as the level of soluble solids, fruit taste and the colour of the fruit are enhanced.

Rufat *et al.* (2010) observed that peach fruit show increased fruit firmness and total soluble solid under deficit irrigation during stage 3rd of growth.

Panigrahi *et al.* (2012) evaluated the effect of drip and basin irrigation on fruit quality of Nagpur mandarin and recorded significantly higher TSS in drip irrigation with 80% Ecp (Cumulative Pan Evaporation) compared with basin irrigation.

Compared to DI, PRD significantly increased the fruit concentrations of Ca and Mg, and fruit juice concentrations of total soluble solid, P, K and Mg. PRD is better than DI in terms of improving fruit quality, and could be a promising management strategy for simultaneous increase of water use efficiency and fruit quality in tomatoes the result were depicted by Sun *et al.* (2014).

Subbaiah *et al.* (2017) studied the effect of different irrigation levels on yield and physiological-biochemical characteristics of mango cv. Banganpalli and reported that highest total soluble solids was noticed with treatment I4 RDI at 50% Ep. (18.5, 19.0) and the lowest total soluble solids was recorded with treatment I2 RDI at 100% Ep (16.5, 17.0) in the year 2013-14, 2014-15 respectively. The more total soluble solids were recorded in relatively higher water stress conditions over the RDI at 100%, it may be due to reduced fruit water content and greater hydrolysis of starch into sugars (Kramer, 1983). This might have contributed towards an increase in TSS at lower irrigation levels. These findings were conformed to Torrecillas *et al.* (2000); Gelly *et al*. (2004); Pérez-Pastor *et al.* (2007).

2.5.2.2 Titrable Acidity

Lopez *et al.* (2010) reported that soluble solid content and titratable acidity of 'O' Henry peach fruits from unirrigated trees were significantly higher than those from fully irrigated trees. Sotiropoulos *et al.* (2010) reported that in clingstone peach trees regulated deficit irrigation (35 per cent was supplied) in comparison to the fully irrigated trees increased soluble solids content of the fruits with no affect on fruit acidity and fruit firmness.

Ballester *et al.* (2013) studied the response of Navel lane late citrus trees to regulated deficit irrigation, yield components and fruit composition and reported that deficit irrigation treatments increased fruit acidity at harvest in every season with significant differences every year while, the largest increase in acidity was observed in the year when the RDI period lasted longer.

Dolkar *et al.* (2017) studied the effect of deficit Irrigation scheduling on yield and quality of Kinnow Mandarin fruits and reported that the greater plant growth was recorded with fully-irrigated plants ($RDI_{100-100-100}$.) while, maximum fruit yield with better quality was recorded under plant treated with RDI at 100% ETc at early and 50% ETc in final fruit growth period (T_8). Conversely higher acidity and lower total soluble solid with the fruits in $RDI_{0-100-0}$ treatment compared to other treatments and this might be due to water deficit in root zone under this treatment suppressed the vegetative growth of the plants without bringing much effect on leaf photosynthesis rate and the plants invested higher quantity of photosynthates towards reproductive growth (fruiting) than vegetative growth.

Kachwaya *et al.* (2018) studied the performance of strawberry grown in open field conditions in relation to differential irrigation scheduling and depicted that the

TSS and acidity were found higher in drip irrigation at 120% of ETc, followed by drip irrigation at 100% ETc.

2.5.2.3 Sugars

Kumar *et al*. (2012) observed that TSS (8.31%), ascorbic acid (55.3 mg/100g), reducing sugar (2.84%) were comparatively higher in strawberry fruits harvested from drip irrigation (1.0 IW/CPE) irrigation level than those harvested from other irrigation levels. Kim *et al.* (2009) reported that the quality characteristics of 'Maehyang' and ‘Seolhyang’ strawberry cultivars were affected by water stress.

Mali *et al.* (2015) studied the effect of water application method and deficit irrigation on yield, quality and irrigation water use efficiency of litchi (*Litchi Chinensis Sonn.*) cv Shahi and found that deficit water application under drip system resulted in higher reducing sugar content (7.5 %) of litchi fruits.

Subbaiah *et al.* (2017) studied the effect of different irrigation levels on yield and physiological-biochemical characteristics of mango cv. Banganpalli and revealed that the maximum total sugars (16.75% and 17.18%) was found with I6 (PRD at 75% Ep) maximum reducing sugars (5.57% and 5.81%) was noticed in I5 (PRD at 50% Ep) and the highest non reducing sugars (11.9%) (11.42%) noticed with I1 and I6 in 2013-14 and 2014-15 seasons, respectively.

Kachwaya *et al.* (2018) studied the performance of strawberry grown in open field conditions in relation to differential irrigation scheduling and depicted that the total sugar and reducing sugar were found higher in drip irrigation at 120% of ETc, followed by drip irrigation at 100% ETc and this might be due increased water availability leads to increase the water allocation to fruits and thereby caused dilution in the fruits.

2.5.2.4 Proline

Leaf area, shoot length and leaf water potential in almond were reduced by increasing the irrigation intervals, while proline content and stomatal resistance were increased (Zamani *et al.,* 2002).

Laajimi *et al.* (2009) studied the effect of deficit irrigation on apricot cv. Amor El Euch trees grown in the Mediterranean region of Tunisia and reported that deficit irrigation resulted in a significant increase in the leaf proline content during both seasons probably due to the developed response of trees to drought stress. Fruit diameter, length and degree of firmness increased with an increase in water stress. On the other hand, fruit yield was significantly lower for RI 50% ETc (regulated irrigation) and RI 100% ETc treatments than that for the control treatments. He also reported that there was no significant decrease in fruit yield for RI 100% ETc compared with the control.

Srikasetsarakul *et al.* (2011) studied the effects of partial root-zone drying irrigation on proline content and yield of mango in a commercial orchard. Irrigation treatments were (a) Full irrigation (FI) with 100% of ETc, evenly distributed over the root-zone, (b) Partial root-zone drying (PRD) with 50% of ETc on alternating sides of the trunk, and reported that the differences in average proline concentration between PRD and full irrigation were not significant. However, a strong correlation was found between proline concentration and average water content. The fruit growth rates, yield and water use efficiency were similar in both treatments with a share of more than 90% marketable fruit.

Proline was significantly increased with PRD and there was no significant reduction in yield between well-watered and PRD-treated plants. Water use efficiency also was significantly increased with PRD as reported by Ali *et al.* (2014) who studied the effect of partial rootzone drying (PRD) on growth, water use efficiency (WUE) and yield of tomatoes grown in soilless culture.

2.5.2.5 Pectin methylesterase(PME)

Barbagallo *et al.* (2008) studied the pectin methylesterase, polyphenol oxidase and physicochemical properties of typical long-storage cherry tomatoes cultivated under water stress regime and reported that PME activity decreased greatly with increasing water stress.

Singh *et al.* (2018) studied the ripening associated biochemical changes with relation to jelly seed formation in mango cv. Dashehari, Langra and Chausa and reported that the pectin methyl esterase (PME) activity increased initially up to 4 days (895 unit / min / g FW) and decreased slowly on 7 day (600 unit / min / g FW). This might be due to PME is responsible for the de-esterfication of pectin required before polygalacturonase starts the depolymerization of pectin associated with fruit softening.

Bisht, 2011studied the effect of harvest maturity and pre- and postharvest treatments on storage quality of mango (*Mangifera indica*) for submontane areas of himachal Pradesh and found that the highest mean PME activity was recorded in control fruits and it was significantly higher in comparison to all other treatments. $CaCl_2$ treatments were the most effective in reducing PME activity with the lowest activity being recorded in fruits treated with 1.5 per cent $CaCl_2$ (T_9) and this might be due to the activity of PME mainly increases during the early period of ripening and then declines later on (Tieman *et al.,* 2001), when the activity of polygalacturonases and cellulase starts increasing.

2.6 Effect of deficit irrigation on fruiting characteristics of mango

2.6.1 Fruit set and Fruit drop

Fruit set and yield per plant was lowest in trees receiving 50% regulated deficit irrigation (RDI). The highest fruit set and yield was recorded in trees receiving full irrigation followed by trees receiving 80% RDI levels of irrigation (Marsel *et al.*, 2010). The study concluded that the highest fruit set and fruit yield in sweet cherry occurred with full to 80% irrigation while as the fruit quality parameters were highest with lower RDI (50%) level.

Grijalva *et al.* (2013) determined the effect of regulated deficit irrigation on productivity, quality and water use in olive cv "manzanilla" and reported that RDI applying 50% ETc during post-harvest period reduced significantly fruit set and table olive yield and the RDI using an ETc of 75% resulted in the highest water-use efficiency for oil or table olive production.

Kumar (2004) observed higher flowering intensity, fruit set and yield of apple with drip irrigation at 100 per cent ETc.

2.6.2 Yield

Castel and Buj (1990) studied on the response of salustiano oranges to high frequency deficit irrigation and reported that 40% reduction in irrigation water supply during flowering and fruit set period did not reduce the fruit yield significantly in 'Salustiano' orange (*Citrus sinensis* Osbeck) trees in Spain.

Fahad and Hagemann (1992), while working on irrigation scheduling in container grown and open field grown strawberry plants recorded 37 per cent higher yield in drip irrigation as compared to furrow method of irrigation.

Serrano *et al.* (1992) studied the performance of four irrigation treatments in strawberry by watering the plants when soil water potential reached -0.01, 0.03, -0.05 and -0.07 MPa. The maximum yield was obtained in plots irrigated at 0.01 MPa soil water potential. Further they observed that yield reduction was associated with reduction in total assimilation rate resulting from the decreased assimilatory surface area in plants irrigated at lower soil water potentials.

Mpelasoka *et al*. (2001a) investigated that irrigation treatments did not affect the crop load. Irrespective of fruit thinning treatment, deficit irrigated stress resulted in lower fruit weight, total yield and fresh-market yield at harvest than control. However, under deficit treatment, thinned trees resulted higher fruit weight and equal fresh-market yield. Regarding quality parameters, deficit irrigated plants exhibited higher contents of TSS than fully irrigated plants. In a similar experiment, with apple, the fruit firmness was higher under water restriction treatments compared to fully irrigated treatments despite of fruit size (Mpelasoka *et al*., 2000).

Kang *et al.* (2002) studied the soil water distribution, water use and yield response to partial root zone drying under a shallow water table condition in pear orchard. Irrigation was applied in three ways: conventional flood (CFI), fixed partial root zone (FPI) and alternate partial root zone (API). When less irrigation was introduced in the CFI, the number of fruits, yield per tree and total yield in unit were not affected, hence fixed partial root zone drying technique substantially saved water and maintained the yield potential.

Yield increase due to irrigation normally results from a higher crop load (number of fruit) rather than greater fruit size (Pavel and de Villiers, 2004; Spreer *et al.*, 2009).

For apple under micro-irrigation, Einhorn and Caspari (2004), Caspari *et al*. (2004); Leib *et al*. (2005) and Lombardini *et al*. (2004) showed that PRD allowed for substantial water savings with minor to no impact on yield while potentially increasing fruit quality.

Spreer *et al.* (2007) studied the effect of regulated deficit irrigation and partial rootzone drying on the quality of mango fruits (*Mangifera indica* L., cv. 'Chok Anan') and found that yields were reduced in deficit irrigation treatments as compared to the fully irrigated control. However, development and post-harvest quality of fruits grown under deficit irrigation were not adversely influenced. Under PRD in particular, fruit size was increased and fruits had a higher fraction of edible parts as compared to all other treatments.

Shao Guang-Cheng *et al*. (2008) found that the yield of 1PRD was significantly reduced by 23.98 per cent compared to CI (19,566 kg hm^{-2}) over a period of 109 days after transplanting. However, the 1PRD treatment had 17.21 per cent and 24.54 per cent additional yield over the DI50 and 2PRD treatments and had 52.05 per cent higher irrigation water use efficiency (IWUE) than CI treatment.

Gasque *et al.* (2010) concluded that DI scheduled with 40% and 60% reduction in irrigation water quantity at initial fruit enlargement stage of 'Navelina' sweet orange (*Citrus sinensis* Osbeck) did not affect the yield and fruit quality. Similarly, Garcia-Tejero *et al.* (2010a) studied the positive impact of regulated deficit irrigation on yield and fruit quality in a commercial citrus orchard (*Citrus sinensis* (L.) Osbeck, cv. Salustiano) and demonstrated that irrigation at 0.5, 0.65, 0.75 and 1.0 water stress index (ratio of actual volume of water supply to estimated crop evaporation) did not showed any significant impact on tree yield.

Fruit soluble solid concentration (SSC) and fruit relative dry matter in sweet cherry was highest in trees receiving 50% regulated deficit irrigation (RDI) whereas the fruit set and yield per plant was lowest in trees receiving 50% regulated deficit irrigation (RDI) (Marsel *et al.*, 2010).

Panigrahi and Srivastava (2011) advocated for irrigation at 70% crop water requirement for 'Nagpur' mandarin (*Citrus reticulate* Blanco) grown in clay soil, which enhanced the water use efficiency substantially without affecting the yield significantly.

Dolkar *et al.* (2017) studied the effect of deficit Irrigation scheduling on yield and quality of Kinnow Mandarin fruits and reported that the greater plant growth was recorded with fully-irrigated plants ($RDI_{100-100-100}$.) while, maximum fruit yield with better quality was recorded under plant treated with RDI at 100% ETc at early and 50% ETc in final fruit growth period (T_8). This might be due to water deficit in root zone under this treatment suppressed the vegetative growth of the plants without bringing much effect on leaf photosynthesis rate and the plants invested higher quantity of photosynthates towards reproductive growth (fruiting) than vegetative growth.

Subbaiah *et al.* (2017) studied the effect of different irrigation levels on yield and physiological-biochemical characteristics of mango cv. Banganpalli and revealed that the maximum yield per plant (52.9kg and 50.0kg), were observed in I2 (RDI at 100 % Ep) during both the seasons.

Rzekanowski and Rolbiecki (2000) conducted a study on drip irrigation in different cvs. of apple and observed that drip irrigation resulted in an increased yield of 9 per cent in cv. Melba, 22 per cent in McIntosh and 25 per cent in Spartan to that of control.

Ramana Rao *et al.* (2017) studied the influence of growth, yield and quality of guava (*Psidium guajava L.*) by drip irrigation and fertigation and found that the maximum yield per plant (kg/plant) and yield (t/ha) were higher under D1F1 (100 % irrigation with 100 % fertigation) followed by D2F1 (80 % irrigation with 100 % fertigation) and minimum under D3F2 (60 % irrigation with 75 % fertigation).

Kachwaya *et al.* (2018) studied the performance of strawberry grown in open field conditions in relation to differential irrigation scheduling and depicted that the growth, yield and fruit quality under drip irrigation at 120% of ETc were obtained slightly better compared to that under 100% of ETc. The higher yield under drip irrigation at 120% and 100% ETc may be attributed to optimum soil moisture condition owing to frequent, precise and direct application of water in the root zone.

2.6.3 Number of Fruits per tree

Spreer *et al.* (2009) studied the yield and fruit development in mango (*Mangifera indica* L. cv. Chok Anan) under different irrigation regimes and found that the maximum fruit number (101.60) were observed in plants treated with regulated deficit irrigation and minimum fruit number (97.67) were observed in plants treated with partial root zone drying irrigation.

Subbaiah *et al.* (2017) studied the effect of different irrigation levels on yield and physiological-biochemical characteristics of mango cv. Banganpalli and revealed that the maximum fruit number (139.5 and 129.0), yield per plant (52.9kg and 50.0kg), were observed in I2 (RDI at 100 % Ep) during both the seasons.

A major factor that affects mango exportation is the sorting and grading procedures after harvest. Categorization is the procedure of classifying the mango into distinctive groups based on their diversities. Grading is the process of classification based on the quality. Grading is significant commercially because a quality-grade fruit fetching higher price and demand in the market. In addition, the overall external appearance the mango fruit determines the purchasing decision of a customer Alejandro, (2018).

2.7 Economics

Kavitha (2005) reported that, application of 100 per cent water soluble fertilizers under shade secured the highest net returns with the highest benefit cost ratio of 2.90, 3.13 and 3.18 during season, I, II and III respectively in tomato.

Sujatha and Haris (2006) indicated that, drip irrigation resulted in realizing a net return of `. 68,581 ha-1. Similarly the net return per rupee investment was also higher with drip fertigation system in arecanut.

Satpute *et al.* (2008) revealed that, the maximum yield (216.17q ha-1) was obtained with fertigation level of 80 per cent recommended dose of fertilizer and irrigation level 0.3 pan evaporation. The maximum net income (`. 44,580 ha-1) and B:C ratio (1.94) was gained from treatment combination of 0.3 pan evaporation with 80 per cent recommended dose of fertilizer, whereas minimum was reported in control (`. 12,819 ha-1) in cucumber

Fertigation with only 60 per cent recommended dose of nitrogen at 15 days intervals was also found to be most economical and preferable fetching the highest net profit and the highest cost benefit when compared to control in guava (*Psidium guajava L*) cv. Lucknow – 49 (Patel *et al.*, 2010).

Panigrahi *et al*. (2010) studied the effect of drip irrigation and polythene mulch on the fruit yield and quality parameters of mango (*Mangifera indica* L.) and found that the net income and benefit cost ratio was also higher under the treatment

T8 (drip irrigation with 0.6 V volume of water + polythene mulch) as compared to surface method of irrigation.

2.8 Effect of fertigation on growth, yield and quality parameters

Applying fertilizers through an efficient irrigation system, termed as fertigation, offers a vast potential for more accurate and timely crop nutrition. Fertilizers applied through broadcasting are not efficiently utilized by the plant, whereas, fertigation allows an accurate and uniform application of nutrients to the wetted area, where the active roots are concentrated. Fertigation increases the efficiency in the application of the fertilizers, which also allows reducing the amount of applied fertilizers. This not only reduces the production cost but also lessens the potential of ground water pollution caused by the fertilizer leaching. Fertigation allows to adopt the amount and concentration of the applied nutrients in order to meet the actual nutritional requirement of the crop throughout the growing season. (Raina, 2002 and Raina *et al*., 2005).

Application of fertilizer via drip irrigation has attracted research attentions of several workers in major fruit growing areas worldwide (Goode *et al.*, 1978; Koo, 1984; Locascio and Martin, 1985; Wolf *et al.*, 1990; Willis *et al.*, 1991; Hipps, 1992 and Neilsen *et al.*, 1995). Their results suggest that tree growth, fruit yield and quality of fruits could be best maintained through fertigation as compared with soil fertilization, besides achieving considerable savings in the fertilizers.

2.8.1 Leaf nutrient

Noe *et al*. (1995) recorded significant increase in leaf nutrients content (2.49% N, 1.81% Ca and 0.27% Mg) in drip fertigation as compared to non fertilization treatment.

Albregts *et al.* (1996) evaluated the potassium fertigation requirements of drip irrigated strawberries. Potassium was injected weekly into drip irrigation system @ 0.28, 0.56, 0.84, 1.12 and 1.40 kg K per ha per day and observed highest leaf K concentration under treatment comprising application of 1.40 kg K per ha. He also reported that leaf K concentrations were positively correlated with applied K.

Murthy *et al.* (2001) studied the effect of soil application or drip fertigation of normal fertilizers such as urea, single supper phosphate and murate of potash and of water soluble fertilizers on the grapes cv. ‘Banglore Blue’. Their results revealed that soil application of 100 per cent normal fertilizers and drip irrigation with 80 per cent water soluble fertilizers registered highest mean potassium and calcium content in the leaf petiole of grapes.

Ali *et al*. (2004) noted gradual increase in Cl content in leaves of strawberry plant that received >60 per cent of potassium requirement as KCL in fertigation. Murthy *et al*. (2001) observed that the application of 100 per cent normal fertilizers and drip fertigation of 80 per cent water soluble fertilizers resulted in the highest mean potassium and calcium content in the leaf petioles of grapes. Treder (2006) reported that leaf nutrients content (0.26% P and 2.23% K) were significantly higher in fertigation treatment as compared to broadcast method of fertilization.

Chauhan *et al.* (2005) studied the effect of micro-irrigation levels on growth, yield, fruit quality and nutrient assimilation of ‘Delicious’ apple and concluded that micro irrigation levels exhibit a significant influence on leaf micro and macro nutrient content as compared to un-irrigated control. Maximum leaf N, K Ca and Zn content was recorded in 100%ETc. So far as leaf P, Mg and Fe content is concerned, maximum values were recorded in similar treatment, however, was found statistically at par with 80%ETc.

2.8.2 Growth and Yield

Foliar application of boric acid at 0.8 per cent concentration to mango cultivar ‘Langra’ significantly influenced the growth, flowering and fruit set (Rajput and Chand, 1976). The highest yield (42.3 kg per plant) was obtained with 40 ppm boron spray in papaya (Chattopadhyay and Gogoi, 1990). Hassan (2000) reported that, the improvement in fruit set percent of olive could be explained as result to increase pollen grain germination and pollen tube elongation due to boron treatments. Boron has important role on pollination, fruit set and total yield in sweet cherry (Motesharezade *et al.*, 2001). Foliar application of boron has increased yield and fruit quality, in raspberry (Wojcik, 2005).

Tomar and Navdeep (2007) reported that highest fruit set, fruit retention and nut yield was recorded with foliar spray of 0.1 percent borax. Munikrishnappa (1996) found that, fertigation treatment with 80 per cent water soluble fertilizers having treatment with 80 per cent boron was found to be superior with respect to most of the growth and yield parameters in tuber rose.

Garcia (2000) obtained higher yield and cumulative fresh fruit yield of oranges in fertigated plots than in the broadcasting plots. Peterson (1998) studied the effect of fertigation on strawberry and found that the fruit size and overall fruit quality of fertigated plants was considerably better as compared to that of the non-fertigated plants. It seems that uniform distribution of nutrients, coupled with its confinement in the root zone under fertigation, might have leads to the increased nutrient uptake.

Application of KNO_3 followed by KH_2PO_4 sprays advanced flowering in mango cv. Baneshan (Kumar, 2001). The time taken from initiation of panicle to full bloom was observed to be minimum in Ca $(NO_3)_2$ followed by KNO_3. Application of KNO3 increased the hermaphrodite flowers followed by KH2PO4 over control. The yield was more when KH_2PO_4 was sprayed (Kumar, 2001).

Aruna *et al.* (2007) also reported that early flowering was achieved by drip fertigation with water soluble fertilizers at regular intervals. The availability of nutrients at adequate level to roots at appropriate stages would have enhanced synthesis of hormones such as cytokinins and better uptake of potassium by fertigation treatment would have also helped transport of cytokinins and metabolites towards the sink developed namely flower buds.

Opstad and Sonsteby (2008) studied the effects of fertilizer timing and application method on yield and ripening in strawberry cv. Korona. They found that significant differences were found in yield of fertilized plant as compared to non fertilized plants. Similarly, Martinsson *et al*. (2006) studied the impact of fertilizer application on yield and quality of strawberries and they found that fertigation with full nutrient package increased yield (186.6 g/plant) as compared to common practice (113.8 g/plant). The increased nutrients content might have increased the rate of various physiological and metabolic processes in the plant system, ultimately resulted in higher vegetative growth parameters.

Fallahi *et al*. (2010) studied the effect of potassium fertigation on yield and fruit quality in apple and recorded significantly higher yield (5.34 kg/tree) in 15 g K/tree/year fertigated tree than 0 g K/tree/year fertigated tree (4.53 kg/tree).

Lodolini *et al.* (2011) stated that fertigation in young olive trees increased average fruit production per tree, by maintaining a higher crop load without decreasing the final fruit weight.

In sweet orange (*Citrus sinensis* Osbeck), fertigation treatments showed significant effects on increasing fruit yield with 29.4 – 36.5 per cent more accumulative yield than the control (Liang *et al.,* 2011).

Raina *et al.* (2011) studied the effect of drip fertigation with different fertilizer on yield and quality of apricot and found that drip fertigation significantly influenced the fruit weight of apricot. Fertigation with 100% recommended dose of NPK fertilizers had higher fruit weight (16.8 g/fruit) in comparison to soil fertilization with 100 per cent recommended dose of conventional fertilizers. Jeyakumar *et al*. (2001) obtained significantly higher fruit weight (2.43 kg) and fruit length (29.6 cm) with fertigation as compared to soil application in papaya. Similarly Jeyakumar *et al*. (2010) observed that total sugar (8.85%), ascorbic acid (69.54 mg/g) and TSS (11.4%) were comparatively higher in papaya fruits harvested from 100% recommended dose of N and K_2O through drip irrigation. Similarly increase in fruit length, fruit diameter, fruit weight and TSS of Papaya under fertigation at 100% recommended dose of N and K_2O through drip irrigation was recorded by Sadarunnisa *et al*. (2010). Ramniwas *et al*. (2012) studied the effect of irrigation and fertigation scheduling on growth and yield of guava under meadow orcharding and recorded significantly higher fruit weight (182.17 g) in fertigated treatment.

Nehete *et al.* (2011) reported in mango cv. Kesar that the lower level of $ZnSO_4$, $FeSO_4$ and borax in combination had influenced flowering in terms of minimum days taken to 50 per cent flowering and increased length of panicle compared to other treatments and control.

Seong *et al.* (2011) reported that in persimmon, adjusting supplemental N and K was necessary to ensure fruit growth and N and K accumulation for trees with high fruit loads, but high levels of fertigation are not necessarily preferable in persimmon trees. The leaf fruit ratios changed to 10 from 20, the percentage of N and K partitioned to fruits in the non - fertigated trees increased from 38 per cent to 51 per cent and from 67 per cent to 96 per cent, respectively. Of the trees total N and K increases, the percentage decreased with increasing fertigation level.

Patil *et al.* (2013) reported that the sources of nitrogen *i.e.,* thiourea (0.5%) and potassium nitrate (3%) resulted in significantly higher flowering percentage (77.17% and 67.5%) over rest of the treatments in 'Alphonso' mango, whereas KNO_3 induced early flowering by 19.87 days, over control. Similarly, KNO_3 (3%) retained significantly higher number of fruits per panicle (4.20), followed by light pruning (4.13) over control.

Highest number of fruits (515.9) and yield per hectare (258.7 quintals) was registered with the interaction effect of 0.8 volume of water and 80% RDF through drip irrigation reported by Vijaya *et al.* (2017).

2.8.3 Fruit quality

Foliar application of boron increased yield and fruit quality of grape (Donna, 1986). Foliar application of boron has increased fruit quality, in raspberry (Wojcik, 2005).

Fertigation through high density mango orchard recorded higher fruit length (106.01mm), fruit diameter (65.93mm), pulp weight (151.6 g), higher yield (10.65 t ha-1) and higher net returns (`.166480 ha-1). However, 80 per cent recommended dose of fertilizer through drip fertigation enhanced peel to pulp ratio (3.84) and pulp to peel ratio (3.63) (Hanamanth, 2002). Meena *et al*. (2007) reported that, foliar spraying of borax 0.9 per cent in ber fruits increased the total sugar, reducing and non reducing sugar content of fruits.

Fallahi *et al*. (2010) studied the effect of potassium fertigation on yield and fruit quality in apple and recorded significantly higher yield (5.34 kg/tree) in 15 g K/tree/year fertigated tree than 0 g K/tree/year fertigated tree (4.53 kg/tree).

Application of 100 per cent recommended dose of fertilizers (120:75:100g NPK tree-1 year-1) through drip fertigation recorded the highest TSS, ascorbic acid, sugars and carotenoids in mango cv. Alphonso (Prakash, 2010).

The influence of foliar application of calcium chloride and borax on the fruit quality of litchi cultivars was investigated by applying 1 to 3 per cent Calcium either alone or in combination with 0.5 to 1.5 Borax. The litchi cultivars varied significantly for quality traits. Cultivar Gola had the highest fruit weight (23.54 g), pulp weight (17.16 g), TSS (22.54%), total sugars (21.45%), reducing sugars (17.96%) and specific gravity (1.1051), while cultivar Bedana had the highest non reducing sugars (9.72%). Foliar application of calcium chloride (CaCl2) alone had no significant effect on most of the quality variables, however, CaCl2 + Borax (Na2B4O7·10H2O) application increased the fruit weight (19.87 g), pulp weight (14.88 g) and pulp dry weight (13.76%) in control fruits to the maximum of 20.79, 15.69 g and 15.40% respectively with CaCl2 (3%) + Borax (1.5%). No variations were observed in total sugars, reducing sugars and non-reducing sugars of litchi fruit with application of CaCl2 alone, which increased significantly with foliar application of CaCl2 3% + Borax (Haq *et al*., 2013).

Sarker and Rahim (2013) found that the among five treatments (*i.e.*, KNO_3 at 4%, 6% and 8%; urea at 2% and 4% and the water spray as control) foliar spraying of urea at 4 per cent exhibited better performance in relation to terminal shoot length, number of leaves and leaf area and KNO3 at 4 per cent gave superior results with respect to length and breadth of panicle and number of secondary branches per panicle compared to control. The plants sprayed with KNO_3 at 4 per cent expressed earlier panicle appearance by 17 days as compared to delayed appearance of panicle in untreated control plants. The plants that received KNO_3 at 4 per cent produced the highest number of panicles per plant (220.67) whereas the control plants had the least number of panicles (107.67). Regardless of concentration, KNO_3 and urea manifested slightly earlier harvest (5 days) compared to control. Plants treated with KNO_3 at 4 per cent noted the highest number of fruits per plant (136.67) compared to control (62.67). The treatment urea at 4 per cent resulted in the biggest fruit (202.83 g) and the control plants exhibited the smallest fruit (175.00 g). Potassium nitrate at 4 per cent gave maximum yield (23.14 Kg plant-1) as compared to minimum yield (9.12 Kg plant-1) in the control (water spray).

Compared to DI, PRD significantly increased the fruit concentrations of Ca and Mg, and fruit juice concentrations of total soluble solid, P, K and Mg. PRD is better than DI in terms of improving fruit quality, and could be a promising management strategy for simultaneous increase of water use efficiency and fruit quality in tomatoes the result were depicted by Sun *et al.* (2014).

2.9 Effect of different deficit irrigation regimes and fertigation on shelf life on mango

Antognozzi and Proietti (1996) studied the effect of irrigation on fruit quality of table olive (*Olea europea),* cultivar Ascoland tenera and observed that increasing irrigation water decreased the fruit firmness.

Bender (1998) reported that calcium 0.6-2% enhances the fruit quality of mango by improving shelf life and reducing the physiological loss in weight. Kluge *et al.*, (1999) studied the Ripening of “Tommy Atkins” mangoes treated with Ca pre-harvest and concluded that weight loss was reduced by $CaCl_2$ treatment on Tommy Atkins mangoes.

Rathore *et al.* (2007) studied the effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety Dashehari and reported that the reduction in moisture content may be due to fruit skin transpiration and to some extent to fruit respiration. The present results are also similar with the finding of Proietti and Antognozzi (1996) who reported that with increasing irrigation regime, pulp water content of olive was increased.

Abdel-Razik (2012) studied the effect of different irrigation regimes on quality and storability of mango fruits *(Mangifera indica* L.) and the results indicated that irrigation trees with 70 per cent of ETc increased pulp firmness, decay per cent, TSS per cent, total acidity in fruit juice, TSS/acid ratio of mature fruit when compared with those irrigated with 100% Etc under cold storage. Fruit moisture content, weight loss per cent, firmness, fruit decay per cent and total acidity were decreased with increasing number of storage days, while TSS% and TSS/ acid ratio were increased.

Effect of different irrigation regimes on quality and storability of mango fruits *(Mangifera indica* L.) and the results indicated that irrigation trees with 70 per cent of Etc decreased pulp moisture content and this might be due to fruit skin transpiration and to some extent to fruit respiration as reported by Abdel-Razik (2012).

Abdel-Razik (2012) studied the effect of different irrigation regimes on quality and storability of mango fruits *(Mangifera indica* L.) and the results indicated that irrigation trees with 70 per cent of Etc decreased weight loss percentage and this might be due to respiration and transpiration of water through fruit peel tissue and to some biological changes occurred in fruit.

Agbemafle *et al.* (2014) studied the effect of deficit irrigation and storage on physicochemical quality of tomato (*Lycopersicon esculentum* mill. var. pechtomech) and reported that firmness increased with increasing deficit irrigation.

Bhusan *et al.* (2015) studied the effect of pre-harvest chemical treatments and mulching on marketability of mango (*Mangifera indica* L.) cv. Amrapali and reported that the use of black LDPE mulching with borax at 1.0% spray is found to improve fruit size significantly, whereas, $CaCl_2$ at 2.0% with mulching is found effective for improving fruit marketability, reducing decay percentage and reducing physiological loss in weight of the fruit during storage in Amrapali.

Foliar application of KNO_3 @ 2% treatment improved the quality parameters like shelf life, TSS, total sugar, non reducing sugar, reducing sugar, fruit firmness and minimum titrable acidity in Dashehari mango under ultra high density plantation as reported by Patoliya *et al.*, (2017).

Sharma *et al.* (2017) studied the effect of irrigation intervals and calcium sprays on shelf life of litchi (*Litchi chinensis* Sonn.) cv. dehradun and suggested that if litchi was sprayed with 2% $CaCl_2$ better shelf life can be obtained even with less irrigation without affecting quality thereby, optimising the use of precious input *i.e.* water which is getting scarce day by day.

Materials and Methods

CHAPTER-III

MATERIALS AND METHODS

The present investigation entitled "**Studies on water and nutrient management in mango (*Mangifera indica* L.) cultivar Dashehari under Jammu sub-tropics**" were carried out at farmer field located at Akhnoor Jammu during 2017 and 2018. The details about the experimental site, material used and the methodology adopted during the course of investigation are presented under following heads and sub-heads.

3.1 EXPERIMENTAL SITE

3.1.1 CLIMATE OF EXPRIMENTAL SITE

Akhnoor is situated in the sub-tropical zone at latitude of 32.89^0 North and longitude of 74.74^0 East. The altitude of the place is 301 meters from the sea level. Annual precipitation is about 1200 mm mostly coinciding during July to October (about 70 per cent). The mean annual maximum and minimum temperatures are 29.6^0C and 16.7^0C, respectively. Summer months are hot with temperature and humidity ranging from 23.5^0C to 35.5^0C and 53.0 to 73.5 per cent, respectively. The winter months experience mild temperature ranging from 6.5^0C to 21.7^0C. December is the coldest month, when minimum temperature touches to 4^0C. The highest temperature is recorded in the month of June (45^0C). The meteorological data received from the University Agrometrology Centre are given in Appendix-I.

3.1.2 Rainfall, effective rainfall, pan evaporation

The drip irrigation scheduling of mango was carried during 6^{th} to 22^{nd} standard week where the rainfall amount was found maximum 0 to 23.6 mm during 2017 and 0 to 24.2 mm during 2018. The effective rainfall was worked out by using the following formula Effective Rainfall (mm) = [Rainfall amount (mm) – 6.35 mm)] x 0.8. As regards the pan evaporation data, it was found minimum of 0.2 mm during the 6^{th} standard week to as high as 12.6 mm during the 19^{th} standard week during 2017. Similarly, the pan evaporation value was found to be minimum of 1.6 mm during the 6^{th} standard week, whereas a maximum of 15.2 mm on 22^{nd} standard week during 2018.

3.2 SOIL OF THE EXPERIMENTAL SITE

Water and plant nutrients are two key inputs for enhancing the mango productivity, for which the soil of the site play an instrumental role. However the soil of the study are lighter in texture along with presence of rocks; which characteristically are of highly permeable soil, low water holding capacity, low organic carbon content, and invariably possesses very low soil nutrients. These characteristics attributes the soil moisture stress during flowering and fruit setting of mango (particularly during March, April and May) under rainfed north-western Himalayan conditions. Initial soil status of the experimental orchard with regard to mechanical, chemical and biological properties was recorded and the same is being presented in Table 1.

Table 1: Physico-chemical properties of experimental orchard soil.

	Particulars	**Contents**	**Method used**
A.	**Mechanical analysis**		
	Sand (%)	64.35	International pipette method (Piper, 1966).
	Silt (%)	19.48	International pipette method (Piper, 1966).
	Clay (%)	16.17	International dispersion method (Piper,1966)
B.	**Chemical analysis**		
	pH	6.92	1:2 soil water suspension method, Glass Electrode pH meter (Jackson, 1967).
	Organic carbon (%)	0.61	Walkley and Black's rapid titration method (Walkley and Black, 1934).
	Electrical conductivity (dS-1)	0.028	1:2.5 soil water suspension method, Systronic conductivity meter (Jackson, 1973).
	Available Nitrogen (Kg ha-1)	244.36	Alkaline potassium permanganate method (Subbiah and Asija, 1956).

Figure 1a: The graph showing the rainfall and pan evaporation during the flowering and fruit growth of mango during the year 2017.

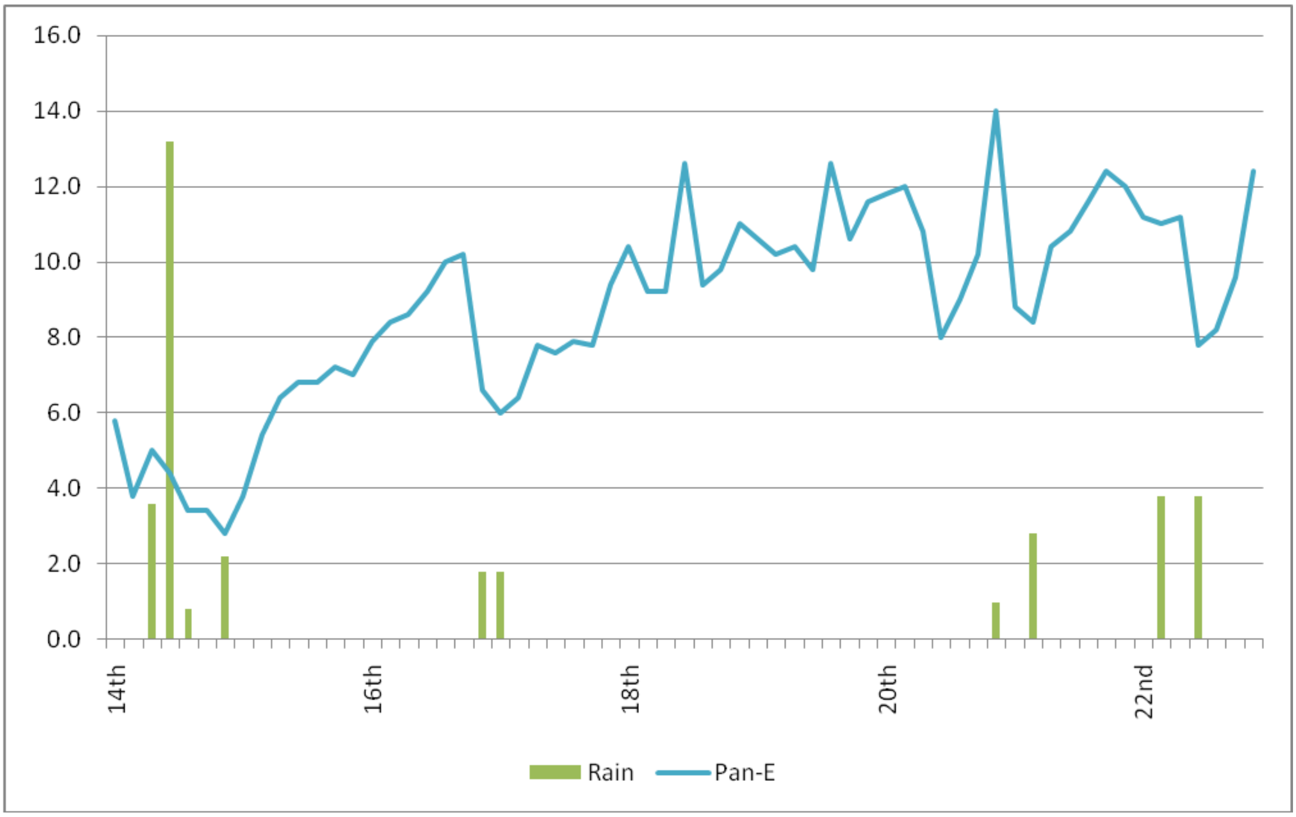
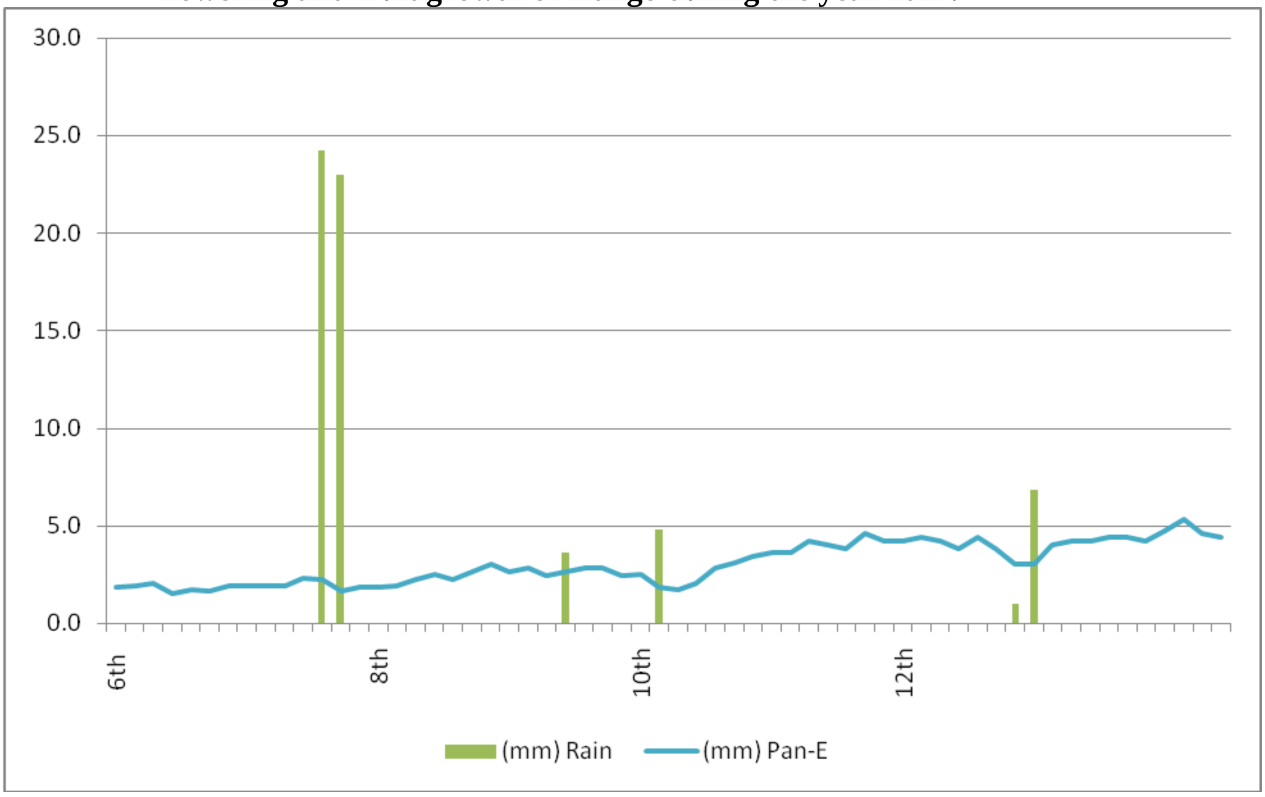


Figure 1b: The graph showing the rainfall and pan evaporation during the flowering and fruit growth of mango during the year 2017.



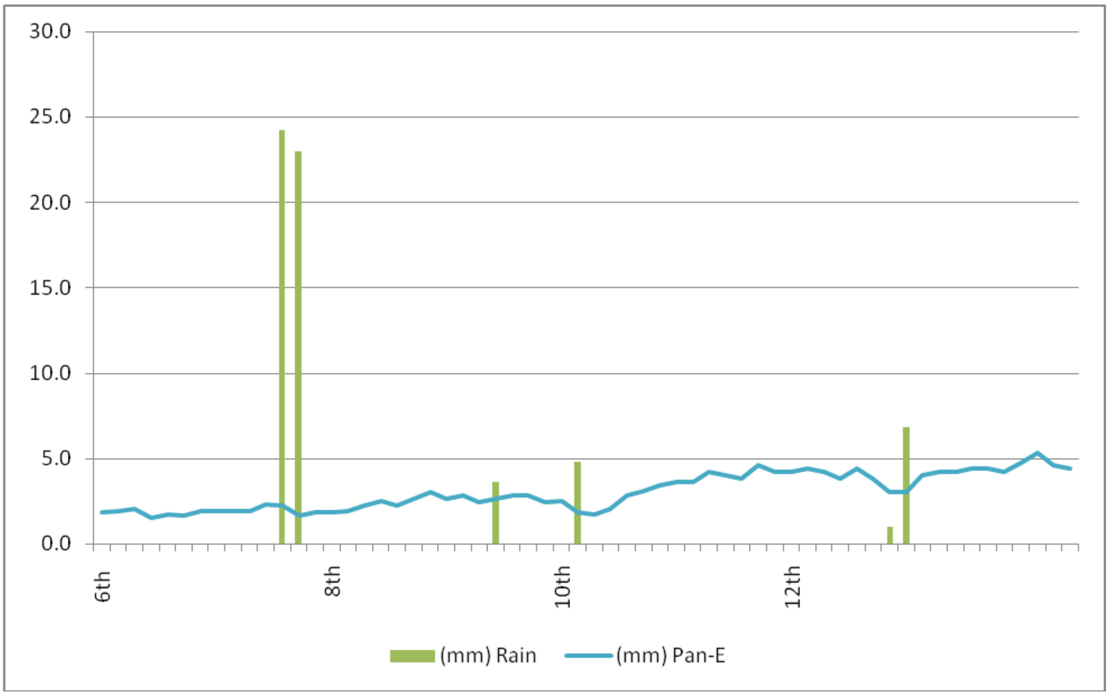


Figure 2a: The graph showing the rainfall and pan evaporation during the flowering and fruit growth of mango during the year 2018.

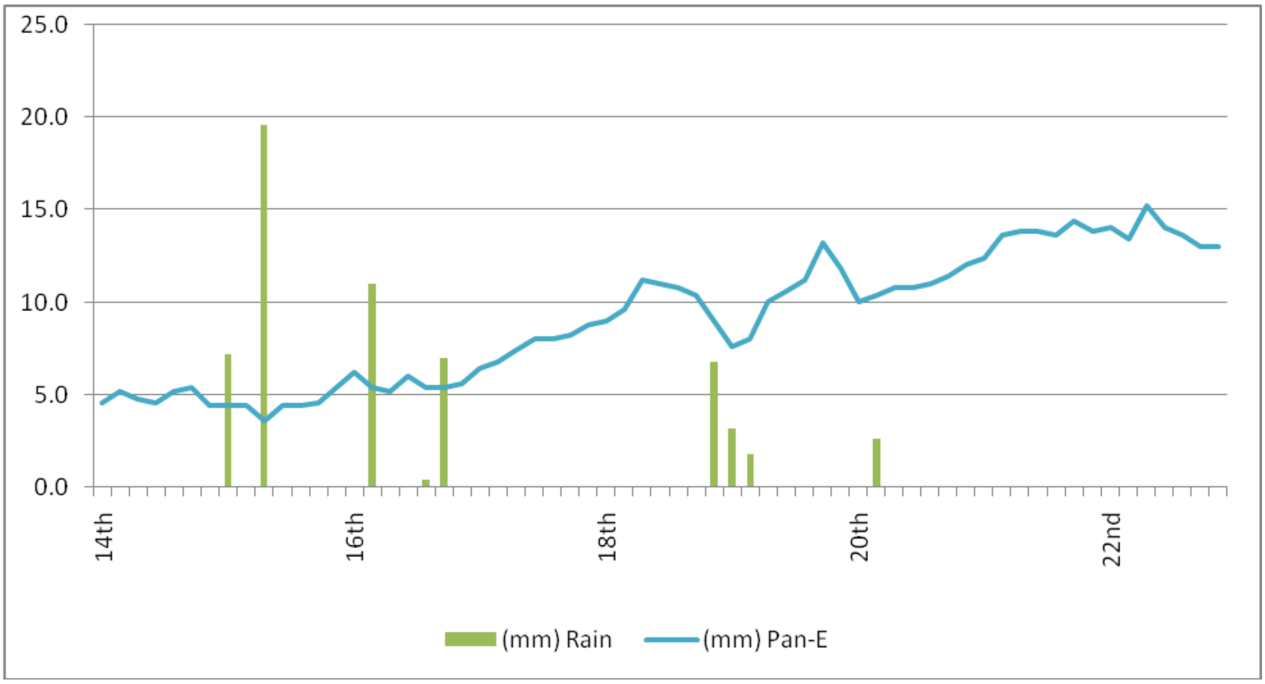


Figure 2b: The graph showing the rainfall and pan evaporation during the flowering and fruit growth of mango during the year 2018.

	Available Phosphorus (Kg ha-1)	37.00	Extraction with 0.5 M $NaHCO_3$ (pH 8.5) and development of colour by stannous chloride reduced ammonium molybdate method (Olsen *et al*., 1954).
	Available Potassium (Kg ha-1)	81.00	Ammonium acetate (1N) extraction and determination using Flame Photometer (Jackson, 1973).

The data presented in Table 1 indicate that the texture of soil was sandy loam and soil was acidic to neutral in reaction. The soil available nitrogen, phosphorus, potassium, and micronutrients are low in status.

3.3 EXPERIMENTAL DETAILS

3.3.1 Layout of experimental site

The experiment was conducted in a representative mango orchard at Akhnoor, Jammu under subtropical rainfed conditions. The mango plants (cv. *Dashehari*) of the orchard were 12 years old, healthy, disease free and bearing plants. The experiment was laid out in randomized block design. Plant to plant spacing was 8m × 8m. The pertinent details of the experiment are described here under:

1. Name of cultivar : Dashehari
2. Number of treatments : 10
3. Number of replications : 3
4. Total number of plants : 10 × 3 = 30
5. Experimental design : Randomized Block Design (RBD)
6. Site of experiment: Akhnoor (Jammu)

3.3.2 Treatment details

The experimental details adopted during the current investigation are given below:

T_1	100% ETc
T_2	Regulated deficit irrigation (75% ETc) evenly applied under the canopy (RDI $_{75\%\ ETc}$)
T_3	Partial root zone drying (75% ETc) applied to alternating sides of the root system (PRD $_{75\%\ ETc}$)
T_4	Regulated deficit irrigation (50% ETc) evenly applied under the canopy (RDI $_{50\%\ ETc}$)
T_5	Partial root zone drying (50% ETc) applied to alternating sides of the root system (PRD $_{50\%\ ETc}$)
T_6	Regulated deficit irrigation (75% ETc) evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%) (RDI $_{75\%\ ETc}$ + F)
T_7	Partial root zone drying (75% ETc) applied to alternating sides of the root system + Fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%) (PRD $_{75\%\ ETc}$ + F)
T_8	Regulated deficit irrigation (50% ETc) evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%) (RDI $_{50\%\ ETc}$ + F)
T_9	Partial root zone drying (50% ETc) applied to alternating sides of the root system + Fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%) (PRD $_{50\%\ ETc}$ + F)
T_{10}	No Irrigation

*RDI: Regulated deficit irrigation

*PRD: Partial root zone drying

*ETc: Crop Evapo-transpiration

*F: Fertigation

3.3.3 Seasonal variations: Two years

2017 (1st year)

2018 (2nd year)

3.3.4 Drip system description

A drip system system comprised of of the following components:

Plate 1. Soil characteristics of the experimental site

3.3.5 Water source

The drip system under study was supplied with water through a storage tank of 30 m cube capacity.

3.3.6 Drip system

As a test crop mango plant having 12 years of age was selected in a cluster of farmers at Akhnoor block. The drip line was installed in two lateral lines and spaced at 60 cm away from tree trunk of mango. Around each tree there was 4 drippers having discharge rate of 8 litres/dripper. A ventury assembly was used for mixing fertilizers with irrigation water. Based on the water requirement of mango trees, the duration of irrigation through drip system per day was worked out. Fertigation to individual tree in each replication was controlled by providing a manual regulating valve fixed to the lateral lines to ensure precise delivery of the required inputs thus enabling full control of experimental set up. Tree basins, laterals and drippers were cleaned periodically and kept weed free.

3.3.7 Water requirement of mango

The water requirement of mango was worked out using the following formula Subbaiah *et al.* (2017).

Volume of water per day per tree (litre) = Ep × Kp x Kc x Sp x Wp

where,

Ep = Pan evaporation (mm)

Kp = Pan coefficient

Kc = Crop coefficient

Sp = Plant to plant and row to spacing (8 m x8 m)

Wp = Wetted area out of plant spacing (0.3)

During Feburary and March the drip irrigation scheduling was carried out twice in a week, however, during April, May and first week of June it was carried out in 2 days interval in both the years of 2017 and 2018. The effective rainfall was deducted from the cumulative pan evaporation of 2 days for estimation of volume of water required by drip. The volume of water was expressed in terms of meter cube per plant as well as meter cube per hectare.

3.4 METHODLOGY ADOPTED

3.4.1 Daily weather data of the experimental site

The daily metrological data collected from the Agro meteorological Section were used in this experimental study. The weather parameters recorded were maximum temperature, minimum temperature, morning and evening relative humidity, bright sunshine hours, pan evaporation and rainfall for the ecological study.

3.5 OBSERVATION RECORDED

3.5.1 Soil moisture content

Treatment wise soil samples were drawn from different depths comprising of 0-20 cm, 20-40 cm, 40-60 cm and 60-100 cm of the experimental orchard with the help of soil auger. Then the samples were weighed at moist stage and after drying the sample in hot air oven. As such, soil moisture content was assessed gravimetrically.

3.5.2 Soil water potential

Tensiometers were placed at 20, 40 and 60 cm depth of soil profile and 60 cm away from main trunk to measure the soil moisture potential of mango orchard soil. Treatment-wise soil moisture tension was monitored periodically to get the insight about the degree of stress a mango plant undergone with deficit irrigation i.e. PRD-irrigation and RDI-irrigation.

3.5.3 Water use efficiency:

Water use efficiency (WUE) was worked out as the ratio of fruit yield to water use in due course of flowering and fruit development of mango through drip irrigation. WUE = Mango yield per plant /Amount of water used by plant (kg/m^3).

3.5.4 Leaf temperature:

Leaf temperature is one of the criteria for irrigation scheduling in fruit crops. Leaf temperature was used to assess whether the mango plant undergo any water stress or not with the imposition of PRD or RDI irrigation. Leaf temperature was measured during mid-afternoon (1300–1530 hours) on four dry fully-expanded sunlit leaves per plot using an infrared thermometer on clear sky days. The thermometer was held close (≈7 cm) to each leaf to avoid soil and cover crop interference under low canopy cover conditions. Air temperature was simultaneously measured.

3.5.2.1 Phenological observation

3.5.2.1.1 Date of appearance of panicle:

The date of panicle appearance was recorded when maximum panicle emergence took place.

3.5.2.1.2 Date of full blossom:

The day on which more than 70-80 percent flowers were opened was considered as date of full bloom. The record was made date-wise for each treatment.

3.5.2.1.3 Length of panicle (cm):

The length of the panicle was recorded and expressed in centimetres. The panicle lengths of ten randomly selected (North, South, East and West directions) shoots were recorded and the mean was calculated.

3.5.2.1.4 Breadth of panicle (cm):

The breadth of the panicle was recorded and expressed in centimetres. The panicle breadths of ten randomly selected (North, South, East and West directions) shoots were recorded and the mean was calculated.

3.5.2.1.5 Duration of flowering (days):

The duration of flowering was calculated by counting the total number of days from commencement of flowering to end of flowering.

3.5.2.1.6 Date of maximum fruit set:

The date of fruit set was recorded when 70-80 per cent fruit set took place. The record was made date-wise for each treatment.

3.5.2.1.7 Date of harvest:

The date on which more fruit were harvested was considered as date of harvest. The record was made date-wise for each treatment.

3.5.2.2 Tree growth characteristics

3.5.2.2.1 Tree height (m):

Height of the tree was recorded with the help of a graduated staff from the ground surface to the maximum height attained by the plant and means height was worked out and expressed in meter.

3.5.2.2.2 Tree spread (m):

Spread of the tree was measured by putting the graduated staff horizontally with the tree from east-west and north-south and mean spread was worked out and expressed in meter.

3.5.2.2.3 Scion stock ratio:

The stock as well as scion girth thus measured was expressed as ratio.

3.5.2.2.4 Stock girth (cm):

The stock girth was measured with the help of measuring tape at a height of 20 cm above the ground level and expressed in centimeter.

3.5.2.2.5 Scion girth (cm):

The scion girth was measured just above the graft union with measuring tape and was expressed in centimeter.

3.5.2.3 Physical, Physiological and Bio-chemical characteristics

3.5.2.3.1 Fruit weight (g):

The weight of ten randomly selected fruits from each treatment of each replication was taken by electronic balance. Subsequently, the average fruit weight was calculated and expressed in gram (g).

3.5.2.3.2 Fruit size (cm):

Length and breadth of ten randomly harvested fruits from each treatment of each replication was measured by using vernier callipers. Mean length was computed and expressed in centimeter (cm).

3.5.2.3.3 Fruit volume (cm^3):

Volume of fruit was measured by water displacement method. The average of ten fruits from each replication was calculated and expressed in cubic centimeter (cc).

3.5.2.3.4 Specific gravity:

Specific gravity of fruits was calculated by the following formula:

$$\text{Specific gravity} = \frac{\text{Weight of fruit (g)}}{\text{Volume of fruit (cc)}}$$

3.5.2.3.5 Total soluble solids (^{0}Brix):

The total soluble solids (TSS) of the fruit juice was recorded with the help of Erma hand refractometer (0-32^{0}B), according to standard procedure as given in AOAC (1995) in terms of degree Brix (^{0}B) at room temperature. The refractometer was calibrated with distilled water before use.

3.5.2.3.6 Titratable Acidity (%):

Titratable acidity in fresh fruits was determined by the method as suggested in AOAC (1995). Five ml of fruit juice in 250 ml flask and then diluted to approximately 50 ml with distilled water. Solution was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The total per cent titratable acidity was calculated on the basis of one ml NaOH equivalent to 0.0064 g of anhydrous citric acid. The results were expressed as per cent total titratable acidity.

Calculation

$$\text{Acidity (\%)} = \frac{\text{Titre value x normality of alkali x volume made x equivalent wt. of acid}}{\text{Volume of sample taken x wt. of sample x 1000}} \text{ x } 100$$

3.5.2.3.7 Total sugars:

Twenty five gram of fruit pulp was thoroughly homogenized with distilled water and volume made up to 250 ml. To it was added 5 ml of potassium lead acetate and precipitated was filtered into a flask containing 5 ml of potassium oxalate. The content were shaken and filtered again. 100 ml of filtrate was taken into 250 ml flask and few drops of concentrated HCL was added and kept it overnight to obtain complete hydrolysis of sugars. Excess HCL was neutralized by standard NaOH solution using phenolphthalein as an indicator. Boiling mixture aliquot in a burette using methylene blue indicator to a brick red end point (A.O.A.C., 1994)

$$\text{Total sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Aliquot used x Sample weight}} \text{ x } 100$$

3.5.2.3.8 Reducing sugars

Reducing sugars of lead free solution were estimated by titrating it against boiling standard Fehling solutions A and B (5 ml each), using methylene blue as indicator to a brick red colour at end point. The reducing sugars were expressed as %.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Aliquot used x Sample weight}} \times 100$$

3.5.2.3.9 Non-reducing sugars:

The non-reducing sugars were obtained by subtracting reducing sugars from total sugars and multiplying the difference by standard factor 0.95, the calculation was done as per the procedure described in A.O.A.C (1995).

3.5.2.3.10 Sugar:Acid ratio:

The sugar as well as acid thus measured was expressed as ratio.

3.5.2.3.11 Leaf nutrients:

Leaf samples consisting of recently matured leaves from mid position of plants were collected at full bloom stage (Nayak *et al.*, 2011). The leaf samples were decontaminated by washing in sequence viz. 0.2% detergent solution, followed by 0.1 N hydrochloric acid (HCl), distilled water and finally in double distilled water (Bhargava and Raghupathi, 1993). Leaf samples were air dried at 70^0 C and ground using Wiley grinding machine to pass through a 60-mesh stainless steel sieve to obtain homogeneous samples. The washed leaf samples were surface dried and then oven dried at 70^0 C for 48 hours. Washing, cleaning, drying, grinding and storing of the samples were carried as per the method outlined by Chapman (1964).

Digestion of leaf sample:

One gram of leaf sample was taken for digestion of various elements (except nitrogen) in diacid (HNO_3 and $HClO_4$ in 4:1 ratio v/v) and all relevant precautions were taken in to consideration as suggested by Piper (1966).

Nutrient estimation in leaves:

Potassium content was estimated by Flame Photometer results were expressed in per cent. Calcium were measured on atomic absorption spectrophotometer and results were expressed as per cent. Boron by dry ashing method were expressed in ppm.

3.5.2.3.12 Proline:

Proline content was estimated by using the method of (Bates *et al.*, 1973).

Reagents

I. 3% aqueous sulphosalicylic acid (w/v)
II. Acid ninhydrin (prepared by dissolving 1.25 g ninhydrin in 30 ml glacial acetic acid and 20 ml 6.0 M *o*-phosphoric acid until dissloved)
III. Toluene

Extraction

Three hundred mg of leaves were separately homogenized in 5 ml of 3 % sulphosalicylic acid and then centrifuged at 5000 rpm for 15 minutes and supernatant was taken.

Procedure

Two ml of supernatant was taken in a test tube and 2.0 ml reagent acid ninhydrin was added. This mixture was then kept in boiling water bath for 1 h at 100^0 C and thereafter reaction was terminated by keeping tubes in ice bath. Then 4.0 ml of toluene was added. After vigorous shaking, the upper coloured organic phase was taken after attainment of room temperature and absorbance was recorded at 520 nm by using toluene as blank. Standard curve was prepared by using graded concentration of proline in 3% sulphosalicylic acid. The proline content was expressed as microgram g^{-1} FW.

3.5.2.3.12 Pectin methylesterase (PME):

PME was extracted following the method of Hagerman and Austin (1986).

Procedure

The fruit tissue (25g) was homogenized with 50 ml of chilled 0.1 M Tris –HCl buffer (pH 7.5), containing 10 percent NaCl. Homogenate was extracted in ice for 1 h with slow and constant stirring before centrifugation at 10,000xg for 30min. The supernatant represented the enzyme extract. The reaction mixture contained 100 micro liter of enzyme extract, 2.5 ml of 0.5 percent (w/v) citrus pectin in buffer (2 mM Tris-HCl, pH 7.5) and 0.4 ml of 0.01percent (w/v) bromothymol blue in the same buffer. The change in absorbance at 620 nm for 30 min was converted to galacturonic acid from the standard curve (50 to 500 micro gram) prepared under the same assay conditions. Enzyme activity was expressed as µg galacturonic acid /min/gFW.

3.5.2.3.13 Fruiting characterstics

3.5.2.3.13.1 Yield (kg/tree):

Total number of fruits in each replication were counted. The counting was made two to three times for minimizing the counting error. The fruits harvested from each tree were weighed on electronic balance. The crop load removed from the tree during harvesting season was recorded as yield per tree and expressed in kg/plant.

3.5.2.3.13.2 Fruit set (%):

Per cent of fruit set in mango at 21 days after petal fall was recorded on the selected and tagged panicles and was computed by using formula:

$$\text{Fruit set (\%)} = \frac{\text{No. of fruits per panicles}}{\text{No. of flowers}} \times 100$$

3.5.2.3.13.3 Fruit drop (%):

Number of fruits present on the randomly selected branches of the trees the time of fruit was recorded and number of fruits retained on these branches till maturity/harvest was recorded. The data that recorded was expressed as per cent fruit drop.

$$\text{Fruit drop (\%)} = \frac{\text{Fruit set – Final Fruit retention}}{\text{Initial fruit set}} \times 100$$

3.5.2.3.13.4 Fruits/tree:

The total number of fruits harvested tree^{-1} was counted after harvest and expressed as number of fruits plant^{-1}.

3.5.2.3.13.5 Number of fruits according to size classes: A- 200-350, B-351-550, C-551-800 (g):

Total number of fruits were graded into 3 categories on basis of fruit weight (g), grade A 200-350 g , grade B 351-550 g and grade C 551-800 g. Fruits in each category were counted and expressed as per cent of total no. of fruits harvested from the tree.

3.5.2.3.14 Economic analysis

3.5.2.3.14.1 Benefit cost ratio:

The benefit to cost ratio for each treatment was calculated by using the following formula.

$$\text{Benefit to cost ratio} = \frac{\text{Gross return}}{\text{Cost of cultivation}}$$

3.5.2.4 Shelf Life

3.5.2.4.1 PLW (Physiological loss in weight) (%):

Pre-weighed fruit samples were weighed on a physical balance after each storage interval. The loss in weight at each interval during storage was expressed as per cent of initial weight.

3.5.2.4.2 Decay loss (%):

Decay percentage of mango fruits was calculated as the number of decayed fruit divided by initial number of all fruits.

3.5.2.4.3 Fruit Moisture Content:

The moisture content was determined by using an electronic moisture analyser at 105 ^{0}C by spreading a weighed sample (2 g) in an aluminium sample holder and evaporative moisture losses were automatically expressed as per cent moisture content.

3.5.2.4.4 Fruit Firmness:

Fruit firmness of the fruit was recorded with the help of pentrameter**.**

3.5.2.4.5 Total Soluble Solids:

The total soluble solids (TSS) of the fruit juice was recorded with the help of Erma hand refractometer (0-32^{0}B), according to standard procedure as given in AOAC (1994) in terms of degree Brix (^{0}B) at room temperature. The refractometer was calibrated with distilled water before use.

3.5.2.4.6 Total Acidity (%):

Titratable acidity in fresh fruits was determined by the method as suggested in AOAC (1995). Five ml of fruit juice in 250 ml flask and then diluted to approximately 50 ml with distilled water. Solution was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. The total per cent titratable acidity was calculated on the basis of one ml NaOH equivalent to 0.0064 g of anhydrous citric acid. The results were expressed as per cent total titratable acidity.

Calculation

$$\text{Acidity (\%)} = \frac{\text{Titre value x normality of alkali x volume made x equivalent wt. of acid}}{\text{Volume of sample taken x wt. of sample x 1000}} \text{ x 100}$$

3.5.2.4.7 Carotenoids (%):

Total carotenoids was measured by using a spectrophotometer and expressed in mg/100g pulp (Mahadevan and Sridhar, 1986).

Procedure:

A known fresh weight of sample (1gm) was extracted with acetone and add a few drops of sodium sulphate. The extractions were repeated and the extract was collected in a beaker and to it added 10% KOH. The extract was heated on a water bath for 30 minutes and then transferred to separating funnel. To this 50 ml of petroleum ether was added. The separating funnel was shaken and allowed to stand for at least 10 minutes till the layers got separated. The lower layer was drained and the upper layer of petroleum ether containing pigment was collected in a volumetric flask and the volume was made up to 50 ml with petroleum ether and O.D. was recorded as 452 nm against petroleum ether as blank. The total carotenoids were calculated as per the formula:

$$\text{Total cerotenoids (mg/100g pulp)} = \frac{\text{O.D x 13.9 x } 10^4 \text{ x Volume made}}{\text{Weight of sample x 560 x 1000}}$$

3.5.2.4.8 Fruit nutrients

Ten grams of fresh fruit pulp was digested for nitrogen in concentrated HNO_3:H_2SO_4:$HClO_4$ (9:4:1) as described by Jackson (1973). Separate digestion was carried out for estimation of other nutrients in diacid (HNO_3 and $HClO_4$ in 4:1 ratio v/v) as suggested by Piper (1966).

Potassium content was estimated by Flame Photometer and results were expressed in per cent (%). Calcium were measured on atomic absorption spectrophotometer and results were expressed as per cent. Boron was estimated by dry ashing method.

3.5.2.4.9 Total sugars:

Twenty five gram of fruit pulp was thoroughly homogenized with distilled water and volume made up to 250 ml. To it was added 5 ml of potassium lead acetate and precipitated was filtered into a flask containing 5 ml of potassium oxalate. The content were shaken and filtered again. 100 ml of filtrate was taken into 250 ml flask and few drops of concentrated HCL was added and kept it overnight to obtain complete hydrolysis of sugars. Excess HCL was neutralized by standard NaOH solution using phenolphthalein as an indicator. Boiling mixture aliquot in a burette using methylene blue indicator to a brick red end point (A.O.A.C., 1994)

$$\text{Total sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Aliquot used x Sample weight}} \text{ x } 100$$

3.5.2.4.10 Reducing sugars

Reducing sugars of lead free solution were estimated by titrating it against boiling standard Fehling solutions A and B (5 ml each), using methylene blue as indicator to a brick red colour at end point. The reducing sugars were expressed as %.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor x Dilution}}{\text{Aliquot used x Sample weight}} \text{ x } 100$$

3.5.2.4.11 Non-reducing sugars:

The non-reducing sugars were expressed on per cent basis. The non-reducing sugars were calculated as under,

Non-reducing sugars (%) = (Total sugars-Reducing sugars) x factor

3.5.2.4.12 Pectin:

Pectin was extracted by the method of Rangana (1977).

Reagents

Acetic acid: Added 30 ml glacial acid in 500 ml water.

Calcium chloride: Added 55g anhydrous $CaCl_2$ in water, dissolved and diluted to 100 ml.

Silver nitrate (1%): Dissolved 5g $AgNO_3$ in water and diluted to 500 ml. It was dissolved by keeping it in hot water bath for 10min.

Procedure

25g of fruit sample was taken in one litre beaker with 400 ml water. Then boiled for one hour. The evaporated water was replaced by addition of distilled water. Cooled it. Transferred to 500 ml volumetric flask then filtered through Whatman No. 4 filter paper. 100 ml of filtrate was taken in two beakers. 300 ml distilled water was added to each beaker. 10 ml 1N NaOH solution was added and kept overnight. 50 ml 1N acetic acid was added. Waited for 5 minutes. $CaCl_2$ solution was added and kept for one hour. Thereafter it was boiled for one minute. Two Whatman No.4 filter paper were taken. Washed with distilled water, dried in an oven at 100 ^{0}C for two hours and then weighed these two filter papers. The solution was filtered through Whatman No.4 filter paper. It was washed with distilled water to make free from chloride ions. A few drops of silver nitrate solution was added. The white precipitates (one filter paper in a petri dish) was put in an oven, dried and weighed again.

Calculation

$$\text{Pectin (\%)} = \frac{\text{Weight of calcium pectate x 100}}{\text{Weight of fruit sample}}$$

Statistical analysis

The data generated during the course of study was subjected to Duncan's multiple-ranged test was performed using SPSS v. 16 software and Panse and Sukhatme (2000) to identify the homogeneous type of the data sets among different treatments for different plant parameters.

Chapter-4

Results

CHAPTER IV

EXPERIMENTAL RESULTS

The present investigations entitled "**Studies on water and nutrient management in mango (*Mangifera indica* L.) cultivar Dashehari under Jammu subtropics**" was carried out during 2017 and 2018 at mango growing clusters of Akhnoor (Jammu). The result obtained during the course of present investigation has been presented under suitable heads.

Observations on various phenological characters including date of appearance of panicle, date of full bloom, length of panicle, breadth of panicle, duration of flowering, date of maximum fruit set, date of harvest were recorded. Growth characteristics with respect to tree height, tree spread, scion-stock ratio, stock girth, scion girth were also recorded. Mango physical and biochemical characteristics including fruit weight, fruit size, fruit volume, specific gravity, total soluble solids, titrable acidity, sugars, sugar:acid ratio, concentration of Ca, K, B in leaves, proline, pectin methylesterase were also observed. Fruiting characteristics including yield, fruit drop, fruit set, fruits/tree, number of fruits according to size classes. Economic analyses including cost benefit ratio and observation on shelf life of mango fruit. The findings of the aforesaid characters are presented from Table 1 to Table 61. The recoded data were illustrated by graphs and diagrams from Figure 1 to Figure 2.

After the observations recorded, the data was statistically analyzed as per randomized block design. The findings are presented in the forgoing pages.

4.1 **Effect of deficit irrigation on phenological characteristics of mango**

4.1.1 Date of appearance of panicle

4.1.2 Date of full blossom (80%)

4.1.3 Length of panicle (cm)

4.1.4 Breadth of panicle (cm)

4.1.5 Duration of flowering (days)

4.1.6 Date of maximum fruit set (80%)

4.1.7 Date of harvest

4.2 Effect of deficit irrigation on tree growth characteristics of mango

4.2.1 Tree height (m)

4.2.2 Tree spread (m)

4.2.3 Scion stock ratio

4.2.4 Stock girth (cm)

4.2.5 Scion girth (cm)

4.3 Effect of deficit irrigation on physiochemical characteristics of mango

4.3.1 Fruit weight (g)

4.3.2 Fruit volume (cm^3)

4.3.3 Fruit size (cm)

4.3.4 Specific gravity

4.3.5 Total soluble solids (^{0}Brix)

4.3.6 Titrable Acidity (%)

4.3.7 Sugars (Total sugar, reducing and non reducing sugar (%)

4.3.8 Sugar:Acid ratio

4.3.9 Concentration of Ca, K and B in leaves (%)

4.3.10 Proline

4.3.11 Pectin methylesterase (PME)

4.4 Effect of deficit irrigation on fruiting characteristics of mango

4.4.1 Yield (kg/tree)

4.4.2 Fruits/tree

4.4.3 Fruit set (%)

4.4.4 Fruit drop (%)

4.4.5 Number of fruits according to size classes: A- 200-350, B-351-550, C-551-800 (g)

4.5 Irrigation water productivity of mango

4.5.1 Effect of deficit irrigations on water use efficiency (WUE) or water productivity (WP) of mango

4.6 Soil and plant water characteristics

4.6.1 Soil moisture content

4.6.2 Soil moisture potential

4.6.3 Leaf temperature

4.7 Economic

4.7.1 Cost benefit ratio

4.8 Effect of deficit irrigation on shelf life of mango fruit

4.8.1 PLW (Physiological loss in weight) (%)

4.8.2 Decay loss (%)

4.8.3 Fruit Moisture Content (%)

4.8.4 Fruit Firmness (Lb/inch)

4.8.5 Total Soluble Solids (TSS %)

4.8.6 Total Acidity (%)

4.8.7 Carotenoids (%)

4.8.8 Fruit K, B, Ca content

4.8.9 Sugar

4.8.10 Pectin

4.1 Effect of deficit irrigation on phenological characteristics of mango

The phenological parameters *viz.*, date of appearance of panicle, date of full blossom (80%), length of panicle (cm), breadth of panicle (cm), duration of flowering, date of maximum fruit set (80%) and date of harvest of the mango plants as affected by different deficit irrigation treatments were recorded for two years (2017 and 2018) of experimentation and are explained as under:

4.1.1 Date of appearance of panicle

Date of appearance of panicle recorded under various treatments for the two consecutive years (2017 and 2018) have been presented in Table 2. An examination of the data reveals that during the year 2017, date of appearance of panicle was earlier (16 February) in plants receiving deficit irrigation at 75% ETc both in RDI and PRD i.e. T_2 ($RDI_{75\%\ ETc}$) and T_3 ($PRD_{75\ \%\ ETc}$), whereas date of appearance of panicle was delayed (18 February) when deficit irrigation was provided at 50% ETc i.e T_4 ($RDI_{50\%\ ETc}$) and T_5 ($PRD_{50\%\ ETc}$). In case plants treated with deficit irrigation with fertigation date of appearance of panicle was recorded to be earliest i.e. 13th February under T_6 comprising of $RDI_{75\%\ ETc}$ + F and T_7 $PRD_{75\%ETc}$ + F and date of appearance of panicle was maximum delayed in treatment T_1 (100 % ETc) (19th February). Similar trend was followed during the second year of investigation.

4.1.2 Date of full bloom

Table 2 corresponds to the data on full bloom in mango cv. Dashehari under various treatments for the two consecutive years (2017 and 2018). An examination of the data reveals that during the year 2017, date of full bloom was earlier (9 March) in plants subjected to deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 ($RDI_{75\ \%\ ETc}$) and T_3 ($PRD_{75\ \%\ ETc}$) , whereas date of full bloom was recorded to be delayed (10 March) when deficit irrigation was provided at 50% ETc i.e T_4 ($RDI_{50\ \%\ ETc}$ evenly applied under the canopy) and T_5 ($PRD_{50\ \%\ ETc}$). In case of plants treated with deficit irrigation with fertigation date of full bloom was recorded to earliest i.e. 6 March under T_6 comprising of $RDI_{75\%\ ETc}$ + F. This was same as treatment T_7 having irrigation schedule with $PRD_{75\%\ ETc}$ + F and date of full bloom was maximum delayed in treatment T_1(100 % ETc) (11 March). Similar trend was followed during second year of investigation.

4.1.3 Length of panicle

The statistical analysis of panicle length revealed significant difference during 2017 and 2018 and in pooled estimates as well (represented in Table 3). In the first year of experimental trial, panicle length was recorded maximum (26.57 cm) under T_7 comprising of $PRD_{75\%\ ETc}$ + F. This was significantly higher than treatment having irrigation schedule with $RDI_{75\%\ ETc}$ + F where panicle length of 24.38 cm was

Table 2: Effect of different irrigation regimes and fertigation on date of appearance of panicle and date of full blossom of mango cv. Dashehari

	Date of appearance of panicle		Date of full blossom	
Treatment	**2017**	**2018**	**2017**	**2018**
T_1: 100% ETc	19th of Feb	21st of Feb	11th of March	15th of March
T_2: RDI 75% ETc evenly applied under the canopy	16th of Feb	18th of Feb	9th of March	12th of March
T_3: PRD 75% ETc applied to alternating sides of the root system	16th of Feb	18th of Feb	9th of March	12th of March
T_4: RDI 50% ETc evenly applied under the canopy	18th of Feb	19th of Feb	10th of March	14th of March
T_5: PRD 50% ETc applied to alternating sides of the root system	18th of Feb	19th of Feb	10th of March	14th of March
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	13th of Feb	15th of Feb	6th of March	8th of March
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	13th of Feb	15th of Feb	6th of March	8th of March
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	15th of Feb	17th of Feb	8th of March	11th of March
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	15th of Feb	17th of Feb	8th of March	11th of March
T_{10}: No Irrigation	14th of Feb	15th of Feb	7th of March	7th of March

Table 3: Effect of different irrigation regimes and fertigation on length of panicle (cm) and breadth of panicle (cm) of mango cv. Dashehari

	Length of Panicle (cm)			Breadth of Panicle (cm)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	19.89ef	18.62ef	19.25ef	12.54ab	10.27bc	11.40ab
T_2: RDI 75% ETc evenly applied under the canopy	20.38de	19.24def	19.81ef	12.58ab	12.31abc	12.44ab
T_3: PRD 75% ETc applied to alternating sides of the root system	20.71de	19.57de	20.14de	12.71ab	10.65abc	11.68ab
T_4: RDI 50% ETc evenly applied under the canopy	19.27ef	18.03gh	18.65fg	12.32ab	10.01bc	11.65bc
T_5: PRD 50% ETc applied to alternating sides of the root system	19.64ef	18.28gh	18.96efg	12.39ab	10.13bc	11.26bc
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	24.38b	23.71b	24.04b	13.34a	11.72a	12.53ab
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	26.57a	25.18a	25.87a	13.53a	11.78a	12.65a
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	21.88cd	20.36d	21.12d	12.96a	10.82abc	11.89ab
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	22.96bc	21.57c	22.26c	13.25a	11.34ab	12.29ab
T_{10}: No Irrigation	18.52f	17.37h	17.94g	10.88b	9.52c	10.20c

recorded and minimum panicle length was recorded under T_{10} i.e no irrigation (18.52 cm). During second year of experimental study the influence of irrigation level on panicle length of mango showed the same trend as followed during first year of investigation. However, better panicle length was recorded during first year in comparison to second year of study in all the treatments. The perusal of pooled data reveals that treatment T_7 maintained the superiority as far as panicle length was concerned wherein maximum panicle length of 25.87 cm was recorded followed by T_6 with value of 24.04 cm.

4.1.4 Breadth of panicle

The data regarding the effect of deficit irrigation on panicle breadth presented in Table 3 clearly shows that in the first year of study, maximum panicle breadth of 13.53 cm was recorded under treatment T_7 $PRD_{75\%\ ETc}$ + F and minimum panicle breadth (10.88 cm) was found under control with no irrigation (T_{10}). The data of the second year did not show any different trend as observed in the first year of experimental trial. The maximum panicle breadth during 2018 was recorded in treatment T_7 (11.78 cm). On the basis of pooled data, panicle breadth under T_7 (PRD $_{75\%\ ETc}$ + F reached maximum of 12.65 cm being closely followed by T_6 (RDI $_{75\%\ ETc}$ + F where 12.53 cm of panicle breadth was recorded and minimum panicle breadth (10.20 cm) was found under control with no irrigation (T_{10}).

4.1.5 Duration of flowering

The data recorded on the effect of different irrigation regimes and fertigation on duration of flowering for the two consecutive years (2017 and 2018) presented in Table 4 reveal that the duration of flowering was found maximum (25 days) under treatment T_6 i.e (RDI $_{75\%\ ETc}$+ F), and under T_7 having irrigation schedule with $PRD_{75\%\ ETc}$ + F which also reached (25 days) whereas, minimum number of days (22 days) were recorded under treatment T_{10} (no irrigation) during first year of experiment. During second year of experiment maximum duration of flowering (27 days) was recorded under T_6 ($RDI_{75\%\ ETc}$ + F) and was closely followed by trees under T_7 having irrigation schedule with $PRD_{75\%\ ETc}$ + F) which also reached (27 days) and minimum number of days (21 days) were recorded under treatment T_{10} (no irrigation).

4.1.6 Date of maximum fruit set

The data related to effect of different irrigation regimes and fertigation on date of maximum fruit set presented in Table 4 reveals that during first year of the study (2017), the maximum fruit set (80 per cent) was recorded on 22nd March under treatment T_6 i.e. $RDI_{75\%\ ETc}$ + F) and under T_7 having irrigation schedule with $PRD_{75\%\ ETc}$ + F) which reached maximum fruit set stage on 22nd March whereas, trees under T_1(100 % ETc) were last ones to reach maximum fruit set stage i.e on 29th March. Similar pattern was repeated in the second year of experiment i.e 2018. During second year of experiment i.e 2018 trees under T_6 comprising of $RDI_{75\%\ ETc}$ + F) were earliest to reach full bloom (24th March) and were closely followed by trees under T_7 having irrigation schedule with $PRD_{75\%\ ETc}$ + F) which reached full bloom stage on 24th March whereas, trees under T_1(100 % ETc) were last ones to reach full bloom stage i.e on 30th March.

4.1.7 Date of harvest

The dates of fruit harvest as influenced by different irrigation and fertigation level are presented in Table 5. An examination of the data reveals that during the year 2017, date of harvest of mango fruits was recorded earlier (14th June) in plants subjected to deficit irrigation under treatment T_6, T_7, T_{10} followed by 17th June under treatment T_8 ($RDI_{50\%\ ETc}$ + F) whereas date of harvest was recorded to be delayed (20th June) when deficit irrigation was provided at 100% ETc i.e T_1. During 2018-19, mango fruits under treatment T_6 i.e. $RDI_{75\%\ ETc}$ + F) and T_7 i.e. $PRD_{75\%\ ETc}$ + F) were first to be harvested on 15th June followed by treatment T_8 i.e. $RDI_{50\%\ ETc}$ + F) on 18th June, while fruits under treatment T_1 with 100% irrigation were last to harvest on 22th of June.

4.2 Effect of deficit irrigation on tree growth characteristics of mango

The vegetative growth parameters *viz.*, tree height, tree spread, stock girth, scion girth and scion stock ratio of the mango plant were recorded under different deficit irrigation treatments during the two years (2017 and 2018) of experimentation.

4.2.1 Tree height

The result presented in Table-6, pertaining to the effect of various irrigation regimes along with fertigation, revealed that there was significant decrease in plant height with the deficit irrigations of PRD and RDI as compared to the full irrigated

Table 4: Effect of different irrigation regimes and fertigation on duration of flowering and date of maximum fruit set of mango cv. Dashehari

	Duration of flowering		Date of maximum fruit set	
Treatment	**2017**	**2018**	**2017**	**2018**
T_1: 100% ETc	24	23	29th of March	30th of March
T_2: RDI 75% ETc evenly applied under the canopy	25	25	26th of March	28th of March
T_3: PRD 75% ETc applied to alternating sides of the root system	25	25	26th of March	28th of March
T_4: RDI 50% ETc evenly applied under the canopy	22	24	28th of March	29th of March
T_5: PRD 50% ETc applied to alternating sides of the root system	22	24	28th of March	29th of March
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	25	27	22nd of March	24th of March
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	25	27	22nd of March	24th of March
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	23	26	24th of March	26th of March
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	23	26	24th of March	26th of March
T_{10}: No Irrigation	22	21	23rd of March	25th of March

Table 5: Effect of different irrigation regimes and fertigation on date of harvest of mango cv. Dashehari

	Date of harvest	
Treatment	**2017**	**2018**
T_1: 100% ETc	20th of June	22nd of June
T_2: RDI 75% ETc evenly applied under the canopy	18th of June	19th of June
T_3: PRD 75% ETc applied to alternating sides of the root system	18th of June	19th of June
T_4: RDI 50% ETc evenly applied under the canopy	19th of June	20th of June
T_5: PRD 50% ETc applied to alternating sides of the root system	19th of June	20th of June
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	14th of June	15th of June
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	14th of June	15th of June
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	17th of June	18th of June
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	17th of June	18th of June
T_{10}: No Irrigation	14th of June	15th of June

mango plant (i.e. control). During the experimentation of 2017, the highest plant height of 5.97 m was recorded with the irrigation treatment of 100% ETc (T_1), while the lowest plant height of 4.78 m was witnessed in T_{10} (i.e. rainfed) treatment. Drip irrigation imposed at 75% ETc in PRD mode, the plant height achieved was 5.35 m (T_3) and differed significantly when imposed in conjunction with fertigation 5.76 m (T_7). The plant height of 5.26 m was registered with RDI 75% ETc (T_2) as compared to 5.69 m with RDI 75% along with fertigation (i.e. T_6), and exhibited that the fertigation led to significant difference in plant height. Drip irrigation imposed at 50% ETc having PRD mode, the plant height achieved was 5.18 m (T_5) and differed significantly when imposed in conjunction with fertigation 5.60 m (T_9). The plant height of 5.11 m was registered with $RDI_{50\%\ ETc}$ (T_4) as compared to 5.48 m with RDI 50% along with fertigation (i.e. T_8), and exhibited that the fertigation led to significant difference in plant height.

During the experimentation of 2018, the highest plant height of 6.18 m was recorded with the irrigation treatment of 100% ETc (T_1), while the lowest plant height of 4.95 m was witnessed at T_{10} (i.e. rainfed) treatment. Drip irrigation imposed at 75% ETc having PRD mode, the plant height achieved was 5.47 m (T_3) and differed significantly when imposed in conjunction with fertigation 5.90 m (T_7). The plant height of 5.39 m was registered with RDI $_{75\%\ ETc}$ (T_2) as compared to 5.81 m with RDI 75% along with fertigation (i.e. T_6), and exhibited that the fertigation led to significant difference in plant height. Drip irrigation imposed at 50% ETc having PRD mode, the plant height achieved was 5.26 m (T_5) and differed significantly when imposed in conjunction with fertigation 5.70 m (T_9). The plant height of 5.22 m was registered with RDI $_{50\%\ ETc}$ (T_4) as compared to 5.59 m with RDI 50% along with fertigation (i.e. T_8), and exhibited that the fertigation led to significant difference in plant height. A similar pattern was observed in the pooled data of tree height where maximum tree height was observed at T_1 (100% ETc) 6.07 m whereas lowest tree height was observed at T_{10} (4.86 m).

4.2.2 Tree spread

From the perusal of the data presented in Table 7, it is clear that the tree spread (east-west and north-south) was significantly affected by different irrigation levels during both the years of experimental trial. In 2017 and 2018, the highest tree spread in east-west direction of 4.91 m and 5.22 m was recorded with the irrigation treatment of 100% ETc (T_1), while the lowest tree spread in east-west direction of 2.72 m and 3.18 m was witnessed in T_{10} (i.e. rainfed) treatment.

Drip irrigation imposed at 75% ETc in PRD mode, the tree spread in east-west direction achieved was 3.74 m and 4.17 m (T_3) and differed significantly when imposed in conjunction with fertigation 4.63 m and 4.95 m (T_7) during both the years. The tree spread in east-west direction of 3.58 m and 3.95 m was registered with RDI 75% ETc (T_2) as compared to 4.40 m and 4.72 m with RDI 75% along with fertigation (i.e. T_6), and exhibited that the fertigation led to significant difference in tree north-south direction. Drip irrigation imposed at 50% ETc having PRD mode, the tree spread in east-west direction achieved was 3.25 m and 3.63 m (T_5) and differed significantly when imposed in conjunction with fertigation 4.16 m and 4.49 m (T_9) during both the years. The tree spread in east-west direction of 2.97 m and 3.39 m was registered with $RDI_{50\%\ ETc}$ (T_4) as compared to 3.82 m and 4.25 m with RDI 50% along with fertigation (i.e. T_8), and exhibited that the fertigation led to significant difference in tree spread in east-west direction during 2017 and 2018 respectively. Further pooled data showed similar pattern where tree spread in east-west direction was significantly higher (5.06 m) in T_1 i.e 100 % ETc.

Again, In 2017 and 2018, drip irrigation imposed at 75% ETc in PRD mode, the tree spread in tree spread of north-south direction achieved was 3.58 m and 3.83 m (T_3) and differed significantly when imposed in conjunction with fertigation 4.39 m and 4.68 m (T_7) during both the years. The tree spread in north-south direction of 3.31 m and 3.77 m was registered with RDI 75% ETc (T_2) as compared to 4.28 m and 4.45 m with RDI 75% along with fertigation (i.e. T_6), and exhibited that the fertigation led to significant difference in north-south direction. Drip irrigation imposed at 50% ETc having PRD mode, the tree spread in north-south direction achieved was 3.06 m and 3.35 m (T_5) and differed significantly when imposed in conjunction with fertigation 3.88 m and 4.23 m (T_9) during both the years. The tree spread in north-south direction of 2.72 m and 3.04 m was registered with $RDI_{50\%\ ETc}$ (T_4) as compared to 3.66 m and 4.01 m with RDI 50% along with fertigation (i.e. T_8), and exhibited that the fertigation led to significant difference in tree spread in north-south direction during 2017 and 2018 respectively.

Higher tree spread of north-south direction was observed under full irrigation i.e T_1 (100 % ETc) 4.64 m and 4.93 m during 2017 and 2018, respectively. However,

Table 6: Effect of different irrigation regimes and fertigation on tree height (m) of mango cv. Dashehari

	Tree height (m)		
Treatment	**2017**	**2018**	**Pooled**
T_1: 100% ETc	5.97[a]	6.18[a]	6.07[a]
T_2: RDI 75% ETc evenly applied under the canopy	5.26[ef]	5.39[fg]	5.32[ef]
T_3: PRD 75% ETc applied to alternating sides of the root system	5.35[de]	5.47[ef]	5.41[de]
T_4: RDI 50% ETc evenly applied under the canopy	5.11[f]	5.22[g]	5.16f[g]
T_5: PRD 50% ETc applied to alternating sides of the root system	5.18[f]	5.26[g]	5.22[fg]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	5.69[b]	5.81[bc]	5.75[bc]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	5.76[b]	5.90[b]	5.83[b]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.48[cd]	5.59[de]	5.53[cd]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.60[bc]	5.70[cd]	5.65[cd]
T_{10}: No Irrigation	4.78[g]	4.95[h]	4.86[h]

Table 7: Effect of different irrigation regimes and fertigation on tree spread of east-west (m) and north-south (m) of mango cv. Dashehari

	East-West (m)			North-South (m)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	4.91^{a}	5.22^{a}	5.06^{a}	4.64^{a}	4.93^{a}	4.78^{a}
T_2: RDI 75% ETc evenly applied under the canopy	3.58^{cd}	3.95^{bc}	3.76^{def}	3.31^{cd}	3.77^{cde}	3.54^{de}
T_3: PRD 75% ETc applied to alternating sides of the root system	$3.74b^{cd}$	4.17^{bc}	3.95^{cde}	3.58^{bc}	3.83^{bcde}	3.70^{cde}
T_4: RDI 50% ETc evenly applied under the canopy	2.97^{d}	3.39^{de}	3.18^{fg}	2.72^{d}	3.04^{ef}	2.88^{f}
T_5: PRD 50% ETc applied to alternating sides of the root system	3.25^{cd}	3.63^{cde}	3.44^{efg}	3.06^{cd}	3.35^{def}	3.20^{ef}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	4.40^{ab}	4.72^{ab}	4.56^{ab}	4.28^{ab}	4.45^{abc}	4.36^{abc}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	4.63^{ab}	4.95^{ab}	4.79^{ab}	4.39^{ab}	4.68^{ab}	4.53^{ab}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	3.82^{bcd}	4.25^{bc}	4.03^{cde}	3.66^{bc}	4.01^{bcd}	3.83^{cde}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	4.16^{abc}	4.49^{abc}	4.32^{bcd}	3.88^{abc}	4.23^{abcd}	4.05^{bcd}
T_{10}: No Irrigation	2.72^{d}	3.18^{e}	2.95^{g}	2.53^{d}	2.76^{f}	2.64^{f}

lowest tree spread in north-south direction was recorded under no irrigation (T_{10}) i.e. 2.53 m and 2.76 m during first and second year of experimental study, respectively. A similar pattern was observed in the pooled data of tree spread of north-south direction where T_1 i.e 100% ETc (4.78 m) NS spread was higher as compare to all others treatments.

4.2.3 Scion stock ratio

The data on scion stock ratio of mango presented in Table 8 can be explained as that in both the years of study (2017 and 2018), minimum scion stock ratio of 0.871 and 0.883 was attained in plants with no irrigation i.e. T_2, whereas maximum scion stock ratio (0.941 and 0.954) was attained in plants with provided with 100% ETc followed by T_7 (PRD $_{75\% \text{ ETc}}$ + F) with the value of 0.936 and 0.943, respectively.

Scion stock ratio was higher in plants with deficit irrigation supplemented with fertigation at 75% ETc both in RDI and PRD i.e T_6 with values of 0.935 and 0.936 during 2017 and 2018, respectively and in T_7 with values of 0.936 and 0.943 in 2017 and 2018, respectively, whereas scion stock ratio was recorded to be lower when deficit irrigation was provided without fertigation at 75% ETc i.e T_2 0.941 and 0.954 and in T_3 0.921 and 0.929 during both the years 2017 and 2018, respectively. In case of deficit irrigation supplemented with fertigation at 50% ETc both in RDI and PRD the scion stock ratio was higher in treatment T_8 with values of 0.917 and 0.919 during 2017 and 2018, respectively and in T_9 with values of 0.935 and 0.936 in 2017 and 2018, respectively, whereas scion stock ratio was recorded to be lower when deficit irrigation was provided without fertigation at 50% ETc i.e T_4 0.916 and 0.917 and in T_5 0.907 and 0.909 during both the years 2017 and 2018, respectively. On the basis of pooled data, maximum scion stock ratio of 0.947 was recorded in T_1

4.2.4 Stock girth

The analysis data on stock girth of mango has been presented in Table 9. In first and second year of study, stock girth was higher in plants supplemented with deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\ \% \text{ ETc}}$) 58.79 cm and 60.77 cm in 2017 and 2018, respectively and in T_3 (PRD $_{75\ \% \text{ ETc}}$) 59.67 cm and 61.39 cm in 2017 and 2018, respectively, whereas stock girth was recorded to be lower when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\ \% \text{ ETc}}$) 57.54 cm and

60.55 cm, respectively in 2017 and 2018 and in T_5 (PRD $_{50\ \%\ ETc}$) 57.26 cm and 59.42 cm during both the years 2017 and 2018, respectively.

Stock girth was highest in case of full irrigation i.e 100 % ETc (T_1) (63.53 cm and 65.72 cm) during 2017 and 2018, respectively, than plants treated at 50% ETc i.e T_4 and T_5. Highest stock girth was observed when deficit irrigation was supplemented with fertigation under treatment T_7 i.e. PRD $_{75\ \%\ ETc}$ + F with 63.37 cm and 65.58 cm during 2017 and 2018, respectively. However, the lowest stock girth was recorded under no irrigation (T_{10}) with 54.36 cm and 56.67 cm during first and second year of experimental study, respectively. A similar pattern was observed in the pooled data of stock girth.

4.2.5 Scion girth

The data pertaining to scion girth of mango presented in Table 9 shows that during both the years (2017 and 2018), scion girth was higher in plants treated with 100 % ETc i.e T_1 (53.95 cm and 55.89 cm) during 2017 and 2018, respectively, than plants treated at 50% ETc i.e T_4 (RDI $_{50\%\ ETc}$) 53.69 cm and 55.56 cm in 2017 and 2018, respectively and T_5 i.e (PRD $_{50\%\ ETc}$) 51.24 cm and 53.68 cm during 2017 and 2018, respectively. Maximum scion girth was recorded when deficit irrigation was provided with fertigation under T_7 i.e PRD $_{75\%\ ETc}$ + F with values of 59.81 cm and 62.70 cm during 2017 and 2018, respectively, whereas minimum scion girth was observed under T_{10} i.e no irrigation (48.34 cm and 50.83 cm) during first and second year of experiment.

Scion girth was higher in plants when deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\%\ ETc}$) 54.53 cm and 56.87 cm during 2017 and 2018, respectively and in T_3 (PRD $_{75\%\ ETc}$) 54.79 cm and 57.09 cm in 2017 and 2018, respectively, whereas scion girth was recorded to be lower when deficit irrigation was provided at 50% ETc i.e T_4 and in T_5 during both the years 2017 and 2018. A similar pattern in scion girth was observed in pooled data.

4.3 Effect of deficit irrigation on physiochemical characteristics of mango

4.3.1 Fruit weight

Perusal of the data presented in Table 10 revealed that fruit weight was significantly affected by different treatments during 2017 and 2018. During both the years, it was observed that fruit weight was higher in plants with deficit irrigation at

Table 8: Effect of different irrigation regimes and fertigation on scion stock ratio of mango cv. Dashehari

	Scion Stock ratio		
Treatment	**2017**	**2018**	**Pooled**
T_1: 100% ETc	0.941[a]	0.954[a]	0.947[a]
T_2: RDI 75% ETc evenly applied under the canopy	0.871[b]	0.883[b]	0.877[b]
T_3: PRD 75% ETc applied to alternating sides of the root system	0.921[b]	0.929[b]	0.925[b]
T_4: RDI 50% ETc evenly applied under the canopy	0.916[b]	0.917[b]	0.916[b]
T_5: PRD 50% ETc applied to alternating sides of the root system	0.907[b]	0.909[b]	0.908[b]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.935[a]	0.936[a]	0.936[a]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.936[a]	0.943[a]	0.940[a]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.917[b]	0.919[b]	0.918[b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.935[a]	0.936[a]	0.935[a]
T_{10}: No Irrigation	0.889[b]	0.896[b]	0.893[b]

Table 9: Effect of different **irrigation regimes and fertigation on stock girth (cm) and scion girth (cm) of mango cv. Dashehari**

	Stock girth (cm)			Scion girth (cm)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	63.53[a]	65.72[a]	64.62[a]	59.81[a]	62.70[a]	61.25[a]
T_2: RDI 75% ETc evenly applied under the canopy	58.79[de]	60.77[d]	59.78[cd]	51.24[de]	53.68[e]	52.46[e]
T_3: PRD 75% ETc applied to alternating sides of the root system	59.67[bc]	61.39[c]	60.53[c]	54.98[cd]	57.09[c]	56.03[cd]
T_4: RDI 50% ETc evenly applied under the canopy	57.47[d]	59.72[cd]	58.59[cd]	52.65[cd]	54.79[cde]	53.72[de]
T_5: PRD 50% ETc applied to alternating sides of the root system	57.54[d]	60.55[cd]	59.04[ef]	52.19[cde]	55.06[de]	53.62[de]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	62.28[ab]	63.47[b]	62.87[ab]	58.26[ab]	59.45[b]	58.85[b]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	63.37[ab]	65.58[a]	64.47[ab]	59.35[a]	61.89[a]	60.62[a]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	59.44[cd]	61.82[c]	60.63[cd]	54.53[cd]	56.87[cd]	55.70[cde]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	62.04[bc]	63.34[b]	62.69[b]	58.02[bc]	59.32[b]	58.66[b]
T_{10}: No Irrigation	54.36[e]	56.67[e]	55.51[e]	48.34[e]	50.83[f]	49.58[f]

75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\%\ ETc}$) with fruit weight of 181.92 g and 188.41 g, in 2017 and 2018, respectively and 187.38 and 190.42 g in T_3 (PRD 75 % ETc) in 2017 and 2018, respectively, whereas fruit weight was recorded to be lower when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\%\ ETc}$) with value recorded to be 168.76 g and 180.42 g , respectively in 2017 and 2018 and in T_5 (PRD $_{50\%\ ETc}$) with 172.88 g and 183.88 g during both the years 2017 and 2018, respectively.

Fruit weight was higher in case of full irrigation i.e 100 % ETc (T_1) (177.52 g and 185.72 g) during 2017 and 2018, respectively, than plants treated with 50% ETc i.e T_4 and T_5. Highest fruit weight was observed when deficit irrigation was supplemented with fertigation under treatment T_7 i.e. PRD $_{75\%\ ETc}$ + F) with 206.45 g and 208.29 g during 2017 and 2018, respectively followed by T_6 i.e. RDI $_{75\%\ ETc}$ + F) 200.36 g and 200.52 g during both the years 2017 and 2018. However, lowest fruit weight was recorded under no irrigation (T_{10}) which was recorded as 157.76 g and 175.44 g during first and second year of experimental study, respectively. A similar pattern was observed in the pooled data of fruit weight. Pooled fruit weight was significantly higher in T_7 (207.37 g) as compared to all others treatments.

4.3.2 Fruit volume

The effect of different irrigation levels on fruit volume of mango at harvest during two experimental trials, presented in Table 10 reveal that fruit volume was higher in plants when deficit irrigation was provided at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\%\ ETc}$) with 174.98 cm^3 and 180.72 cm^3, in 2017 and 2018, respectively and in T_3 (PRD $_{75\%\ ETc}$) with 184.79 cm^3 and 187.51 cm^3 in 2017 and 2018, respectively, whereas fruit volume was recorded to be lower when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) with 162.98 cm^3 and 174.72 cm^3 during (2017 and 2018, respectively) and in T_5 (PRD $_{50\ \%\ ETc}$) with 169.43 cm^3 and 176.95 cm^3 during both the years 2017 and 2018, respectively. Fruit volume was higher in case of full irrigation i.e 100 % ETc (T_1) (173.25 cm^3 and 179.87 cm^3) during 2017 and 2018, respectively, than plants treated at 50% ETc i.e T_4 and T_5. Highest fruit volume was observed when deficit irrigation was supplemented with fertigation under treatment T_7 i.e. PRD $_{75\%\ ETc}$ + F with 213.87 cm^3 and 216.56 cm^3 during 2017 and 2018, respectively followed by T_6 i.e. RDI $_{75\%\ ETc}$ + F with 207.85 cm^3 and 201.75 cm^3 respectively, during both the years 2017 and 2018. However, lowest fruit volume was recorded under no irrigation (T_{10}) which was recorded as 158.95 cm^3 and 173.85 cm^3 during first and second year of experimental study, respectively. Further on pooled data basis similar trend was recorded, the results revealed that various treatments have significant effect on pooled average fruit volume, which reached to maximum of 215.21 cm^3 in T_7 i.e PRD $_{75\%\ ETc}$ + F and minimum pooled fruit weight of 166.40 cm^3 was found in no irrigation (T_{10}).

4.3.3 Fruit size

4.3.3.1 Fruit length

Data pertaining to the fruit length under various treatments for the two consecutive years (2017 and 2018) are given in Table 11. An examination of the data revealed that during 2017, fruit length was higher in plants when deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\%\ ETc}$) 9.60 cm and in T_3 (PRD $_{75\%\ ETc}$) 9.64 cm, whereas fruit length was recorded to be lower when deficit irrigation was provided at 50% ETc with 9.53 cm in T_4 (RDI $_{50\ \%\ ETc}$) and 9.55 cm in T_5 (PRD $_{50\ \%\ ETc}$). Fruit length was higher in case of full irrigation i.e 100 % ETc (T_1) (9.58 cm), than plants treated at 50% ETc i.e T_4 and T_5. Highest fruit length (10.37 cm) was observed when deficit irrigation was supplemented with fertigation under treatment T_7 i.e. PRD $_{75\%\ ETc}$ + F followed by (10.34 cm) T_6 i.e. RDI $_{75\%\ ETc}$ + F. However, lowest fruit length was observed under no irrigation (T_{10}) which recorded fruit length of 8.75 cm. During second year of experimental study the fruit length of mango showed the same trend as followed during the first year of investigation. However, better fruit length was recorded during second year in comparison to first year of study in all treatments. On the basis of pooled data similar trend was recorded and maximum fruit length of 10.38 cm was recorded in T_7 while, minimum of 8.76 cm in T_{10}.

4.3.3.2 Fruit breadth

Data regarding fruit breadth under various treatments for the two consecutive years (2017 and 2018) have been presented in Table 11. A close perusal of the data reveals that during 2017 and 2018, fruit breadth was higher in plants at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\%\ ETc}$) with 16.13 cm and 16.15 cm, in 2017 and 2018, respectively and T_3 (PRD $_{75\%\ ETc}$) with 6.16 cm and 16.19 cm during 2017 and 2018, respectively, whereas fruit breadth was recorded to be lower when deficit irrigation

Table 10: Effect of different irrigation regimes and fertigation on fruit weight (g) and fruit volume (cm^3) of mango cv. Dashehari

	Fruit weight (g)			Fruit volume (cm^3)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	177.52^g	185.72^g	181.62^g	173.25^f	179.87^f	176.56^g
T_2: RDI 75% ETc evenly applied under the canopy	181.92^f	188.41f	185.16^f	174.98^f	180.72^f	177.85^f
T_3: PRD 75% ETc applied to alternating sides of the root system	187.38^e	190.42^e	188.90^e	184.79^e	187.51^e	186.15^e
T_4: RDI 50% ETc evenly applied under the canopy	168.76^i	180.42^i	174.59^i	162.98^h	174.72^h	168.85^i
T_5: PRD 50% ETc applied to alternating sides of the root system	172.88^h	183.88^h	178.38^h	169.43^g	176.95^g	173.19^h
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	200.36^b	200.52^b	200.44^b	207.85^b	201.75^b	204.80^b
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	206.45^a	208.29^a	207.37^a	213.87^a	216.56^a	215.21^a
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	192.64^d	194.51^d	193.57^d	191.29^d	191.74^d	191.51^d
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	196.57^c	198.44^c	197.50^c	199.62^c	196.66^c	198.14^c
T_{10}: No Irrigation	157.76^j	175.44^j	166.60^j	158.95^i	173.85^h	166.40^j

Table 11: Effect of different irrigation regimes and fertigation on fruit size (cm) of mango cv. Dashehari

	Fruit size					
	Fruit length (cm)			**Fruit breadth (cm)**		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	9.58^{ab}	9.60^{ab}	9.59^{ab}	6.09^{b}	6.11^{ab}	6.10^{b}
T_2: RDI 75% ETc evenly applied under the canopy	9.61^{ab}	9.64^{ab}	9.62^{ab}	6.13^{b}	6.15^{ab}	6.14^{b}
T_3: PRD 75% ETc applied to alternating sides of the root system	9.64^{ab}	9.66^{ab}	9.65^{ab}	6.16^{ab}	6.19^{a}	6.17^{b}
T_4: RDI 50% ETc evenly applied under the canopy	9.53^{ab}	9.56^{ab}	9.54^{ab}	6.01^{b}	6.03^{ab}	6.02^{b}
T_5: PRD 50% ETc applied to alternating sides of the root system	9.55^{ab}	9.58^{ab}	9.56^{ab}	6.05^{b}	6.08^{ab}	6.06^{b}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	10.34^{a}	10.36^{a}	10.35^{a}	6.27^{ab}	6.29^{a}	6.28^{a}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	10.37^{a}	10.40^{a}	10.38^{a}	6.31^{a}	6.33^{a}	6.32^{a}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	10.28^{a}	10.23^{ab}	10.25^{a}	6.19^{ab}	6.21^{a}	6.20^{ab}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	10.31^{a}	10.34^{a}	10.32^{a}	6.23^{ab}	6.25^{a}	6.24^{a}
T_{10}: No Irrigation	8.75^{b}	8.77^{b}	8.76^{c}	5.97^{b}	5.99^{b}	5.98^{b}

Plate 2. Mango fruits cv. Dashehari subjected to various treatments

was provided at 50% ETc i.e T_4 (RDI $_{50\%\ ETc}$) with 6.01 cm and 6.03 cm during (2017 and 2018, respectively) and in T_5 (PRD $_{50\%\ ETc}$) with 6.05 cm and 6.08 cm during both the years 2017 and 2018, respectively. Fruit breadth was higher in case of full irrigation i.e 100 % ETc (T_1) (6.09 cm and 6.11 cm) during 2017 and 2018, respectively, than plants treated at 50% ETc i.e T_4 and T_5. Highest fruit breadth was observed when deficit irrigation was supplemented with fertigation under treatment T_7 i.e. PRD $_{75\%\ ETc}$ + F (6.31cm and 6.33 cm) during 2017 and 2018, respectively. However, lowest fruit breadth was recorded under no irrigation (T_{10}) which was recorded fruit breadth of 5.97 cm and 5.99 cm during first and second year of experimental study, respectively. Further on pooled data basis similar trend was recorded, the results revealed that various treatments have significant effect on average fruit breadth, which reached to maximum of 6.32 cm in T_7 i.e PRD $_{75\%\ ETc}$ + F and was significantly higher than all other treatments.

4.3.4 Specific gravity

Data observed on specific gravity of mango cv. Dashehari as affected by various treatments for the two consecutive years (2017 and 2018) and depicted in Table 12 shows that during 2017, specific gravity was recorded to be maximum (1.03 g/cc) under T_7 i.e. PRD $_{75\%\ ETc}$ + F. Minimum specific gravity of 0.95 g/cc was observed under treatment T_{10} i.e no irrigation. In the second year (2018), specific gravity was found again maximum (1.04 g/cc) under T_7, T_6, T_8, and T_9 and minimum specific gravity of 0.97 g/cc was observed under treatment T_{10} i.e No irrigation. The data on specific gravity of both years did not show any significant difference. On the basis of pooled data, maximum specific gravity of 1.03 g/cc was recorded in T_7 while, minimum of 0.96 g/cc in T_{10}.

4.3.5 Total soluble solids

The Total soluble solid content (TSS) in fruits obtained from mango cv. Dashehari subjected to various treatments has been depicted in Table 13. During both the years (2017 and 2018) it was observed that TSS was higher in plants treated with deficit irrigation at 50% and 75 % ETc both in RDI and PRD i.e T_4 (RDI $_{50\%\ ETc}$) recorded 19.10 ^{0}Brix and 19.17 ^{0}Brix during both the years (2017 and 2018) respectively and in T_5 i.e PRD $_{50\%\ ETc}$ recorded 19.36 ^{0}Brix and 19.39 ^{0}Brix, T_3(RDI 75 % ETc recorded 18.50 ^{0}Brix and 18.54 ^{0}Brix) and in T_4 i.e PRD $_{75\%\ ETc}$ recorded

(18.68 ^{0}Brix and 18.75 ^{0}Brix) during both the year 2017 and 2018, respectively, as compare to 100 per cent ETc i.e T_1(18.19 ^{0}Brix and 18.75 ^{0}Brix) during 2017 and 2018 respectively and no irrigation i.e T_{10} (17.96 ^{0}Brix and 18.00 ^{0}Brix) during 2017 and 2018 respectively. However, highest total soluble solid was observed when deficit irrigation was supplemented with fertigation under treatment T_9 PRD $_{50\ \%\ ETc}$ + F i.e (20.42 ^{0}Brix and 20.50 ^{0}Brix) in 2017 and 2018 respectively, followed by T_8 RDI $_{50\%\ ETc}$ + F i.e (20.37 ^{0}Brix and 20.45 ^{0}Brix) during 2017 and 2018 respectively. However, lowest TSS was recorded under no irrigation (T_{10}) during first and second year of experimental trail. Further, similar pattern was observed in pooled data, which indicates that treatment T_9 i.e PRD $_{50\%\ ETc}$ + F (20.46 ^{0}Brix) was significant as compared to other treatments.

4.3.6 Acidity

The titratable acidity in fruits obtained from mango trees under different treatments tabulated in Table 13 reveal that in 2017, it was observed that titratable acidity was lower in plants treated with deficit irrigation T_2 i.e RDI $_{75\%\ ETc}$ recorded and T_3 i.e PRD $_{75\%\ ETc}$ recorded 0.25 per cent of titrable acidity, T_4 i.e RDI 50 % ETc and T_5 i.e PRD $_{50\%\ ETc}$ recorded 0.24 per cent of titrable acidity while 100 per cent ETc i.e T_1 recorded 0.26 per cent of titrable acidity during 2017. However, highest titratable acidity (0.27 per cent) was recorded under treatment T_{10} i.e no irrigation and lowest titratable acidity (0.22 per cent) was observed under treatment T_9 i.e PRD $_{50\ \%\ ETc}$ + F. Similar data was recorded, during second year of experimental study. On the basis of pooled data similar trend was recorded and maximum titratable acidity was recorded under T_{10} i.e no irrigation 0.27 per cent.

4.3.7 Sugars

4.3.7.1 Total sugars

Data pertaining to the total sugars under various treatments for the two consecutive years (2017 and 2018) are depicted in Table 14. In the first experimental trail, highest total sugars of 15.25 per cent were recorded in treatment T_9 i.e PRD $_{50\%\ ETc}$ + F followed by 15.13 per cent in plants under T_8 i.e RDI 50% ETc + F as compared to control with no irrigation T_{10} (12.11 per cent). However, it was observed that total sugar was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\%\ ETc}$ (12.75 %), T_3 i.e PRD $_{75\%\ ETc}$ (12.86 %), T_4 i.e RDI $_{50\%\ ETc}$ (13.24 %) and in T_5 i.e

Table 12: Effect of different irrigation regimes and fertigation on specific gravity (g/cc) of mango cv. Dashehari

	Specific gravity (g/cc)		
Treatment	**2017**	**2018**	**Pooled**
T_1: 100% ETc	1.01[a]	1.01[a]	1.01[a]
T_2: RDI 75% ETc evenly applied under the canopy	1.02[a]	1.03[a]	1.02[a]
T_3: PRD 75% ETc applied to alternating sides of the root system	1.02[a]	1.03[a]	1.02[a]
T_4: RDI 50% ETc evenly applied under the canopy	0.98[a]	1.00[a]	0.99[a]
T_5: PRD 50% ETc applied to alternating sides of the root system	0.98[a]	1.00[a]	0.99[a]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	1.03[a]	1.04[a]	1.03[a]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	1.03[a]	1.04[a]	1.03[a]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	1.03[a]	1.04[a]	1.03[a]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	1.03[a]	1.04[a]	1.03[a]
T_{10}: No Irrigation	0.95[a]	0.97[a]	0.96[a]

Table 13: Effect of different irrigation regimes and fertigation on TSS (^{0}brix) and acidity (%)of mango cv. Dashehari

	TSS (^{0}brix)			Acidity (%)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	18.19^{bc}	18.25^{c}	18.22^{de}	0.26^{ab}	0.26^{ab}	0.26^{ab}
T_2: RDI 75% ETc evenly applied under the canopy	18.50^{bc}	18.54^{bc}	18.52^{cde}	0.25^{ab}	0.25^{ab}	0.25^{bc}
T_3: PRD 75% ETc applied to alternating sides of the root system	18.68^{bc}	18.75^{abc}	18.71^{cde}	0.25^{ab}	0.25^{ab}	0.25^{bc}
T_4: RDI 50% ETc evenly applied under the canopy	19.10^{abc}	19.17^{abc}	19.13^{bcd}	0.24^{ab}	0.24^{ab}	0.24^{cde}
T_5: PRD 50% ETc applied to alternating sides of the root system	19.36^{ab}	19.39^{abc}	19.37^{abc}	0.24^{ab}	0.24^{ab}	0.24^{cd}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	20.13^{a}	20.19^{ab}	20.16^{ab}	0.23^{ab}	0.23^{ab}	0.22^{de}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	20.24^{a}	20.32^{a}	20.28^{a}	0.23^{ab}	0.23^{ab}	0.23^{cde}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	20.37^{a}	20.45^{a}	20.41^{a}	0.22^{b}	0.22^{b}	0.22^{de}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	20.42^{a}	20.50^{a}	20.46^{a}	0.22^{b}	0.22^{b}	0.22^{e}
T_{10}: No Irrigation	17.96^{c}	18.00^{c}	17.98^{e}	0.27^{a}	0.27^{a}	0.27^{a}

PRD 50 % ETc (13.39 %) as compared to 100 per cent ETc i.e T_1 (12.28 %) during 2017. The total sugar during 2018 also, followed the similar trend wherein maximum total sugars of 15.30 per cent was attained by the plants with PRD $_{50\%\ ETc}$ + F i.e T_9, while minimum total sugars of 12.16 per cent was attained under no irrigation (T_{10}). However, total sugar was higher in plants treated with deficit irrigation T_2 i.e RDI 75 % ETc (12.78 %), T_3 i.e PRD $_{75\%\ ETc}$ (12.89 %), T_4 i.e RDI $_{50\ \%\ ETc}$ (13.28%) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (13.43 %) as compare to 100 per cent ETc i.e T_1 (12.31 %) during 2018. Further, similar pattern was observed in pooled data.

4.3.7.1 Reducing sugars

Reducing sugars of mango fruits as recorded under various treatments for the two consecutive years (2017 and 2018) have been tabulated in Table 14. During 2017 highest reducing sugar content of 3.71 per cent was recorded in treatment T_9 i.e PRD $_{50\%\ ETc}$ + F followed by 3.68 per cent in plants treated T_8 i.e RDI $_{50\%\ ETc}$ + F as compared to control with no irrigation T_{10}(2.18 per cent). However, it was observed that reducing sugar content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (2.69 %), T_3 i.e PRD $_{75\ \%\ ETc}$ (2.76 %), T_4 i.e RDI $_{50\ \%\ ETc}$ (3.12 %) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (3.19 %) as compared to 100 per cent ETc i.e. T_1(2.33 %) during 2017. The reducing sugar content during 2018 also, followed the similar trend as first year of experimental study. Further, similar pattern was observed in pooled data, wherein maximum reducing sugar content of 3.72 per cent was attained by the plants with PRD 50% ETc i.e T_9, while minimum reducing sugar content of 2.19 per cent was attained under no irrigation (T_{10}). However, reducing sugar content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (2.70%), T_3 i.e PRD $_{75\ \%\ ETc}$ (2.77 %), T_4 i.e RDI $_{50\ \%\ ETc}$ (3.13 %) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (3.20 %) as compared to 100 per cent ETc i.e T_1 (2.34 %).

4.3.7.2 Non reducing sugars

Non reducing sugars in mango fruit cv. Dashehari as affected by various treatments for the two consecutive years (2017 and 2018) depicted in Table 15 explain that in the first experimental trial non reducing sugar content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (9.55 per cent) , T_3 i.e PRD $_{75\ \%\ ETc}$ (9.59 per cent), T_4 i.e RDI $_{50\ \%\ ETc}$ (9.61 per cent) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (9.69 per cent) as compared to 100 per cent ETc i.e T_1(9.45 per cent) during 2017.

However, highest non reducing sugar content was observed under treatment T_9 i.e PRD $_{50\ \%\ ETc}$ + F (10.96 per cent), whereas lowest non reducing sugar content was recorded in T_{10} i.e no irrigation (9.44 per cent). Similar data was recorded, during second year of experimental study. On the basis of pooled data similar trend was recorded and maximum non reducing sugar content was recorded under T_9 i.e PRD $_{50\ \%\ ETc}$ + F (10.99 per cent).

4.3.8 Sugar: acid ratio

Sugar: acid ratio as influenced by different irrigation levels was calculated and presented in Table 15. During both the years of investigation sugar: acid ratio was significantly affected by the treatments as compared to control. A close perusal of the data reveals that during 2017 and 2018, sugar: acid ratio was recorded highest (92.81 and 93.18 during both the year 2017 and 2018, respectively) in T_9 i.e PRD 50 % ETc + F and it was recorded lowest (66.59 and 66.66 during 2017 and 2018, respectively) under treatment T_{10} i.e no irrigation. However, it was observed that sugar: acid ratio was higher in plants treated with deficit irrigation in treatments T_2 i.e RDI $_{75\ \%\ ETc}$ (74.00 and 74.16), T_3 i.e PRD $_{75\ \%\ ETc}$ (74.72 and 75.00), T_4 i.e RDI 50 $_{\%\ ETC}$ (79.58 and 79.87) and in T_5 i.e PRD 50 % ETc (80.60 and 80.79) respectively, as compared to 100 per cent ETc i.e T_1(69.96 and 70.19) during 2017 and 2018, respectively. Further, similar pattern was observed in pooled data.

4.3.9 Concentration of leaf K, Ca and B

4.3.9.1 Leaf potassium

The leaf potassium data obtained from mango trees subjected to various treatments depicted in Table 16 revealed that during 2017, highest leaf potassium content 0.28 % was obtained under treatment T_7 i.e PRD $_{75\ \%\ ETc}$ + F. This was followed closely by the treatment T_6 i.e RDI $_{75\ \%\ ETc}$ + F, T_8 and T_9 where leaf potassium of 0.27 per cent was recorded, whereas, minimum leaf potassium content was observed under no irrigation i.e T_{10} (0.20 %) during first year of experimental study. Similarly, during 2018 maximum leaf potassium (0.30 %) was obtained under treatment T_7 (PRD $_{75\ \%\ ETc}$ + F) followed by the treatment T_6 i.e RDI $_{75\ \%\ ETc}$ + F whereas minimum leaf potassium of 0.29 per cent was recorded under T_{10} i.e no irrigation. The data on leaf potassium of both years did not show any significant

Table 14: Effect of different irrigation regimes and fertigation on total sugars (%) and reducing sugars (%) of mango cv. Dashehari

	Total sugars (%)			Reducing sugars (%)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	12.28^{d}	12.31^{c}	12.29^{bc}	2.33^{h}	2.35^{i}	2.34^{c}
T_2: RDI 75% ETc evenly applied under the canopy	12.75^{d}	12.78^{c}	12.76^{bc}	2.69^{g}	2.71^{h}	2.70^{bc}
T_3: PRD 75% ETc applied to alternating sides of the root system	12.86^{d}	12.89^{c}	12.87^{bc}	2.76^{f}	2.78^{g}	2.77^{bc}
T_4: RDI 50% ETc evenly applied under the canopy	13.24^{cd}	13.28^{bc}	13.26^{b}	3.12^{e}	3.14^{f}	3.13^{ab}
T_5: PRD 50% ETc applied to alternating sides of the root system	13.39^{bcd}	13.43^{bc}	13.41^{b}	3.19^{d}	3.22^{e}	3.20^{ab}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	14.65^{abc}	14.68^{ab}	14.66^{a}	3.57^{c}	3.59^{d}	3.58^{a}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	14.86^{ab}	14.89^{ab}	14.87^{a}	3.62^{b}	3.64^{c}	3.63^{a}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	15.13^{a}	15.16^{a}	15.14^{a}	3.68^{a}	3.70^{b}	3.69^{a}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	15.25^{a}	15.30^{a}	15.27^{a}	3.71^{a}	3.73^{a}	3.72^{a}
T_{10}: No Irrigation	12.11^{d}	12.16^{c}	12.13^{c}	2.18^{i}	2.21^{j}	2.19^{c}

Table 15: Effect of different irrigation regimes and fertigation on non reducing sugar (%) and sugar acid ratio of mango cv. Dashehari

	Non Reducing sugar (%)			Sugar: acid ratio		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	9.45[b]	9.46[b]	9.45[b]	69.96[e]	70.19[e]	70.07[e]
T_2: RDI 75% ETc evenly applied under the canopy	9.55[b]	9.56[b]	9.55[b]	74.00[d]	74.16[d]	74.08[d]
T_3: PRD 75% ETc applied to alternating sides of the root system	9.59[b]	9.60[b]	9.59[b]	74.72[d]	75.00[d]	74.86[d]
T_4: RDI 50% ETc evenly applied under the canopy	9.61[b]	9.63[b]	9.62[b]	79.58[c]	79.87[c]	79.72[c]
T_5: PRD 50% ETc applied to alternating sides of the root system	9.69[b]	9.69[b]	9.69[b]	80.66[c]	80.79[c]	80.72[c]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	10.52[a]	10.53[a]	10.52[a]	87.52[b]	87.78[b]	87.65[b]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	10.67[a]	10.68[a]	10.67[a]	88.00[b]	88.34[b]	88.17[b]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	10.87[a]	10.88[a]	10.87[a]	92.59[a]	92.95[a]	92.77[a]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	10.96[a]	10.99[a]	10.99[a]	92.81[a]	93.18[a]	92.99[a]
T_{10}: No Irrigation	9.44[b]	9.45[b]	9.44[b]	66.59[f]	66.66[f]	66.62[f]

Table 16: Effect of different irrigation regimes and fertigation on leaf potassium (%) and leaf calcium (%) of mango cv. Dashehari

	Potassium (%)			**Calcium (%)**		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	0.22[a]	0.23[a]	0.22[a]	1.73[a]	1.74[a]	1.73[a]
T_2: RDI 75% ETc evenly applied under the canopy	0.25[a]	0.26[a]	0.25[a]	1.75[a]	1.76[a]	1.75[a]
T_3: PRD 75% ETc applied to alternating sides of the root system	0.26[a]	0.26[a]	0.26[a]	1.75[a]	1.76[a]	1.75[a]
T_4: RDI 50% ETc evenly applied under the canopy	0.23[a]	0.24[a]	0.23[a]	1.74[a]	1.75[a]	1.74[a]
T_5: PRD 50% ETc applied to alternating sides of the root system	0.23[a]	0.24[a]	0.23[a]	1.74[a]	1.75[a]	1.74[a]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.27[a]	0.29[a]	0.28[a]	1.78[a]	1.80[a]	1.79[a]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.28[a]	0.30[a]	0.29[a]	1.79[a]	1.81[a]	1.80[a]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.27[a]	0.27[a]	0.27[a]	1.77[a]	1.78[a]	1.77[a]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.27[a]	0.28[a]	0.27[a]	1.78[a]	1.78[a]	1.78[a]
T_{10}: No Irrigation	0.20[a]	0.21[a]	0.20[a]	1.70[a]	1.72[a]	1.71[a]

difference. A similar pattern was observed in the pooled data of leaf potassium content.

4.3.9.2 Leaf calcium

Data pertaining to the leaf calcium under various treatments for the two consecutive years (2017 and 2018) are given in Table 16. During 2017, highest leaf calcium of 1.79 per cent was obtained under treatment T_7 (PRD $_{75\ \%\ ETc}$ + F) followed closely by the treatment T_6 i.e RDI $_{75\ \%\ ETc}$ + F where leaf calcium of 1.78 per cent was recorded whereas minimum leaf calcium was recorded in treatment T_{10} (no irrigation) i.e 1.70 per cent. Similarly, during 2018-19 maximum leaf calcium (1.81 %) was obtained under treatment T_7 PRD $_{75\ \%\ ETc}$ + F followed closely by the treatment T_6 i.e RDI $_{75\ \%\ ETc}$ + F where leaf calcium of 1.80 per cent was recorded and minimum leaf calcium was recorded in treatment T_{10}(no irrigation) i.e 1.72 per cent. The data on leaf calcium of both years did not varied significantly. A similar pattern was observed in the pooled data of leaf calcium.

4.3.9.3 Leaf boron

Values of leaf boron content under various treatments for the two consecutive years (2017 and 2018) presented in Table 17 reveal that during 2017, leaf boron content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (16.30 ppm), T_3 i.e PRD $_{75\ \%\ ETc}$ (16.58 ppm), T_4 i.e RDI $_{50\ \%\ ETc}$ (15.28 ppm) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (15.69 ppm) as compared to 100 per cent ETc i.e T_1(14.09 ppm) during 2017. However, highest boron content in leaf was observed under treatment T_7 i.e PRD $_{75\ \%\ ETc}$ + F (19.84 ppm), whereas, lowest leaf boron content was recorded in T_{10} i.e no irrigation (13.83 ppm). Similar data was recorded, during second year of experimental study. On the basis of pooled data also same results were observed and maximum boron content (20.00 ppm) was recorded under T_7 i.e PRD $_{75\ \%\ ETc}$ + F.

4.3.10 Proline

Proline content of mango leaves as recorded under various treatments for two consecutive years (2017 and 2018) shown in Table 18 can be interpreted as that during 2017 highest proline content of 36.20 μg g^{-1} FW was recorded under no irrigation i.e T_{10} followed by 29.42 μg g^{-1} FW in plants treated with T_5 i.e PRD 50% ETc + F as compared to 19.60 μg g^{-1} FW in treatment T_6 (RDI $_{75\ \%\ ETc}$ + F) which is significantly low then all other treatments. However, it was observed that proline content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (24.84 μg g^{-1} FW), T_3 i.e PRD $_{75\ \%\ ETc}$ (25.13 μg g^{-1} FW), T_4 i.e RDI $_{50\ \%\ ETc}$ (28.29 μg g^{-1} FW) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (29.42 μg g^{-1} FW) as compared to 100 per cent ETc i.e T_1(23.09 μg g^{-1} FW) during 2017. The proline content during 2018 also, followed the similar trend as in first year of experimental study. On the basis of pooled data also it was observed that maximum proline content of 36.21 μg g^{-1} FW was attained by the plants with no irrigation i.e T_{10}, while minimum leaf proline content of 19.61 μg g^{-1} FW was attained under T_6 (RDI $_{75\ \%\ ETc}$ + F). However, proline content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (24.85 μg g^{-1} FW), T_3 i.e PRD $_{75\ \%\ ETc}$ (25.14 μg g^{-1} FW), T_4 i.e RDI $_{50\ \%\ ETc}$ (28.30 μg g^{-1} FW) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (29.43 μg g^{-1} FW) as compared to 100 per cent ETc i.e T_1 (23.10 μg g^{-1} FW). Pooled data also recorded similar pattern.

4.3.11 Pectinmethylesterase

Data pertaining to the activity of hydrolysing enzyme pectinmethylesterase under various treatments for the two consecutive years (2017 and 2018) has been tabulated in Table 18. Close observation of data reveals that during 2017, pectinmethyl esterase recorded maximum activity of 185.2 μg galacturonic acid min^{-1} g^{-1} FW under treatment T_{10} (no irrigation), whereas, under T_8 i.e. RDI $_{50\ \%\ ETc}$ + F minimum (86.6 μg galacturonic acid min^{-1} g^{-1} FW) pectinmethyl esterase activity was recorded. However, it was observed that pectinmethyl esterase activity was lower in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (155.2 μg galacturonic acid min^{-1} g^{-1} FW), T_3 PRD $_{75\ \%\ ETc}$ (155.2 μg galacturonic acid min^{-1} g^{-1} FW), T_4 i.e RDI $_{50\ \%\ ETc}$ (136.6 μg galacturonic acid min^{-1} g^{-1} FW) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (145.0 μg galacturonic acid min^{-1} g^{-1} FW) as compared to 100 per cent ETc i.e T_1(171.2 μg galacturonic acid min^{-1} g^{-1} FW) during 2017. Similarly, during 2018 maximum pectinmethyl esterase activity (179.2 μg galacturonic acid $min^{-1}g^{-1}$ FW) was obtained under treatment T_{10} (no irrigation), whereas, under treatment T_6 i.e. RDI $_{75\ \%\ ETc}$ + F (82.6 μg galacturonic acid $min^{-1}g^{-1}$ FW) minimum pectinmethyl esterase activity was recorded. However, it was observed that pectinmethyl esterase activity was lower in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$ (142.8 μg galacturonic acid min^{-1} g^{-1} FW), T_3 i.e PRD $_{75\ \%\ ETc}$ (147.2 μg galacturonic acid min^{-1} g^{-1} FW), T_4 i.e RDI $_{50\ \%\ ETc}$ (134.6 μg min^{-1} g^{-1} FW) and in T_5 i.e PRD $_{50\ \%\ ETc}$ (138.6 μg min^{-1} g^{-1}

Table 17: Effect of different irrigation regimes and fertigation on leaf boron (ppm) of mango cv. Dashehari

	Boron (ppm)		
Treatment	**2017**	**2018**	**Pooled**
T_1: 100% ETc	14.09^{e}	14.26^{cd}	14.17^{e}
T_2: RDI 75% ETc evenly applied under the canopy	16.30^{c}	16.42^{b}	16.36^{c}
T_3: PRD 75% ETc applied to alternating sides of the root system	16.58^{c}	16.75^{b}	16.66^{c}
T_4: RDI 50% ETc evenly applied under the canopy	15.28^{d}	15.43^{bc}	15.35^{d}
T_5: PRD 50% ETc applied to alternating sides of the root system	15.69^{cd}	15.88^{b}	15.78^{cd}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	19.43^{ab}	19.56^{a}	19.49^{ab}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	19.84^{a}	20.16^{a}	20.00^{a}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	18.71^{b}	18.87^{a}	18.79^{b}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	19.08^{ab}	19.21^{a}	19.14^{ab}
T_{10}: No Irrigation	13.83^{e}	13.94^{d}	13.88^{e}

Table 18: Effect of different irrigation regimes and fertigation on proline ((µg g–1 FW) and PME ((µg galacturonic acid /min/gFW)) of mango cv. Dashehari

	Proline (µg g–1 FW)			PME (µg galacturonic acid /min/gFW)		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	23.09^{e}	23.12^{d}	23.10^{e}	171.2^{b}	161.4^{b}	166.3^{b}
T_2: RDI 75% ETc evenly applied under the canopy	24.84^{d}	24.87^{c}	24.85^{d}	155.2^{c}	142.8^{cd}	149^{c}
T_3: PRD 75% ETc applied to alternating sides of the root system	25.13^{d}	25.16^{c}	25.14^{d}	155.2^{c}	147.2^{c}	151.2^{c}
T_4: RDI 50% ETc evenly applied under the canopy	28.29^{c}	28.32^{b}	28.30^{c}	136.6e	134.6^{d}	135.6^{d}
T_5: PRD 50% ETc applied to alternating sides of the root system	29.42^{b}	29.45^{b}	29.43^{b}	145.0^{d}	138.6^{cd}	141.8^{d}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	19.60^{h}	19.63^{f}	19.61^{i}	112.6^{g}	102.6^{f}	107.6^{f}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	20.34^{gh}	20.37^{f}	20.35^{h}	128.6^{f}	114.6^{e}	121.6^{e}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	21.03^{g}	21.06^{ef}	21.07^{g}	86.6^{i}	82.6^{g}	84.6^{h}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	22.15^{f}	22.18^{de}	22.16^{f}	96.6^{h}	92.6^{fg}	94.6^{g}
T_{10}: No Irrigation	36.20^{a}	36.23^{a}	36.21^{a}	185.2^{a}	179.2^{a}	182.2^{a}

FW) as compared to 100 per cent ETc i.e T_1(161.4 µg galacturonic acid min^{-1} g^{-1} FW) during 2018. On the basis of pooled similar pattern was recorded.

4.4 Effect of deficit irrigation on fruiting characteristics of mango

Data related to yield attributes like yield, per cent fruit set, per cent fruit drop and number of fruits per tree have been explained under following subheads.

4.4.1 Yield

Perusal of the data presented in Table 19 revealed that mango yield (kg $plant^{-1}$) was significantly affected by different irrigation and fetigation treatments during both the years of 2017 and 2018. Although treatment T_1 (100% ETc) showed improvement in yield in comparison to T_{10} (rainfed), but was below par than T6, T7, T8 and T9. However, the maximum fruit yield of 47.02 and 97.11 kg/tree was observed with treatment T_7 (PRD $_{75\%\ ETc}$ + fertigation) during 2017 and 2018, respectively; while during the corresponding years, a minimum fruit yield of 19.63 and 60.32 kg/tree was noted under treatment T_{10} (i.e. rainfed condition). As such, treatment T_7 exhibited 61.08 and 140% increase in mango yield during 2017 and 26.36 and 61.0% during 2018 over T_1 (100% ETc) and T_{10} (rainfed), respectively.

The average yields (pooled of 2017 & 2018) of water saving irrigations treatments *viz*. T_3 (PRD $_{75\%\ ETc}$), T_2 (RDI $_{75\%\ ETc}$), T_5 (PRD $_{50\%\ ETc}$) and T_4 (RDI $_{50\%\ ETc}$) were 57.34, 55.76, 50.33, and 48.95 kg/plant, respectively. The effect was more pronounced when these deficit irrigations were applied in conjunction with fertigation T_7 (PRD $_{75\%\ ETc}$ +F), T_6 (RDI $_{75\%\ ETc}$ + F), T_9 (PRD $_{50\%\ ETc}$ + F) and T_8 (RDI $_{50\%\ ETc}$ + F) were 72.06, 68.14, 65.00, and 60.38 kg/plant, respectively, as compared to their sole application. Further, the yield difference was significant within the treatments of PRD_{75} with fertigation and PRD $_{50\%\ ETc}$ with fertigation (9.8% decrease in yield) and it does so also within RDI $_{75\%\ ETc}$ with fertigation and RDI_{50} with fertigation (12.2% decrease in yield). The mango yield also tends to differ significantly among the treatments of PRD $_{50\%\ ETc}$ and RDI $_{50\%\ ETc}$, and more so when they are supplemented with fertigation.

4.4.2 Number of fruits/tree

A perusal of data presented in Table 19 with regard to effect of different irrigation regimes on number of mango fruits during 2017 revealed that the treatment T_7 of partial root zone drying irrigation (PRD-irrigation) at 75% ETc (in combination with fertigation registered more number of fruits per tree (227/tree) and differ siginificantly than its counterpart of T_6 i.e. regulated deficit irrigation (RDI-irrigation) at 75% ETc along with fertigation (218/tree). At 75% ET_C, the T_3 (PRD-irrigation) and T_2 (RDI $_{75\%\ ETc}$) which were devoid of fertigation, also exhibited significant differences with respective number of fruits as 182/tree and 179/tree. The observed number of fruits was 202 and 189/tree with T_9 (PRD $_{50\%\ ETc}$ + fertigation) and T_8 (RDI $_{50\%\ ETc}$ + fertigation), respectively; while T_5 (PRD $_{50\%\ ETc}$) and T_4 (RDI $_{50\%\ ETc}$) with corresponding 157 and 155 fruits / tree differed significantly. Drip irrigation to replenish 100% ETc (T_1) registered only 164 fruit/tree, and the lowest number of fruits of 124/ tree was observed with no irrigation (i.e. rainfed) treatment (T_{10}).

The findings of 2018 suggests that the treatment T_7 of partial root zone drying irrigation (PRD-irrigation) at 75% ETc (in combination with fertigation registered more number of fruits per tree (466/tree) and differ siginificantly than its counterpart of T_6 i.e. regulated deficit irrigation (RDI-irrigation) at 75% ETc along with fertigation (461/tree). At 75% ET_C, the T_3 (PRD-irrigation) and T_2 (RDI-irrigation) which were devoid of fertigation, also exhibited significant differences with respective number of fruits as 422/tree and 418/tree. The observed number of fruits was 454 and 432/tree with T_9 (PRD $_{50\%\ ETc}$ + fertigation) and T_8 (RD $_{50\%\ ETc}$ + fertigation), respectively; while T_5 (PRD $_{50\%\ ETc}$) and T_4 (RDI $_{50\%\ ETc}$) with corresponding 399 and 392 fruits / tree differed significantly. Drip irrigation to replenish 100% ETc (T_1) registered only 413 fruit/tree, and the lowest number of fruits of 343 / tree was observed with no irrigation (i.e. rainfed) treatment (T_{10}) .

The statistical pooled data of 2017 and 2018 reflects the sequence of treatments, in terms of fruit number/tree, followed the order: PRD_{75} (fertigation) (346.5) > RDI $_{75\%\ ETc}$ (fertigation) (339.5) > PRD $_{75\%\ ETc}$ (302.0) > RDI $_{75\%\ ETc}$ (298.5) > PRD $_{50\%\ ETc}$ (fertigation) (328.0) > RDI $_{50\%\ ETc}$ (fertigation) (310.5) > PRD $_{50\%\ ETc}$ (278.0) > RDI $_{50\%\ ETc}$ (273.5) > drip irrigation at 100% ET_C (288.5) > Rainfed (266.0).

4.4.3 Fruit set

Data on Fruit set in mango cv. Dashehari recorded during present investigation presented in Table 20 revealed that per cent fruit set was significantly affected by different treatments during 2017 as well as 2018. During both the years, it was observed that fruit set was higher in plants subjected to deficit irrigation at 75%

Table 19: Effect of different irrigation regimes and fertigation on yield ((kg/tree) and fruit/tree of mango cv. Dashehari

	Yield (kg/tree)			Fruits/tree		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	29.19^{f}	76.85^{e}	53.02^{g}	164^{g}	413^{g}	288.5^{g}
T_2: RDI 75% ETc evenly applied under the canopy	32.62^{e}	78.90^{d}	55.76^{f}	179^{f}	418^{f}	298.5^{f}
T_3: PRD 75% ETc applied to alternating sides of the root system	34.24^{e}	80.45^{c}	57.34^{e}	182^{e}	422^{e}	302.0^{e}
T_4: RDI 50% ETc evenly applied under the canopy	26.18^{g}	71.73^{f}	48.95^{i}	155^{i}	392^{i}	273.5^{i}
T_5: PRD 50% ETc applied to alternating sides of the root system	27.24^{g}	73.42^{f}	50.33^{h}	157^{h}	399^{h}	278.0^{h}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	43.86^{b}	92.42^{a}	68.14^{b}	218^{b}	461^{b}	339.5^{b}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	47.02^{a}	97.11^{a}	72.06^{a}	227^{a}	466^{a}	346.5^{a}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	36.57^{d}	84.20^{b}	60.38^{d}	189^{d}	432^{d}	310.5^{d}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	39.88^{c}	90.12^{b}	65.00^{c}	202^{c}	454^{c}	328.0^{c}
T_{10}: No Irrigation	19.63^{h}	60.32^{g}	43.47^{j}	124^{j}	343^{j}	266.0^{j}

Table 20: Effect of different irrigation regimes and fertigation on fruit set (%) and fruits drop (%) of mango cv. Dashehari

	Fruit set (%)			**Fruit drop (%)**		
Treatment	**2017**	**2018**	**Pooled**	**2017**	**2018**	**Pooled**
T_1: 100% ETc	0.93^{bc}	0.94^{bc}	0.93^{bc}	83.86^{c}	84.97^{abc}	84.41^{bc}
T_2: RDI 75% ETc evenly applied under the canopy	0.92^{c}	0.93^{c}	0.92^{c}	83.43^{cd}	84.21^{abcd}	83.82^{cd}
T_3: PRD 75% ETc applied to alternating sides of the root system	0.92^{c}	0.93^{c}	0.92^{c}	82.37^{d}	83.16^{bcde}	82.76^{de}
T_4: RDI 50% ETc evenly applied under the canopy	0.89^{d}	0.91^{d}	0.90^{d}	85.32^{ab}	86.07^{ab}	85.69^{ab}
T_5: PRD 50% ETc applied to alternating sides of the root system	0.90^{d}	0.91^{d}	0.90^{d}	84.63^{bc}	85.81^{ab}	85.22^{abc}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.95^{a}	0.97^{a}	0.96^{a}	78.86^{f}	79.98^{ef}	79.42^{gh}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.96^{a}	0.98^{a}	0.97^{a}	78.59^{f}	79.60^{f}	79.09^{h}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.94^{ab}	0.95^{bc}	0.94^{b}	80.92^{e}	81.73^{cdef}	81.32^{ef}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.94^{ab}	0.94^{b}	0.94^{b}	80.48^{e}	81.32^{def}	80.90^{fg}
T_{10}: No Irrigation	0.89^{d}	0.90^{d}	0.89^{e}	86.24^{a}	87.13^{a}	86.68^{a}

ETc both in RDI and PRD i.e T_2 (RDI $_{75\ \%\ ETc}$) 0.92 per cent and 0.93 per cent (2017 and 2018) respectively, T_3 (PRD $_{75\ \%\ ETc}$) 0.92 per cent and 0.93 per cent during both the years 2017 and 2018, respectively, whereas fruit set was lower when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) (0.89 per cent and 0.91 per cent 2017 and 2018, respectively) and in T_5 i.e (PRD $_{50\ \%\ ETc}$) 0.90 per cent and 0.91 per cent, during both the years 2017 as well as 2018, respectively.

However, in case of full irrigation i.e. 100 % ETc (T_1) (0.93 per cent and 0.94 per cent) fruit set was significantly higher as compared to plants treated with deficit irrigation at 50% ETc T_3 and T_4 during 2017 and 2018, respectively. Highest fruit set (0.96 percent and 0.98 per cent 2017 and 2018, respectively) was recorded when deficit irrigation was supplemented with fertigation under treatment T_7 PRD $_{75\ \%\ ETc}$ + F. However, lowest fruit set (0.89 per cent and 0.90 per cent during both the years 2017 and 2018, respectively) was recorded under no irrigation (T_{10}). A similar pattern was observed in the pooled data of fruit set where pooled fruit set was significantly higher in T_7 (0.97 per cent) as compared to other treatments.

4.4.4 Per cent fruit drop

A perusal of data presented in Table 20 with regard to effect of different irrigation regimes on percent fruit set of mango fruits during 2017 revealed that the treatment T_7 of partial root zone drying irrigation (PRD-irrigation) at 75% ETc (in combination with fertigation registered less number of fruits drop (78.59 per cent). The observed percent of fruit drop was 80.48 per cent and 80.92 per cent with T_9 (PRD $_{50\%\ ETc}$ + fertigation) and T_8 (RDI $_{50\%\ ETc}$ + fertigation), respectively; while T_5 (PRD $_{50\%\ ETc}$) and T_4 (RDI $_{50\%\ ETc}$) with corresponding 84.63 per cent and 85.32 per cent. Drip irrigation to replenish 100% ETc (T_1) registered only 83.86 per cent, and the highest per cent fruit drop of 86.24 per cent was observed with no irrigation (i.e. rainfed) treatment (T_{10}).

The findings of 2018 suggests that the treatment T_7 of partial root zone drying irrigation (PRD-irrigation) at 75% ETc (in combination with fertigation registered less number of fruit drop (79.60 per cent) and were not differ siginificantly than its counterpart of T_6 i.e. regulated deficit irrigation (RDI-irrigation) at 75% ETc along with fertigation (79.98 per cent). The observed percent of fruit drop was 81.32 per cent and 81.73 per cent with T_9 (PRD $_{50\%\ ETc}$ + fertigation) and T_8 (RDI_{50} +

fertigation), respectively; while T_5 (PRD $_{50\%\ ETc}$) and T_4 (RDI $_{50\%\ ETc}$) with corresponding 85.81 per cent and 86.07 per cent. Drip irrigation to replenish 100% ETc (T_1) registered only 84.97 per cent, and the highest per cent fruit drop of 87.13 per cent was observed with no irrigation (i.e. rainfed) treatment (T_{10}). A similar pattern was observed in the pooled data of fruit drop.

4.4.5 Grading

Perusal of the data presented in Figure 3 reveals that all the mango fruits harvested from all the treatments were in same group 200-350 gram. During first year of study (2017), when treatments were compared the maximum fruit weight (206.45 g) was recorded in T_7 i.e. PRD $_{75\ \%\ ETc}$ + F followed by (200.36 g) in treatment T_7 PRD $_{75\%\ ETc}$ + F and minimum (157.76 g) was recorded in treatment T_{10} (no irrigation). Similarly during second year of experimental study (2018), maximum fruit weight (208.29 g) was observed in T_7 i.e. PRD $_{75\ \%\ ETc}$ + F followed by (200.52 g) treatment T_6 RDI $_{75\ \%\ ETc}$ + F and minimum fruit weight (175.44 g) was recorded in treatment T_{10} (no irrigation). Further in case of pooled data maximum pooled fruit weight (207.37 g) was recorded in T_7 i.e. PRD $_{75\%\ ETc}$ + F whereas minimum fruit weight (166.60 g) was recorded under treatment T_{10} (no irrigation).

4.5 Irrigation water productivity of mango

4.5.1 Water use efficiency

The water productivity for different irrigation treatments was computed from fruit yield and irrigation water applied (Table 21 and 22). The minimum water productivity of the order of 2.87 kg m^{-3} and 10.15 kg m^{-3} was recorded under rainfed grown mango during 2017 and 2018, respectively. Among the irrigation treatments imposed, during both the years of 2017 and 2018, the 100% ETc replenishment resulted in lowest water use efficiency of 4.65 kg m^{-3} (in 2017) and 11.18 kg m^{-3} (in 2018). However, with the successive increase of levels of deficit irrigations, the water productivity tends to increase significantly. The water use efficiency value registered with T_9, T_8, T_7, T_6, T_5, T_4, T_3 and T_2 were of the order of 12.70, 11.64, 9.98, 9.31, 8.67, 8.34, 7.27 and 6.92 kg m^{-3} during the year 2017 (off-year); while the corresponding values were 26.27, 24.54, 18.85, 17.94, 21.40, 20.91, 15.62, and 15.32 kg m^{-3} during 2018 (on year).

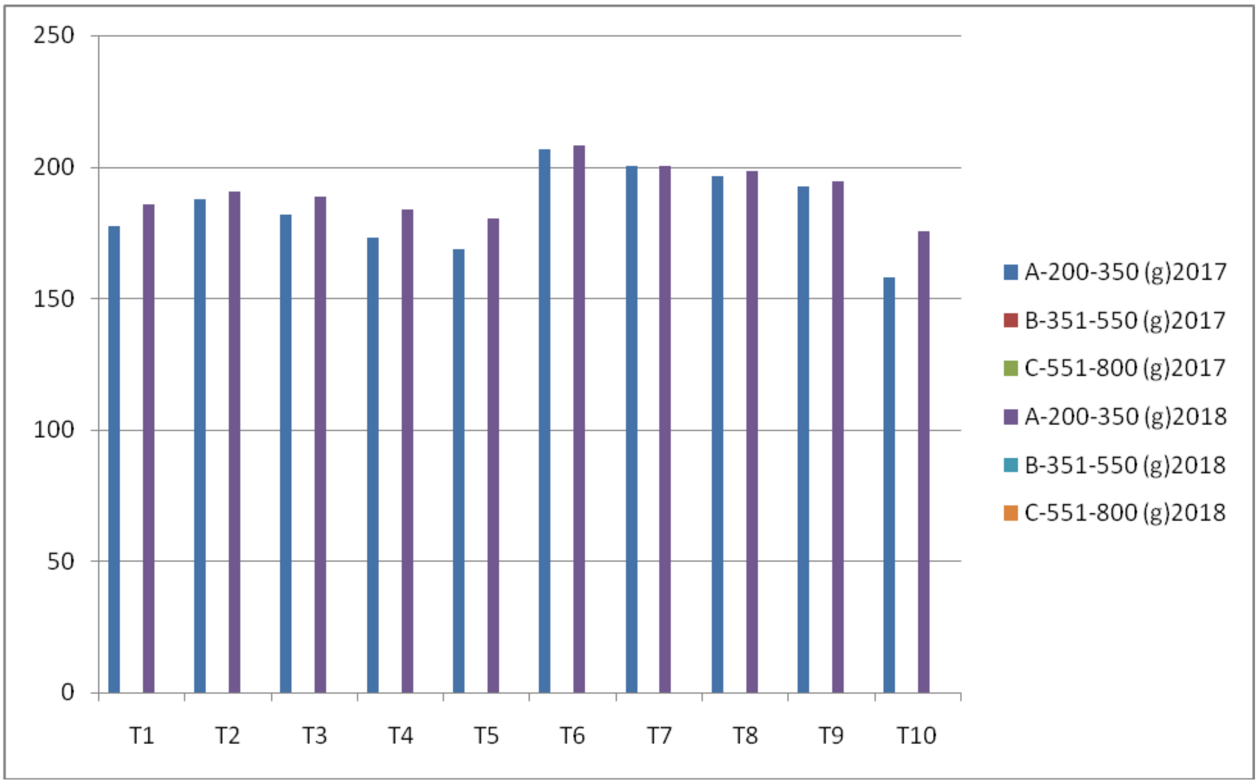


Figure 3: Grade wise yield of mango under different treatments during 2017 and 2018.

21: Effect of different irrigation regimes on water use efficiency 2017

	Yield (kg/tree)	**Irrigation water applied (m^3/plant)**	**Water use efficiency (kg/m^3)**
Treatment			
T_1: 100% ETc	29.19[f]	6.28	4.65[i]
T_2: RDI 75% ETc evenly applied under the canopy	32.62[e]	4.71	6.92[h]
T_3: PRD 75% ETc applied to alternating sides of the root system	34.24[e]	4.71	7.27[g]
T_4: RDI 50% ETc evenly applied under the canopy	26.18[g]	3.14	8.34[f]
T_5: PRD 50% ETc applied to alternating sides of the root system	27.24[g]	3.14	8.67[e]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	43.86[b]	4.71	9.31[d]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	47.02[a]	4.71	9.98[c]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	36.57[d]	3.14	11.64[b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	39.88[c]	3.14	12.70[a]
T_{10}: No Irrigation	19.63[h]	6.82	2.87[j]

Table 22: Effect of different irrigation regimes on water use efficiency 2018

	Yield (kg/tree)	**Irrigation water applied (m^3/plant)**	**Water use efficiency (kg/m^3)**
Treatment			
T_1: 100% ETc	76.85[e]	6.87	11.18[i]
T_2: RDI 75% ETc evenly applied under the canopy	78.90[d]	5.15	15.32[h]
T_3: PRD 75% ETc applied to alternating sides of the root system	80.45[c]	5.15	15.62[g]
T_4: RDI 50% ETc evenly applied under the canopy	71.73[f]	3.43	20.91[d]
T_5: PRD 50% ETc applied to alternating sides of the root system	73.42[f]	3.43	21.40[c]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	92.42[a]	5.15	17.94[f]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	97.11[a]	5.15	18.85[e]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	84.20[b]	3.43	24.54[b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	90.12[b]	3.43	26.27[a]
T_{10}: No Irrigation	60.32[g]	5.94	10.15[j]

Among the PRD_{75} irrigations, significantly differed water productivity value of 9.98 and 7.27 kg m^{-3} registered with T_7 (PRD at 75% ETc with fertigation) and T_3 (PRD at 75% ETc), respectively. The result suggested that there was 37.2% improvement in water productivity when PRD_{75} was imposed along with fertigation as compared to without fertigation. Similarly, there was significant variation in WP value of 9.31 and 6.92 kg m^{-3} for corresponding treatments of T_6 (RDI $_{75\%\ ETc}$ + ferigation) and T_2 (RDI $_{75\%\ ETc}$). The fertigation showed 34.5% improvement in water productivity than that of without fertigation. With further enhancement of stress, i.e. at PRD $_{50\%\ ETc}$ irrigation, with or without fertigation, the water productivity value stands as 12.70 kg m^{-3} (with T_9) and 8.67 kg m^{-3} (with T_5) correspondingly. The result suggested that there was 46.4% improvement in water productivity with fertigation as compared to without fertigation. Similarly, T_8 (RDI $_{50\%\ ETc}$ with ferigation) and T_4 (RDI $_{50\%\ ETc}$) recorded the water productivity of 11.64 and 8.34 kg per meter cube respectively. It shows 39.5 % improvement in water productivity with fertigation then that of with no fertigation. The rainfed mango crop showed the water productivity of 2.87 kg m^{-3} water which is indicative of the fact that lower yield with less amount of moisture availability resulted in lower value of water productivity.

During 2018 the PRD_{75} irrigations, significantly differed water productivity value of 18.85 and 15.62 kg m^{-3} registered with T_7 (PRD at 75% ETc with fertigation) and T_3 (PRD at 75% ETc), respectively. The result suggested that there was 20.6 % improvement in water productivity when PRD_{75} was imposed along with fertigation as compared to without fertigation. Similarly, there was significant variation in water use efficiency value of 17.94 and 15.32 kg m^{-3} for corresponding treatments of T_6 (RDI $_{75\%\ ETc}$ + ferigation) and T_2 (RDI $_{75\%\ ETc}$). The fertigation showed 17.1% improvement in water productivity than that of without fertigation. With further enhancement of stress, i.e. at PRD $_{50\%\ ETc}$ irrigation, with or without fertigation, the water productivity value stands as 26.27 kg m^{-3} (with T_9) and 21.40 kg m^{-3} (with T_5) correspondingly. The result suggested that there was 22.7% improvement in water productivity with fertigation as compared to without fertigation. Similarly, T_8 (RDI $_{50\%\ ETc}$ with ferigation) and T_4 (RDI $_{50\%\ ETc}$) recorded the water productivity of 24.54 and 20.91 kg m^{-3} respectively. It shows 17.3% improvement in water productivity with fertigation then that of with no fertigation. The rainfed mango crop showed the water productivity of 10.15 kg m^{-3}.

4.6 Soil and plant water characteristics

4.6.1 Soil moisture

The data presented in Table 23 and 24 revealed that the average soil moisture during first year (2017) at different depths during the crop growth period of mango cv. Dashehari was found to be maximum (20.2) during 2017 under treatment T_1 (100 % ETc) at 0-20 cm depth whereas it was found minimum at T_{10} (no irrigation) i.e 16.4. During 2017, soil moisture was higher in plants at 0-20 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (18.3 and 18.4) and in T_3, T_7 (17.8 and 17.8) than 50% ETc both in RDI and PRD i.e T_4,T_8 (16.8 and 16.9) and in T_5 ,T_9 (17.0 and 17.0) during 2017.

At 20-40 cm of soil depth the soil moisture was found maximum (22.4) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 16.8 during 2017. During 2017, soil moisture was higher in plants at 20-40 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (19.1 and 19.2) and in T_3, T_7 (18.9 and 18.9) than 50% ETc both in RDI and PRD i.e T_4,T_8 (17.2 and 17.3) and in T_5 ,T_9 (17.5 and 17.5) during 2017.

At 40-60 cm of soil depth the soil moisture was found maximum (22.8) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 17.3 during 2017. During 2017, soil moisture was higher in plants at 40-60 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (20.1 and 20.1) and in T_3, T_7 (20.3 and 20.4) than 50% ETc both in RDI and PRD i.e T_4,T_8 (18.2 and 18.3) and in T_5 ,T_9 (18.4 and 18.4) during 2017.

At 40-60 cm of soil depth the soil moisture was found maximum (22.8) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 17.3. During 2017, soil moisture was higher in plants at 40-60 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (20.1 and 20.1) and in T_3, T_7 (20.3 and 20.4) than 50% ETc both in RDI and PRD i.e T_4,T_8 (18.2 and 18.3) during 2017 and in T_5 ,T_9 (18.4 and 18.4).

At 60-100 cm of soil depth the soil moisture was found maximum (23.1) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 18.2. During 2017, soil moisture was higher in plants at 60-100 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2,

Table 23: Effect of different irrigation regime on soil moisture (%) during crop growth period of mango cv. Dashehari 2017

Different depths	0-20cm	20-40cm	40-60cm	60-100cm
Treatment				
T_1: 100% ETc	20.2^{a}	22.4^{a}	22.8^{a}	23.1^{a}
T_2: RDI 75% ETc evenly applied under the canopy	18.3^{ab}	19.1^{b}	20.1^{b}	20.3^{b}
T_3: PRD 75% ETc applied to alternating sides of the root system	17.8^{ab}	18.9^{b}	20.3^{b}	20.5^{b}
T_4: RDI 50% ETc evenly applied under the canopy	16.8^{ab}	17.2^{b}	18.2^{c}	20.2^{b}
T_5: PRD 50% ETc applied to alternating sides of the root system	17.0^{ab}	17.5^{b}	18.4^{c}	18.8^{c}
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	18.4^{ab}	19.2^{b}	20.1^{b}	20.4^{b}
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	17.8^{ab}	18.9^{b}	20.4^{b}	20.5^{b}
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	16.9^{ab}	17.3^{b}	18.3^{c}	20.3^{b}
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	17.0^{ab}	17.5^{b}	18.4^{c}	18.8^{c}
T_{10}: No Irrigation	16.4^{b}	16.8^{b}	17.3^{c}	18.2^{c}

Table 24: Effect of different irrigation regime on soil moisture (%) during crop growth period of mango cv. Dashehari 2018

Different depths	**0-20cm**	**20-40cm**	**40-60cm**	**60-100cm**
Treatment				
T_1: 100% ETc	22.2[a]	22.8[a]	23.4[a]	24.4[a]
T_2: RDI 75% ETc evenly applied under the canopy	17.6[b]	17.2[e]	18.7[e]	21.3[c]
T_3: PRD 75% ETc applied to alternating sides of the root system	17.4[b]	17.6[cde]	19.2[de]	20.8[c]
T_4: RDI 50% ETc evenly applied under the canopy	14.4[b]	15.6[b]	17.6[bc]	17.2[c]
T_5: PRD 50% ETc applied to alternating sides of the root system	14.0[b]	15.9[bcd]	17.9[b]	17.9[b]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	17.4[b]	17.6[cde]	18.6[ef]	20.4[c]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	17.0[b]	17.4[de]	18.4[ef]	19.0[d]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	14.4[b]	15.7[b]	17.7[bc]	17.2[c]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	14.1[b]	15.9[bcd]	17.9[b]	17.9[b]
T_{10}: No Irrigation	15.4[c]	17.3[de]	17.6[f]	18.8[d]

T_6 (20.3 and 20.4) and in T_3, T_7 (20.5 and 20.5) than 50% ETc both in RDI and PRD i.e T_4,T_8 (20.2 and 20.3) during 2017 and in T_5 ,T_9 (18.8 and 18.8).

During second year of investigation (2018) at different depths during the crop growth period of mango cv. Dashehari was found to be maximum (22.2) during 2018 under treatment T_1 (100 % ETc) at 0-20 cm depth whereas it was found minimum at T_{10} (no irrigation) i.e 15.4. During 2018, soil moisture was higher in plants at 0-20 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (17.6 and 17.4) and in T_3, T_7 (17.4 and 17.0) than 50% ETc both in RDI and PRD i.e T_4,T_8 (14.4 and 14.4) and in T_5 ,T_9 (14.0 and 14.1) during 2018.

At 20-40 cm of soil depth the soil moisture was found maximum (22.8) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 17.3 during 2018. During 2018, soil moisture was higher in plants at 20-40 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (17.2 and 17.6) and in T_3, T_7 (17.6 and 17.4) than 50% ETc both in RDI and PRD i.e T_4,T_8 (15.6 and 15.7) and in T_5 ,T_9 (15.9 and 15.9) during 2018.

At 40-60 cm of soil depth the soil moisture was found maximum (23.4) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 17.6 during 2018. During 2018, soil moisture was higher in plants at 40-60 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (18.7 and 18.6) and in T_3, T_7 (19.2 and 18.4) than 50% ETc both in RDI and PRD i.e T_4,T_8 (17.6 and 17.7) and in T_5 ,T_9 (17.9 and 17.9) during 2018.

At 60-100 cm of soil depth the soil moisture was found maximum (24.4) under treatment T_1 (100 % ETc) whereas it was found minimum at T_{10} (no irrigation) i.e 18.8 during 2018. During 2018, soil moisture was higher in plants at 60-100 cm depth when deficit irrigation and fertigation were given at 75% ETc both in RDI and PRD i.e T_2, T_6 (21.3 and 20.4) and in T_3, T_7 (20.8 and 19.0) than 50% ETc both in RDI and PRD i.e T_4,T_8 (17.2 and 17.2) and in T_5 ,T_9 (17.9 and 17.9) during 2018.

4.6.2 Soil water potential

Data pertaining to the soil water potential of mango recorded with respect to various irrigation treatments for the two consecutive years (2017 and 2018) are depicted in Table-25 and Table-26. The data revealed that the average soil water potential at 20-40 cm of soil depth in month march during first (2017) year of investigation was found maximum under treatment T_{10} (no irrigation) 52 kPa whereas it was found minimum at T_1 (100 %ETc) i.e 25 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 42 kPa and 35 kPa, respectively. Similarly, for PRD-irrigation, with 50%ETc and 75% ETc, the respective the soil water potential values were 43 kPa and 35 kPa, the difference was statistically significant whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 42 kPa and 35 kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc +F and 75% ETc +F, the respective the soil water potential values were 43 kPa and 35 kPa, respectively. However, soil water potential at 60 cm of soil depth in month of march was found maximum under treatment T_{10} (no irrigation) 60kPa whereas it was found minimum at T_1 (100 %ETc) i.e 45 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 55kPa and 50kPa, respectively. Similarly, for PRD-irrigation, with 50%ETc and 75% ETc, the respective the soil water potential values were 56 kPa and 50 kPa, the difference was statistically significant whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 56 kPa and 50 kPa, respectively. Similarly, for PRD-irrigation, with 50%ETc +F and 75% ETc +F, the respective the soil water potential values were 56 kPa and 51 kPa, respectively.

In month of april, soil water potential at 20-40 cm of depth was found maximum under treatment T_{10} (no irrigation) 54 kPa whereas it was found minimum at T_1 (100 %ETc) i.e 23 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 42 kPa and 35 kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc and 75% ETc, the respective the soil water potential values were 43 kPa and 37 kPa whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 42 kPa and 36 kPa, respectively. Similarly, for PRD-irrigation, with 50%ETc +F and 75% ETc +F, the respective the soil water potential values were 43 kPa and 37 kPa, respectively. Similarly, at 60 cm of soil

Table 25: Effect of different irrigation regime on soil water potential (kPa) during crop growth period of mango cv. Dashehari 2017

Different depths	20 to 40cm	60cm	20 to 40cm	60cm	20 to 40cm	60cm
Treatment	**March**		**April**		**May**	
T_1: 100% ETc	25 kPa [d]	45 kPa [d]	23 kPa [e]	45 kPa [e]	25 kPa [d]	45 kPa [d]
T_2: RDI 75% ETc evenly applied under the canopy	35 kPa [c]	50 kPa [c]	35 kPa [d]	50 kPa [d]	35 kPa [c]	50 kPa [c]
T_3: PRD 75% ETc applied to alternating sides of the root system	35 kPa [c]	50 kPa [c]	35 kPa [d]	50 kPa [d]	35 kPa [c]	50 kPa [c]
T_4: RDI 50% ETc evenly applied under the canopy	42 kPa [b]	55 kPa [b]	42 kPa [c]	55 kPa [c]	42 kPa [b]	55 kPa [b]
T_5: PRD 50% ETc applied to alternating sides of the root system	43 kPa [b]	56 kPa [b]	43 kPa [b]	58 kPa [b]	43 kPa [b]	56 kPa [b]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	35 kPa [c]	50 kPa [c]	36 kPa [cd]	54 kPa [c]	35 kPa [c]	50 kPa [c]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	35 kPa [c]	51 kPa [c]	37 kPa [c]	51 kPa [d]	35 kPa [c]	51 kPa [c]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	42 kPa [b]	56 kPa [b]	42 kPa [b]	56 kPa [c]	42 kPa [b]	56 kPa [b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	43 kPa [b]	56 kPa [b]	43 kPa [b]	56 kPa [c]	43 kPa [b]	56 kPa [b]
T_{10}: No Irrigation	52 kPa [a]	60 kPa [a]	54 kPa [a]	62 kPa [a]	52 kPa [a]	60 kPa [a]

Table 26: Effect of different irrigation regime on soil water potential (kPa) during crop growth period of mango cv. Dashehari 2018

Different depths	20 to 40cm	60cm	20 to 40cm	60cm	20 to 40cm	60cm
Treatment	**March**		**April**		**May**	
T_1: 100% ETc	25 kPa [e]	45 kPa [e]	25 kPa [d]	45 kPa [e]	25 kPa [d]	45 kPa [e]
T_2: RDI 75% ETc evenly applied under the canopy	35 kPa [d]	54 kPa [c]	35 kPa [c]	54 kPa [c]	35 kPa [c]	50 kPa [d]
T_3: PRD 75% ETc applied to alternating sides of the root system	35 kPa [d]	51 kPa [d]	35 kPa [c]	51 kPa [d]	35 kPa [c]	50 kPa [d]
T_4: RDI 50% ETc evenly applied under the canopy	42 kPa [c]	55 kPa [c]	42 kPa [b]	55 kPa [b]	42 kPa [b]	55 kPa [b]
T_5: PRD 50% ETc applied to alternating sides of the root system	43 kPa [b]	56 kPa [bc]	43 kPa [b]	56 kPa [b]	43 kPa [b]	56 kPa [b]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	36 kPa [d]	50 kPa [d]	36 kPa [c]	50 kPa [c]	34 kPa [c]	50 kPa [d]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	35 kPa [d]	51 kPa [d]	35 kPa [c]	51 kPa [c]	35 kPa [c]	53 kPa [c]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	42 kPa [c]	57 kPa [b]	42 kPa [b]	57 kPa [b]	42 kPa [b]	56 kPa [b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	44 kPa [b]	56 kPa [b]	44 kPa [b]	56 kPa [b]	43 kPa [b]	56 kPa [b]
T_{10}: No Irrigation	52 kPa [a]	60 kPa [a]	52 kPa [a]	60 kPa [a]	54 kPa [a]	60 kPa [a]

depth in month march the soil water potential was found maximum under treatment T_{10} (no irrigation) 62 kPa whereas it was found minimum at T_1 (100 %ETc) i.e 45 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 55 kPa and 50kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc and 75% ETc, the respective the soil water potential values were 58 kPa and 50 kPa, respectively whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 56 kPa and 54 kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc + F and 75% ETc + F, the respective the soil water potential values were 56 kPa and 51 kPa, respectively.

During the month may, the average soil water potential at 20-40 cm depth was recorded maximum under treatment T_{10} (no irrigation) 52 kPa whereas it was found minimum at T_1 (100 %ETc) i.e 25 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 42 kPa and 35 kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc and 75% ETc, the respective the soil water potential values were 43 kPa and 35 kPa whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 42 kPa and 35 kPa, respectively. Similarly, for PRD-irrigation, with 50%ETc +F and 75% ETc +F, the respective the soil water potential values were 43 kPa and 35 kPa, respectively.

However, at 60 cm of soil depth in month of march the soil water potential was found maximum under treatment T_{10} (no irrigation) 60 kPa whereas it was found minimum at T_1 (100 % ETc) i.e 45 kPa. For RDI-irrigation, with successive increase in degree of deficit i.e 50% ETc to 75% ETc, the soil water potential tended to increase and the value recorded being 55 kPa and 50kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc and 75% ETc, the respective the soil water potential values were 56 kPa and 50 kPa, respectively whereas for RDI-irrigation with fertigation, with successive increase in degree of deficit i.e 50% ETc + F to 75% ETc +F, the soil water potential tended to increase and the value recorded being 56 kPa and 50 kPa, respectively. Similarly, for PRD-irrigation, with 50% ETc + F and 75% ETc + F, the respective the soil water potential values were 56 kPa and 51 kPa, respectively. However, similar pattern was observed during second year of investigation.

4.6.3 Leaf temperature

Data pertaining to the leaf temperature of mango recorded with respect to various irrigation treatments for the two consecutive years (2017 and 2018) are depicted in Table-27 and Table-28. During the first year of investigation average air temperature in month of March was 25.5^0C and leaf temperatures varied from 24.0 to 29.8^0C, with minimum value of 24.0^0C was registered by T_1 (100% ETc), while the maximum value of 29.8^0C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded being 26.8^0C and 27.8^0C, respectively. Similarly, for PRD-irrigation, with 75%ETc and 50% ETc, the respective leaf temperature values were 26.6^0C and 27.4^0C, the difference was statistically significant. In the month of April average air temperature was 33.6^0C and leaf temperatures varied from 32.8^0C to 36.5^0C, with minimum value of 32.8^0C was registered by T_1 (100% ETc), while the maximum value of 36.5^0C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded being 34.9^0C and 35.8^0C, respectively. Similarly, for PRD-irrigation, with 75%ETc and 50% ETc, the respective leaf temperature values were 34.7^0C and 35.8^0C. During the month of May average air temperature was 40.5^0C and canopy temperatures varied from 38.5^0C to 42.6^0C, with minimum value of 40.5^0C was registered by T_1 (100% ETc), while the maximum value of 42.6^0C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded being 39.8^0C and 40.4^0C, respectively. Similarly, for PRD-irrigation, with 75%ETc and 50% ETc, the respective leaf temperature values were 40.2^0C and 40.8^0C. During second year of experimental trial average air temperature in month of March was 28.2^0C and leaf temperatures varied from 27.8^0C to 31.5^0C, with minimum value of 27.8^0C was registered by T_1 (100% ETc), while the maximum value of 31.5^0C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded

Table 27: Effect of different irrigation regime on leaf temperature during crop growth period of mango cv. Dashehari 2017

Different depths	March 2017		April 2017		May 2017	
Treatment	**Air temp.**	**Leaf temp.**	**Air temp.**	**Leaf temp.**	**Air temp.**	**Leaf temp.**
T_1: 100% ETc	25.5	24.0[d]	33.6	32.8[d]	40.5	38.5[c]
T_2: RDI 75% ETc evenly applied under the canopy	25.5	26.8[bc]	33.6	34.9[bc]	40.5	39.8[b]
T_3: PRD 75% ETc applied to alternating sides of the root system	25.5	26.6[c]	33.6	34.7[c]	40.5	40.2[b]
T_4: RDI 50% ETc evenly applied under the canopy	25.5	27.8[b]	33.6	35.8[bc]	40.5	40.4[b]
T_5: PRD 50% ETc applied to alternating sides of the root system	25.5	27.4[b]	33.6	35.8[bc]	40.5	40.8[b]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	25.5	26.9[bc]	33.6	34.8[bc]	40.5	39.7[b]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	25.5	26.7[c]	33.6	34.7[c]	40.5	40.1[b]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	25.5	27.8[b]	33.6	35.9[b]	40.5	40.5[b]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	25.5	27.4[b]	33.6	35.9[b]	40.5	40.8[b]
T_{10}: No Irrigation	25.5	29.8[a]	33.6	36.5[a]	40.5	42.6[a]

Table 28: Effect of different irrigation regime on leaf temperature during crop growth period of mango cv. Dashehari 2018

Different depths	March 2018		April 2018		May 2018	
Treatment	**Air temp.**	**Leaf temp.**	**Air temp.**	**Leaf temp.**	**Air temp.**	**Leaf temp.**
T_1: 100% ETc	28.2	27.8[d]	35.4	34.2[c]	38.8	38.4[d]
T_2: RDI 75% ETc evenly applied under the canopy	28.2	29.8[bc]	35.4	37.3[b]	38.8	40.7[c]
T_3: PRD 75% ETc applied to alternating sides of the root system	28.2	29.7[c]	35.4	37.4[b]	38.8	40.6[bc]
T_4: RDI 50% ETc evenly applied under the canopy	28.2	30.4[bc]	35.4	38.2[ab]	38.8	41.6[bc]
T_5: PRD 50% ETc applied to alternating sides of the root system	28.2	30.6[bc]	35.4	38.4[ab]	38.8	41.2[bc]
T_6: RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	28.2	29.7[c]	35.4	37.3[b]	38.8	40.7[c]
T_7: PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	28.2	29.8[bc]	35.4	37.3[b]	38.8	40.7[bc]
T_8: RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	28.2	30.6[bc]	35.4	38.4[ab]	38.8	41.7[bc]
T_9: PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	28.2	30.7[b]	35.4	38.4[ab]	38.8	41.2[bc]
T_{10}: No Irrigation	28.2	31.5[a]	35.4	39.1[a]	38.8	42.8[a]

being 29.8^{0}C and 30.4^{0}C, respectively. Similarly, for PRD-irrigation, with 75%ETc and 50% ETc, the respective leaf temperature values were 29.7^{0}C and 30.6^{0}C. In the month of April average air temperature was 35.4^{0}C and canopy temperatures varied from 34.2^{0}C to 39.1^{0}C, with minimum value of 34.2^{0}C was registered by T_1 (100% ETc), while the maximum value of 39.1^{0}C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded being 37.3^{0}C and 38.2C, respectively. Similarly, for PRD-irrigation, with 75%ETc and 50% ETc, the respective leaf temperature values were 37.4^{0}C and 38.4^{0}C. During the month of May average air temperature was 38.8^{0}C and canopy temperatures varied from 38.4 ^{0}C to 42.8^{0}C, with minimum value of 38.8^{0}C was registered by T_1 (100% ETc), while the maximum value of 42.8^{0}C was witnessed by T_{10} (rainfed or no irrigation). For RDI-irrigation, with successive increase in degree of deficit i.e 75% ETc to 50% ETc, the leaf temperature also tended to increase and the value recorded being 40.7^{0}C and 41.6^{0}C, respectively. Similarly, for PRD-irrigation, with 75% ETc and 50% ETc, the respective leaf temperature values were 40.6^{0}C and 41.2^{0}C.

4.7 Economics

Benefit cost ratio as influenced by different irrigation and fertigation levels was calculated and is presented in Table 29, 30, 31 and 32. During both the years of investigation benefit: cost ratio was significantly affected by the treatments as compared to control. During the first year, highest benefit cost ratio (1:2.30) was recorded in fruits harvested from mango plants receiving PRD $_{75\%\ ETc}$ + F i.e T_7 followed by treatment T_6 (1:2.14) (RDI $_{75\%\ ETc}$ + F) whereas lowest benefit cost ratio (1:1.31) was recorded under treatment with T_{10} (no irrigation). The findings of second year also recorded the maximum benefit cost ratio (1:4.87) under treatment T_7 (PRD $_{75\%\ ETc}$ +F) as compared to other treatments whereas, minimum benefit cost ratio (1:3.23) was recorded under treatment with T_{10} (no irrigation).

4.8 Effect of deficit irrigation on shelf life of mango

4.8.1 Physiological loss in weight

Data pertaining to the physiological loss in weight under various treatments for the two consecutive years (2017 and 2018) are given in Table 33 and 34. First year of investigation, revealed that with the advancement of storage life, percent physiological loss in weight of mango increased significantly. On mean value basis maximum PLW of 21.06 % and 21.10 % during 2017 and 2018 respectively, was recorded in T_{10} (no irrigation) whereas, minimum PLW (12.81 per cent and 12.85 per cent) during 2017 and 2018, respectively was recorded in T_9 (PRD $_{50\%\ ETc}$ + F throughout the storage period. On mean value basis minimum PLW content was recorded on 2nd day of storage (7.71 % and 7.74 %) during 2017 and 2018 respectively, which increased significantly and continuously up to 12th the day of storage (23.20 % and 23.24 %) during 2017 and 2018 respectively. However, interaction between treatments and storage was observed to be non significant. Physiological loss in weight was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar increase with increase in storage period as in 2017.

4.8.2 Decay loss

The data depicted in table 35 and 36 shows that the percent decay loss in mango cv. Dashehari as effected by different treatments increased with the increase in storage period. On mean value basis maximum decay loss (51.00 %) was recorded in T_{10} (no irrigation) whereas, minimum decay loss (32.33 %) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) throughout the storage period. On mean value basis minimum decay loss content was recorded on 6th day of storage (8.10 %) which increased significantly and continuously upto 10th the day of storage (71.00 %) and it was observed that data was non significant irrespective of the treatment during both the years 2017 and 2018. Interaction between treatments and storage was also observed to be non significant. Percent decay loss was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar increase with increase in storage period as in 2017.

4.8.3 Fruit moisture

The data shown in table 37 and 38 pertaining to fruit moisture mango fruits under different treatments reveals that the fruit moisture decreased with the increase in storage period. On mean value basis maximum percent fruit moisture content (77.46 %) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) whereas, minimum percent fruit moisture content (70.55 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum percent fruit moisture content (76.73 %) was recorded on 0 day of storage which decreased significantly and continuously upto 10th

Table 29: Effect of different irrigation regimes and fertigation on benefit cost ratio of mango cv. Dashehari in the year 2017

S.No.	Treatment/Particular	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	Cost of system for 3 trees	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	-
2	Interest cost@ 12 %	126	126	126	126	126	126	126	126	126	
3	Operation coste. Repair & Maintenance @ 1 %	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	
4	Cost of basin preparation /tree (Rs)	135	135	135	135	135	135	135	135	135	135
5	Cost of FYM/tree (Rs)	420	420	420	420	420	420	420	420	420	420
6	Cost of Urea/tree (Rs.)	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
7	Cost of DAP/tree (Rs)	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50
8	Cost of MOP/tree (Rs)	27	27	27	27	27	27	27	27	27	27
9	Cost of fertigation	-	-	-	-	-	1075.89	1075.89	1075.89	1075.89	-
10	Miscellaneous (plant protection measures, harvesting of fruits etc.) (Rs)	500	500	500	500	500	500	500	500	500	500
11	Total cost/treatment(for three trees)	2304.5	2304.5	2304.5	2304.5	2304.5	3380.39	3380.39	3380.39	3380.39	1118
12	Total cost/Tree	768.16	768.16	768.16	768.16	768.16	1123.45	1123.45	1123.45	1123.45	372.66
13	Total cost/ha	119832.96	119832.96	119832.96	119832.96	119832.96	175258.20	175258.20	175258.20	175258.20	58134.96

Table 30: Effect of different irrigation regimes and fertigation on benefit cost ratio of mango cv. Dashehari in the year 2017

S.No.	Treatment/Particular	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	Average yield/tree(2017)	29.19	32.62	34.24	26.18	27.24	43.86	47.02	36.57	39.88	19.63
2	Average yield/ha	4553.64	5088.72	5341.44	4084.08	4249.44	6842.16	7335.12	5704.92	6221.28	3062.28
	Price/kg (Rs.)	40	40	40	40	40	55	55	55	55	25
3	Gross return/tree(Rs.)	1167.6	1304.8	1369.6	1047.2	1089.6	2412.3	2586.1	2011.35	2193.4	490.75
4	Cost of cultivation/tree (Rs.)	768.16	768.16	768.16	768.16	768.16	1298.08	1298.08	1119.20	1119.20	372.66
5	Net returns/tree (Rs.)	399.44	536.64	601.44	279.04	321.44	1114.22	1288.02	713.27	895.32	118.09
6	Net returns/ha (Rs.)	62312.64	83715.84	93824.64	43530.24	50144.64	173818.32	200931.12	111270.12	139669.92	18422.04
7	Benefit Cost ratio	1:1.51	1:1.69	1:1.78	1:1.36	1:1.41	1:2.14	1:2.30	1:1.79	1:1.95	1:1.31

Table 31: Effect of different irrigation regimes and fertigation on benefit cost ratio of mango cv. Dashehari in the year 2018

S.No.	Treatment/Particular	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	**Cost of system for 3 trees**	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	1050.00	-
2	**Interest cost@ 12 %**	126	126	126	126	126	126	126	126	126	
3	**Operation coste. Repair & Maintenance @ 1 %**	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	
4	**Cost of basin preparation /tree (Rs)**	135	135	135	135	135	135	135	135	135	135
5	**Cost of FYM/tree (Rs)**	420	420	420	420	420	420	420	420	420	420
6	**Cost of Urea/tree (Rs)**	11.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
7	**Cost of DAP/tree (Rs)**	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50
5	**Cost of MOP/tree (Rs)**	27	27	27	27	27	27	27	27	27	27
8	**Cost of fertigation**	-	-	-	-	-	985.62	985.62	985.62	985.62	-
9	**Miscellaneous (plant protection measures, harvesting of fruits etc.) (Rs)**	500	500	500	500	500	500	500	500	500	500
10	**Total cost/treatment(for three trees)**	2304.5	2304.5	2304.5	2304.5	2304.5	3290.12	3290.12	3290.12	3290.12	1118
11	**Total cost/Tree**	768.16	768.16	768.16	768.16	768.16	1096.70	1096.70	1096.70	1096.70	372.66
12	**Total cost/ha**	119832.96	119832.96	119832.96	119832.96	119832.96	171085.20	171085.20	171085.20	171085.20	58134.96

Table 32: Effect of different irrigation regimess and fertigation on benefit cost ratio of mango cv. Dashehari in the year 2018

S.No.	Treatment/Particular	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
1	**Average yield/tree**	76.85	78.90	80.45	71.73	73.42	92.42	97.11	84.20	90.12	60.32
2	**Average yield/ha**	11988.6	12308.4	12550.2	11189.8	11453.52	14417.52	15149.16	13135.2	14058.72	9409.92
	Price/kg (Rs.)	35	35	35	35	35	55	55	55	55	25
3	**Gross return/tree(Rs.)**	2689.75	2761.5	2815.75	2510.55	2569.7	5083.1	5341.05	4631	4956.6	1508
4	**Cost of cultivation/tree (Rs.)**	768.16	768.16	768.16	768.16	768.16	1273.48	1273.48	1198.27	1198.27	372.66
5	**Net returns/tree (Rs.)**	1921.59	1993.34	2047.59	1742.39	1801.54	3809.62	4067.57	3432.73	3758.33	1135.34
6	**Net returns/ha (Rs.)**	299768.04	310961.04	319424.04	271812.84	281040.24	594300.72	634540.92	535505.88	586299.48	177113.04
7	**Benefit Cost ratio**	1:3.50	1:3.59	1:3.66	1:3.26	1:3.34	1:4.63	1:4.87	1:4.22	1:4.51	1:3.23

Table 33: Effect of different irrigation regimes and fertigation on physiological loss in weight (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		2nd day	4th day	6th day	8th day	10th day	12th day	Mean
T_1	100% ETc	8.98	12.06	15.05	18.02	21.07	24.01	16.53
T_2	RDI 75% ETc evenly applied under the canopy	8.60	11.74	14.57	17.79	20.78	23.65	16.18
T_3	PRD 75% ETc applied to alternating sides of the root system	8.52	11.57	14.45	17.28	20.44	23.52	15.96
T_4	RDI 50% ETc evenly applied under the canopy	7.27	10.41	13.24	16.59	19.73	22.27	14.91
T_5	PRD 50% ETc applied to alternating sides of the root system	7.03	10.25	13.11	16.42	19.28	22.21	14.71
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	6.85	9.88	12.92	15.79	18.85	21.75	14.34
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	6.61	9.59	12.77	15.52	18.48	21.48	14.07
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.36	8.24	11.65	14.68	17.65	20.79	13.06
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.24	8.15	11.29	14.19	17.41	20.59	12.81
T_{10}	No Irrigation	12.68	15.25	18.39	21.78	26.49	31.78	21.06
Mean		7.71	10.71	13.74	16.80	20.01	23.20	
CD 0.05(A)	**1.32**							
CD 0.05 (B)	**1.02**							
CD 0.05 (AxB)	**N.S**							

Table 34: Effect of different irrigation regimes and fertigation on physiological loss in weight (%) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	12^{th} day	Mean
T_1	100% ETc	9.02	12.10	15.09	18.06	21.11	24.05	16.57
T_2	RDI 75% ETc evenly applied under the canopy	8.64	11.78	14.61	17.83	20.82	23.69	16.22
T_3	PRD 75% ETc applied to alternating sides of the root system	8.56	11.61	14.49	17.32	20.48	23.56	16.00
T_4	RDI 50% ETc evenly applied under the canopy	7.23	10.45	13.28	16.63	19.77	22.31	14.94
T_5	PRD 50% ETc applied to alternating sides of the root system	7.07	10.29	13.15	16.46	19.32	22.25	14.75
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	6.89	9.92	12.96	15.83	18.89	20.63	14.38
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	6.65	9.63	12.81	15.56	18.52	21.52	14.11
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.40	8.28	11.69	14.72	17.69	21.79	13.10
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.28	8.19	11.32	14.23	17.45	20.83	12.85
T_{10}	No Irrigation	12.73	15.29	18.43	21.82	26.54	31.82	21.10
Mean		7.74	10.75	13.78	16.84	20.05	23.24	
CD 0.05(A)	**0.65**							
CD 0.05 (B)	**0.50**							
CD 0.05 (AxB)	**N.S.**							

Table 35: Effect of different irrigation regimes and fertigation on decay loss (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)			
		6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	14.00	49.00	84	49.00
T_2	RDI 75% ETc evenly applied under the canopy	9.00	44.00	74	42.33
T_3	PRD 75% ETc applied to alternating sides of the root system	9.00	44.00	74	42.33
T_4	RDI 50% ETc evenly applied under the canopy	9.00	39.00	64	37.33
T_5	PRD 50% ETc applied to alternating sides of the root system	9.00	39.00	64	37.33
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	4.00	34.00	74	37.33
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	4.00	29.00	64	32.33
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	4.00	39.00	59	34.00
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	4.00	34.00	69	35.66
T_{10}	No Irrigation	15.00	54.00	84	51.00
Mean		8.10	40.50	71.00	
CD 0.05(A)	**1.88**				
CD 0.05 (B)	**N.S.**				
CD 0.05 (AxB)	**N.S.**				

Table 36: Effect of different irrigation regimes and fertigation on decay loss (%) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**			
		6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	15.00	50.00	85	50
T_2	RDI 75% ETc evenly applied under the canopy	10.00	45.00	75	44
T_3	PRD 75% ETc applied to alternating sides of the root system	10.00	45.00	75	43.33
T_4	RDI 50% ETc evenly applied under the canopy	10.00	40.33	65	38.33
T_5	PRD 50% ETc applied to alternating sides of the root system	10.00	40.33	65	38.33
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	5.00	35.00	75	38.33
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	5.00	30.00	65	33.33
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.00	40.33	60	35.00
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.00	35.00	70	36.33
T_{10}	No Irrigation	16.60	55.00	85	52.20
Mean		9.16	41.50	72.20	
CD 0.05(A)	**1.34**				
CD 0.05 (B)	**N.S.**				
CD 0.05 (AxB)	**N.S.**				

the day of storage (72.20 %). However, interaction between treatments and storage was observed to be non significant. During second year of investigation, percent fruit moisture was higher as compared to year 2017. On mean value basis in 2018 maximum percent fruit moisture content (77.72 %) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) whereas, minimum decay loss (70.83 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum percent fruit moisture content was recorded on 0 day of storage (77.08 %) which decreased significantly and continuously upto 10th the day of storage (72.48 %).

4.8.4 Fruit firmness

Data presented in Table 39 and 40 illustrates the effect of deficit irrigation and fertigation on fruit firmness in mango cv. Dashehari. A perusal of data during the first year of investigation reveals that with advancement of storage life, the fruit firmness decreased. On mean value basis maximum fruit firmness content was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) (21.62 lb/in^2 and 22.47 lb/in^2) during 2017 and 2018 respectively whereas, minimum fruit firmness (14.61 lb/in^2 and 15.46 lb/in^2) during 2017 and 2018 respectively, was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum fruit firmness was recorded on 0 day of storage (24.56 lb/in^2 and 25.15 lb/in^2) during 2017 and 2018 respectively, which decreased significantly and continuously up to 10th the day of storage (10.80 lb/in^2 and 11.20 lb/in^2) during 2017 and 2018 respectively, irrespective of treatment. However, interaction between treatments and storage was observed to be non significant. Fruit firmness was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017.

4.8.5 Total Soluble Solids

Data pertaining to the total soluble solids under various treatments for the two consecutive years (2017 and 2018) are given in Table 41 and 42. During first year of investigation, percent total soluble solid of mango cv. Dashehari increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage. On mean value basis maximum TSS content (17.41 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) while, minimum TSS content (13.91 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis minimum TSS in mango fruits showed a significant increasing trend from 0 day (10.08 %) to 6th day of storage

(19.28 %) and showed a significant and continuous decrease thereafter and was recorded to be 17.20 % at on 10th day of storage i.e. at the end of storage period. However, interaction between treatments and storage was statistically non significant. TSS was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar trend as in 2017.

4.8.6 Acidity

The data depicted in table 43 and 44 shows that the percent titratable acidity in mango cv. Dashehari as affected by different treatments decreased with the increase in storage period. On mean value basis maximum titratable acidity content (0.23 %) was recorded in T_{10} (no irrigation) whereas, minimum titratable acidity (0.15 %) was recorded in T_9 (PRD $_{50\ \%\ ETc}$ + F) throughout the storage period. On mean value basis maximum percent titratable acidity was recorded on 0 day of storage (0.24 %) which decreased significantly and continuously upto 10th the day of storage (0.13 %). However, interaction between treatments and storage was observed to be non significant. Percent titratable acidity was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017-2018.

4.8.7 Carotenoids

Data pertaining to the carotenoids under various treatments for the two consecutive years (2017 and 2018) are given in Table 45 and 46. During first year of investigation, carotenoids content in mango fruits was found to increase significantly upto 6th day of storage and then decreased on 8th and 10th day of storage. Carotenoids were recorded maximum in T_{10} (no irrigation) on 0, 2nd , 4th and 6th day of storage were 2.28 mg/100g pulp, 6.45 mg/100g pulp, 6.48 mg/100g pulp and 12.95 mg/100g pulp, respectively and later on 8th and 10th day of storage T_{10} recorded 11.78 mg/100g pulp and 10.60 mg/100g pulp carotenoids and minimum carotenoids were reported in T_9 (PRD $_{50\%\ ETc}$ + F) i.e 0.97 mg/100g pulp on 0day of storage, 3.99 mg/100g pulp on 2nd day of storage, 4.03 mg/100g pulp on 4th day of storage, 10.14 mg/100g pulp on 6th day of storage, 9.00 mg/100g pulp on 8th day of storage, 8.84 mg/100g pulp on 10th day of storage. The findings of second year revealed that with the advancement of storage life, the carotenoid content in mango fruits was found to increase significantly upto 6th day of storage and then decrease on 8th and 10th day of

Table 37: Effect of different irrigation regimes and fertigation on fruit moisture (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0^{th} day	2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	74.86	74.27	73.07	71.87	71.08	70.05	72.53
T_2	RDI 75% ETc evenly applied under the canopy	76.07	75.18	74.42	73.24	72.17	71.47	73.75
T_3	PRD 75% ETc applied to alternating sides of the root system	77.25	76.36	75.04	74.08	72.88	72.45	74.67
T_4	RDI 50% ETc evenly applied under the canopy	75.04	74.56	73.19	72.19	71.24	70.16	72.73
T_5	PRD 50% ETc applied to alternating sides of the root system	75.80	75.04	74.13	73.06	72.07	71.26	73.56
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	79.43	78.34	77.05	76.65	75.32	75.01	76.96
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	79.76	78.09	77.87	76.98	76.18	75.89	77.46
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	78.14	76.89	75.74	75.27	74.11	73.77	75.65
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	78.22	77.04	76.17	75.46	74.22	73.85	75.82
T_{10}	No Irrigation	72.76	72.18	71.06	69.89	69.24	68.18	70.55
Mean		76.73	75.79	74.77	73.86	72.85	72.20	
CD 0.05(A)	**1.320**							
CD 0.05 (B)	**1.022**							
CD 0.05 (AxB)	**N.S.**							

Table 38: Effect of different irrigation regimes and fertigation on fruit moisture (%) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	75.22	74.62	73.29	72.18	71.32	70.25	72.81
T_2	RDI 75% ETc evenly applied under the canopy	76.31	75.53	74.84	73.61	72.48	71.72	74.06
T_3	PRD 75% ETc applied to alternating sides of the root system	77.64	76.72	75.26	74.30	73.21	72.85	74.99
T_4	RDI 50% ETc evenly applied under the canopy	75.45	74.89	73.51	72.46	71.61	70.48	73.06
T_5	PRD 50% ETc applied to alternating sides of the root system	76.19	75.36	74.40	73.29	72.33	71.53	73.87
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	79.86	78.66	77.48	76.93	75.66	75.23	77.30
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	80.03	78.32	78.11	77.21	76.54	76.11	77.72
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	78.42	77.11	76.03	75.62	74.31	74.08	75.92
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	78.63	77.23	76.52	75.85	74.42	74.13	76.13
T_{10}	No Irrigation	73.09	72.42	71.28	70.16	69.57	68.46	70.83
Mean		77.08	76.08	75.07	74.16	73.14	72.48	
CD 0.05(A)	**1.278**							
CD 0.05 (B)	**0.990**							
CD 0.05 (AxB)	**N.S.**							

Table 39: Effect of different irrigation regimes and fertigation on fruit firmness (Lb/inch^2) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	22.54	21.33	17.75	15.82	9.59	7.48	15.75
T_2	RDI 75% ETc evenly applied under the canopy	23.35	22.42	18.37	16.34	10.14	8.71	16.55
T_3	PRD 75% ETc applied to alternating sides of the root system	23.88	22.78	18.86	16.97	10.72	9.54	17.12
T_4	RDI 50% ETc evenly applied under the canopy	24.22	22.14	19.69	17.25	11.65	10.88	17.63
T_5	PRD 50% ETc applied to alternating sides of the root system	24.71	23.65	20.26	17.89	12.84	11.69	18.50
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	25.62	24.84	20.81	18.74	13.78	12.05	19.30
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	26.14	25.23	21.74	19.68	14.52	12.67	19.99
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	26.85	25.66	22.29	20.18	15.71	13.74	20.73
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	27.33	26.56	23.65	20.77	16.64	14.78	21.62
T_{10}	No Irrigation	20.97	19.71	16.76	15.09	8.63	6.52	14.61
Mean		24.56	23.43	20.01	17.87	12.42	10.80	
CD 0.05(A)	**0.56**							
CD 0.05 (B)	**0.43**							
CD 0.05 (AxB)	**N.S.**							

Table 40: Effect of different irrigation regimes and fertigation on fruit firmness (Lb/inch^2) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	23.42	22.57	18.64	16.86	9.68	7.91	16.51
T_2	RDI 75% ETc evenly applied under the canopy	24.21	23.26	19.25	17.37	11.24	9.52	17.47
T_3	PRD 75% ETc applied to alternating sides of the root system	24.67	23.54	19.66	17.75	11.63	10.47	17.95
T_4	RDI 50% ETc evenly applied under the canopy	25.31	24.42	20.82	18.24	11.89	11.47	18.69
T_5	PRD 50% ETc applied to alternating sides of the root system	25.63	24.78	21.47	18.68	13.63	11.88	19.34
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	26.83	25.71	21.74	19.66	14.66	12.52	20.18
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	27.56	26.59	22.71	20.55	15.33	12.86	20.93
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	27.79	26.86	23.78	21.24	16.65	14.19	21.75
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	28.12	27.74	24.52	21.67	17.73	15.08	22.47
T_{10}	No Irrigation	21.62	20.72	17.66	16.17	9.47	7.14	15.46
Mean		25.51	24.61	21.02	18.81	13.19	11.20	
CD 0.05(A)	**0.78**							
CD 0.05 (B)	**0.41**							
CD 0.05 (AxB)	**N.S.**							

Table 41: Effect of different irrigation regimes and fertigation on TSS (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	8.36	11.20	15.14	18.26	16.17	15.60	14.12
T_2	RDI 75% ETc evenly applied under the canopy	9.27	12.15	16.29	18.45	17.22	16.23	14.93
T_3	PRD 75% ETc applied to alternating sides of the root system	9.40	12.24	16.45	18.50	17.36	16.41	15.06
T_4	RDI 50% ETc evenly applied under the canopy	10.19	13.37	16.19	19.05	18.26	17.24	15.71
T_5	PRD 50% ETc applied to alternating sides of the root system	10.43	13.85	16.71	19.36	18.61	17.82	16.13
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	11.03	14.10	18.23	20.10	19.08	18.11	16.77
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	11.18	14.35	17.53	20.24	19.26	18.26	16.80
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.37	15.24	18.57	20.37	19.40	18.47	17.23
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.50	15.46	18.71	20.42	19.76	18.65	17.41
T_{10}	No Irrigation	8.07	11.14	14.99	18.09	15.99	15.21	13.91
Mean		10.08	13.31	16.88	19.28	18.11	17.20	
CD 0.05(A)	**0.466**							
CD 0.05 (B)	**0.361**							
CD 0.05 (AxB)	**N.S**							

Table 42: Effect of different irrigation regimes and fertigation on TSS (%) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	8.38	11.22	15.16	18.28	16.19	15.62	14.14
T_2	RDI 75% ETc evenly applied under the canopy	9.29	12.17	16.31	18.47	17.24	16.25	14.95
T_3	PRD 75% ETc applied to alternating sides of the root system	9.42	12.26	16.47	18.52	17.38	16.43	15.08
T_4	RDI 50% ETc evenly applied under the canopy	10.21	13.39	16.21	19.07	18.28	17.26	15.73
T_5	PRD 50% ETc applied to alternating sides of the root system	10.45	13.87	16.73	19.38	18.63	17.84	16.15
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	11.06	14.12	18.2	20.15	19.13	18.17	16.81
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	11.25	14.39	17.55	20.28	19.29	18.28	16.83
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.39	15.26	18.59	20.39	19.42	18.49	17.25
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.52	15.48	18.73	20.44	19.78	18.67	17.43
T_{10}	No Irrigation	8.09	11.16	15.01	18.11	16.01	15.23	13.93
Mean		10.10	13.33	16.90	19.30	18.13	17.22	
CD 0.05(A)	**0.676**							
CD 0.05 (B)	**0.523**							
CD 0.05 (AxB)	**N.S.**							

Table 43: Effect of different irrigation regimes and fertigation on total acidity (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.27	0.25	0.23	0.21	0.19	0.17	0.22
T_2	RDI 75% ETc evenly applied under the canopy	0.26	0.24	0.22	0.20	0.18	0.16	0.21
T_3	PRD 75% ETc applied to alternating sides of the root system	0.26	0.24	0.22	0.20	0.18	0.16	0.21
T_4	RDI 50% ETc evenly applied under the canopy	0.25	0.23	0.21	0.19	0.17	0.15	0.20
T_5	PRD 50% ETc applied to alternating sides of the root system	0.24	0.22	0.20	0.18	0.16	0.14	0.19
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.23	0.20	0.18	0.14	0.12	0.10	0.16
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.23	0.20	0.18	0.15	0.13	0.10	0.16
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.22	0.19	0.17	0.14	0.12	0.09	0.15
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.22	0.19	0.17	0.14	0.12	0.09	0.15
T_{10}	No Irrigation	0.28	0.26	0.24	0.22	0.20	0.18	0.23
Mean		0.24	0.22	0.20	0.17	0.15	0.13	
CD 0.05(A)	**0.0302**							
CD 0.05 (B)	**0.0234**							
CD 0.05 (AxB)	**N.S.**							

Table 44: Effect of different irrigation regimes and fertigation on total acidity (%) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.27	0.25	0.23	0.21	0.19	0.17	0.22
T_2	RDI 75% ETc evenly applied under the canopy	0.26	0.24	0.22	0.20	0.18	0.16	0.21
T_3	PRD 75% ETc applied to alternating sides of the root system	0.26	0.24	0.22	0.20	0.18	0.16	0.21
T_4	RDI 50% ETc evenly applied under the canopy	0.25	0.23	0.21	0.19	0.17	0.15	0.20
T_5	PRD 50% ETc applied to alternating sides of the root system	0.24	0.22	0.20	0.18	0.16	0.14	0.19
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.23	0.20	0.18	0.14	0.12	0.10	0.16
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.23	0.20	0.18	0.15	0.13	0.10	0.16
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.22	0.19	0.17	0.14	0.12	0.09	0.15
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.22	0.19	0.17	0.14	0.12	0.09	0.15
T_{10}	No Irrigation	0.28	0.26	0.24	0.22	0.20	0.18	0.23
Mean		0.24	0.22	0.20	0.17	0.15	0.13	
CD 0.05(A)	**0.026**							
CD 0.05 (B)	**0.020**							
CD 0.05 (AxB)	**N.S.**							

Table 45: Effect of different irrigation regimes and fertigation on carotenoids (mg/100g pulp) of mango cv. Dashehari during storage in the year 2017

Treatments		**Storage (No. of days)**						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	2.20	6.33	6.36	12.61	11.49	10.45	8.24
T_2	RDI 75% ETc evenly applied under the canopy	2.15	6.22	6.25	12.37	11.19	10.32	8.08
T_3	PRD 75% ETc applied to alternating sides of the root system	2.13	6.13	6.17	12.14	11.01	10.06	7.94
T_4	RDI 50% ETc evenly applied under the canopy	1.19	5.36	5.31	11.74	10.64	9.43	7.27
T_5	PRD 50% ETc applied to alternating sides of the root system	1.15	5.26	5.24	11.52	10.44	9.21	7.13
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	1.10	5.19	5.16	11.36	10.25	9.04	7.01
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	1.06	5.12	5.12	11.24	10.12	8.95	6.93
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	1.01	5.07	5.10	11.13	10.06	8.89	6.87
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.97	3.99	4.03	10.14	9.00	8.84	6.16
T_{10}	No Irrigation	2.28	6.45	6.48	12.95	11.78	10.60	8.42
Mean		1.52	5.51	5.52	11.72	10.59	9.57	
CD 0.05(A)	**0.107**							
CD 0.05 (B)	**0.083**							
CD 0.05 (AxB)	**0.264**							

Table 46: Effect of different irrigation regimes and fertigation on carotenoids (mg/100g pulp) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	2.22	6.35	6.38	12.63	11.51	10.47	8.26
T_2	RDI 75% ETc evenly applied under the canopy	2.17	6.24	6.27	12.39	11.21	10.34	8.10
T_3	PRD 75% ETc applied to alternating sides of the root system	2.15	6.15	6.19	12.16	11.03	10.08	7.96
T_4	RDI 50% ETc evenly applied under the canopy	1.21	5.38	5.33	11.76	10.66	9.45	7.29
T_5	PRD 50% ETc applied to alternating sides of the root system	1.17	5.28	5.26	11.54	10.46	9.23	7.15
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	1.12	5.21	5.18	11.38	10.27	9.06	7.03
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	1.08	5.14	5.14	11.26	10.14	8.97	6.95
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	1.03	5.09	5.12	11.15	10.08	8.91	6.89
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.99	4.01	4.05	10.16	9.02	8.86	6.18
T_{10}	No Irrigation	2.30	6.47	6.50	12.97	11.80	10.62	8.44
Mean		1.54	5.53	5.54	11.74	10.61	9.59	
CD 0.05(A)	**0.066**							
CD 0.05 (B)	**0.051**							
CD 0.05 (AxB)	**0.163**							

storage. The maximum carotenoids were reported in T_{10} (no irrigation) on 0, 2^{nd}, 4^{th} and 6^{th} day of storage i.e. 2.30 mg/100g pulp, 6.47 mg/100g pulp, 6.50 mg/100g pulp and 12.97 mg/100g pulp, respectively and later on decreased on 8^{th} and 10^{th} day of storage to 11.80 mg/100g pulp and 10.62 mg/100g pulp, respectively and minimum carotenoids were reported in T_9 (PRD $_{50\%\ ETc}$ + F) i.e 0.99 mg/100g pulp on 0 day of storage, 4.01 mg/100g pulp on 2^{nd} day of storage, 4.05 mg/100g pulp on 4^{th} day of storage, 10.16 mg/100g pulp on 6^{th} day of storage, 9.02 mg/100g pulp on 8^{th} day of storage, 8.86 mg/100g pulp on 10^{th} day of storage.

4.8.8 Fruit K, Ca and B

4.8.8.1 Potassium

The data presented in table 47 and 48 pertaining to values of potassium concentration in mango pulp as effected by different treatments reveals that the fruit potassium content decreased with the increase in storage period. On mean value basis maximum potassium content (0.74 %) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) whereas, minimum potassium content (0.36 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum potassium content was recorded on 0 day of storage (0.58 %) which reduced significantly and continuously upto 10^{th} the day of storage (0.52 %) and data was observed to be non significant irrespective of the treatments. Interaction between treatments and storage was also observed to be non significant. Potassium content was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017.

4.8.8.2 Boron

The data presented in table 49 and 50 pertaining to values of boron concentration in mango pulp as effected by different treatments reveals that the fruit boron content decreased with the increase in storage period. On mean value basis maximum boron content (12.13 ppm) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) whereas, minimum boron content (9.04 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum boron content was recorded on 0 day of storage (10.68 ppm) which reduced significantly and continuously upto 10^{th} the day of storage (10.62 ppm) and data was observed to be non significant irrespective of the treatments. However, interaction between treatments and storage was observed to be statistically non significant. Boron content was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017.

4.8.8.3 Calcium

Data pertaining to the calcium content in mango cv. Dashehari under various treatments for the two consecutive years (2017 and 2018) has been presented in Table 51 and 52. The data reveals that the fruit calcium content decreased with the increase in storage period. On mean value basis maximum calcium content (0.045 %) was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) whereas, minimum calcium content (0.022 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum calcium content was recorded on 0 day of storage (0.035 %) which reduced significantly and continuously upto 10^{th} the day of storage (0.031 %) and data was observed to be non significant irrespective of the treatments. However, interactions between treatments and storage period were observed to be non significant. Calcium content was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017.

4.8.9 Sugars

4.8.9.1 Reducing sugar

The data presented in table 53 and 54 pertaining to reducing sugar of mango cv. Dashehari under different treatments shows that during first year of investigation(2017), maximum reducing sugar (7.74 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) on 6^{th} day of storage and was followed by (7.56 %) T_9 on 6^{th} day of storage whereas, minimum reducing sugar (5.09%) was observed in T_{10} (no irrigation) on 10^{th} day of storage. During storage reducing sugar in mango fruits showed a significant increasing trend from 0 day (1.95 %) to 6^{th} day of storage (6.56 %) and showed a significant and continuous decrease thereafter and was recorded to be 6.10 % on 10^{th} day of storage i.e. at the end of storage period. During second year of experimental study the per cent non reducing sugar of mango during storage period followed trend similar to preceding year of investigation.

4.8.9.2 Non reducing sugar

The data depicted in table 55 and 56 pertaining to non reducing sugar of mango cv. Dashehari under different treatments shows that during first year of

Table 47: Effect of different irrigation regimes and fertigation potassium (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.59	0.57	0.58	0.55	0.54	0.54	0.56
T_2	RDI 75% ETc evenly applied under the canopy	0.53	0.51	0.50	0.49	0.48	0.48	0.49
T_3	PRD 75% ETc applied to alternating sides of the root system	0.56	0.54	0.53	0.52	0.51	0.51	0.52
T_4	RDI 50% ETc evenly applied under the canopy	0.45	0.43	0.42	0.41	0.40	0.40	0.41
T_5	PRD 50% ETc applied to alternating sides of the root system	0.48	0.46	0.45	0.44	0.43	0.43	0.44
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.72	0.70	0.69	0.69	0.68	0.68	0.69
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.77	0.75	0.74	0.74	0.73	0.73	0.74
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.64	0.62	0.61	0.61	0.60	0.60	0.61
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.68	0.68	0.65	0.65	0.64	0.64	0.64
T_{10}	No Irrigation	0.40	0.38	0.37	0.36	0.35	0.35	0.36
Mean		0.58	0.56	0.55	0.54	0.53	0.52	
CD 0.05(A)	**0.06**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 48: Effect of different irrigation regimes and fertigation potassium (%) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**						
		0 day	2 day	4 day	6 day	8 day	10 day	Mean
T_1	100% ETc	0.60	0.58	0.57	0.56	0.55	0.55	0.56
T_2	RDI 75% ETc evenly applied under the canopy	0.54	0.52	0.51	0.50	0.49	0.49	0.50
T_3	PRD 75% ETc applied to alternating sides of the root system	0.57	0.55	0.54	0.53	0.52	0.52	0.53
T_4	RDI 50% ETc evenly applied under the canopy	0.46	0.44	0.43	0.42	0.41	0.41	0.42
T_5	PRD 50% ETc applied to alternating sides of the root system	0.49	0.47	0.46	0.45	0.44	0.44	0.45
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.73	0.71	0.70	0.70	0.69	0.69	0.70
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.78	0.76	0.75	0.75	0.74	0.74	0.75
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.65	0.63	0.62	0.62	0.61	0.61	0.62
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.69	0.67	0.66	0.66	0.65	0.65	0.66
T_{10}	No Irrigation	0.41	0.39	0.38	0.37	0.36	0.36	0.37
Mean		0.59	0.57	0.56	0.55	0.54	0.54	
CD 0.05(A)	**0.06**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 49: Effect of different irrigation regimes and fertigation boron (ppm) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2 day	4 day	6 day	8 day	10 day	Mean
T_1	100% ETc	11.07	11.07	11.06	11.04	11.03	11.01	11.04
T_2	RDI 75% ETc evenly applied under the canopy	10.11	10.11	10.10	10.08	10.07	10.05	10.08
T_3	PRD 75% ETc applied to alternating sides of the root system	10.50	10.50	10.49	10.47	10.46	10.44	10.47
T_4	RDI 50% ETc evenly applied under the canopy	9.39	9.39	9.37	9.34	9.33	9.31	9.35
T_5	PRD 50% ETc applied to alternating sides of the root system	9.73	9.73	9.72	9.70	9.69	9.67	9.70
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	12.04	12.04	12.03	12.02	12.01	11.99	12.02
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	12.16	12.16	12.14	12.12	12.11	12.09	12.13
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.22	11.22	11.21	11.19	11.18	11.16	11.19
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.60	11.60	11.59	11.57	11.56	11.54	11.57
T_{10}	No Irrigation	9.06	9.06	9.05	9.04	9.03	9.01	9.04
Mean		10.68	10.68	10.67	10.65	10.64	10.62	
CD 0.05(A)	**0.67**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 50: Effect of different irrigation regimes and fertigation boron (ppm) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	11.09	11.09	11.08	11.06	11.05	11.03	11.06
T_2	RDI 75% ETc evenly applied under the canopy	10.13	10.13	10.12	10.10	10.09	10.07	10.10
T_3	PRD 75% ETc applied to alternating sides of the root system	10.52	10.52	10.51	10.49	10.48	10.46	10.49
T_4	RDI 50% ETc evenly applied under the canopy	9.41	9.41	9.39	9.37	9.35	9.33	9.37
T_5	PRD 50% ETc applied to alternating sides of the root system	9.75	9.75	9.74	9.72	9.71	9.69	9.72
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	12.06	12.06	12.05	12.03	12.03	12.01	12.04
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	12.18	12.18	12.16	12.14	12.13	12.11	12.15
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.24	11.24	11.23	11.21	11.20	11.18	11.21
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	11.62	11.62	11.61	11.59	11.58	11.56	11.52
T_{10}	No Irrigation	9.08	9.08	9.07	9.05	9.05	9.03	9.06
Mean		10.70	10.70	10.65	10.67	10.66	10.64	
CD 0.05(A)	**0.05**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 51: Effect of different irrigation regimes and fertigation calcium (%) of mango cv. Dashehari during storage in the year 2017

Treatments		**Storage (No. of days)**						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.036	0.036	0.035	0.034	0.033	0.032	0.034
T_2	RDI 75% ETc evenly applied under the canopy	0.030	0.030	0.029	0.028	0.027	0.026	0.028
T_3	PRD 75% ETc applied to alternating sides of the root system	0.033	0.033	0.032	0.031	0.030	0.029	0.031
T_4	RDI 50% ETc evenly applied under the canopy	0.027	0.027	0.026	0.025	0.024	0.023	0.025
T_5	PRD 50% ETc applied to alternating sides of the root system	0.028	0.028	0.027	0.026	0.025	0.024	0.026
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.045	0.045	0.044	0.043	0.042	0.041	0.043
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.047	0.047	0.046	0.045	0.044	0.043	0.045
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.040	0.040	0.039	0.038	0.037	0.036	0.038
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.042	0.042	0.041	0.040	0.039	0.038	0.040
T_{10}	No Irrigation	0.024	0.024	0.023	0.022	0.021	0.020	0.022
Mean		0.035	0.035	0.034	0.033	0.032	0.031	
CD 0.05(A)	**0.06**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 52: Effect of different irrigation regimes and fertigation calcium (%) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.037	0.037	0.036	0.035	0.034	0.033	0.035
T_2	RDI 75% ETc evenly applied under the canopy	0.031	0.031	0.030	0.029	0.028	0.027	0.029
T_3	PRD 75% ETc applied to alternating sides of the root system	0.034	0.034	0.033	0.032	0.031	0.030	0.032
T_4	RDI 50% ETc evenly applied under the canopy	0.028	0.028	0.027	0.026	0.025	0.024	0.026
T_5	PRD 50% ETc applied to alternating sides of the root system	0.029	0.029	0.028	0.027	0.026	0.025	0.027
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.046	0.046	0.045	0.044	0.043	0.042	0.044
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.048	0.048	0.047	0.046	0.045	0.044	0.046
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.041	0.041	0.040	0.039	0.038	0.037	0.039
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.043	0.043	0.042	0.041	0.040	0.039	0.041
T_{10}	No Irrigation	0.025	0.025	0.024	0.023	0.022	0.021	0.023
Mean		0.036	0.036	0.035	0.034	0.033	0.032	
CD 0.05(A)	**0.06**							
CD 0.05 (B)	**N.S.**							
CD 0.05 (AxB)	**N.S.**							

Table 53: Effect of different irrigation regimes and fertigation on reducing sugar (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	1.54	2.56	3.56	5.84	5.39	5.26	4.025
T_2	RDI 75% ETc evenly applied under the canopy	1.56	2.94	4.15	6.02	5.91	5.50	4.347
T_3	PRD 75% ETc applied to alternating sides of the root system	1.61	3.07	4.23	6.10	6.16	6.05	4.520
T_4	RDI 50% ETc evenly applied under the canopy	1.67	3.15	4.60	6.22	6.26	6.11	4.668
T_5	PRD 50% ETc applied to alternating sides of the root system	1.72	3.33	4.85	6.49	6.30	6.17	4.810
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	2.15	4.11	5.20	7.06	6.55	6.23	5.217
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	2.17	4.44	5.46	7.19	6.79	6.46	5.418
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	2.69	5.67	7.13	7.56	7.34	7.07	6.243
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	2.95	5.80	7.22	7.74	7.52	7.12	6.392
T_{10}	No Irrigation	1.50	2.12	3.04	5.40	5.21	5.09	3.727
Mean		1.956	3.719	4.944	6.562	6.333	6.106	
CD 0.05(A)	**0.0662**							
CD 0.05 (B)	**0.0513**							
CD 0.05 (AxB)	**0.162**							

Table 54: Effect of different irrigation regimes and fertigation on reducing sugar (%) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**						
		0 day	2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	1.56	2.58	3.58	5.86	5.41	5.28	4.045
T_2	RDI 75% ETc evenly applied under the canopy	1.58	2.97	4.17	6.04	5.93	5.52	4.368
T_3	PRD 75% ETc applied to alternating sides of the root system	1.63	3.09	4.25	6.12	6.18	6.07	4.557
T_4	RDI 50% ETc evenly applied under the canopy	1.69	3.17	4.62	6.24	6.28	6.13	4.688
T_5	PRD 50% ETc applied to alternating sides of the root system	1.74	3.35	4.87	6.51	6.32	6.20	4.832
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	2.17	4.13	5.22	7.08	6.57	6.25	5.237
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	2.19	4.46	5.48	7.21	6.81	6.48	5.438
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	2.81	5.69	7.15	7.58	7.36	7.09	6.28
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	2.97	5.82	7.24	7.76	7.54	7.14	6.412
T_{10}	No Irrigation	1.52	2.14	3.06	5.42	5.23	5.11	3.747
Mean		1.986	3.740	4.964	6.582	6.363	6.127	
CD 0.05(A)	**0.1820**							
CD 0.05 (B)	**0.1410**							
CD 0.05 (AxB)	**0.446**							

investigation(2017-18), maximum non reducing sugar (11.10 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) on 6th day of storage and was followed by T_8 (10.96 %) on 6th day of storage whereas, minimum non reducing sugar was observed in T_{10} (no irrigation) on 10th day of storage (7.38 %). During storage non reducing sugar in mango fruits showed a significant increasing trend from 4.11 % on 0 day to 10.19 % on 6th day of storage and showed a significant and continuous decrease thereafter and was recorded to be 9.07 % on 10th day of storage i.e. at the end of storage period. During second year of experimental study the per cent non reducing sugar of mango during storage period followed trend similar to preceding year of investigation.

4.8.9.3 Total sugar

Data pertaining to the total sugar under various treatments for the two consecutive years (2017 and 2018) are given in Table 57 and 58. During first year of investigation, percent total sugar of mango cv. Dashehari increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage. On mean value basis maximum total sugar content (16.01 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) whereas, minimum total sugar content (10.62 %) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis minimum total sugar in mango fruits showed a significant increasing trend from 0 day (6.28 %) to 6th day of storage (17.28 %) and showed a significant and continuous decrease thereafter and was recorded to be 15.65 % on 10th day of storage i.e. at the end of storage period.

However, interaction between treatments and storage was statistically non significant. The per cent total sugar was higher in the year 2018 as compared to year 2017 irrespective of treatments and followed a similar trend.

4.8.10 Pectin

The data depicted in table 59 and 60 pertaining to pectin content in mango cv. Dashehari reveal that the pectin decreased with the increase in storage period. On mean value of two years basis maximum pectin content (0.294 %) was recorded in T_9 (PRD $_{50\ \%\ ETc}$ + F) and minimum pectin content (0.199) was recorded in T_{10} (no irrigation) throughout the storage period. On mean value basis maximum pectin content in mango fruit was recorded on 0 day of storage (0.472 %) which decreased significantly and continuously upto 10th the day of storage (0.040 %). However, interaction between treatments and storage were observed to be non significant.

Pectin content was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increase in storage period as in 2017.

Table 55: Effect of different irrigation regimes and fertigation on non reducing sugar (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	3.24	5.40	6.86	8.94	8.50	7.74	6.78
T_2	RDI 75% ETc evenly applied under the canopy	3.50	5.72	7.49	9.98	9.64	8.45	7.463
T_3	PRD 75% ETc applied to alternating sides of the root system	3.73	5.84	7.67	10.14	9.86	8.59	7.638
T_4	RDI 50% ETc evenly applied under the canopy	4.05	6.16	8.27	10.26	10.17	9.39	8.05
T_5	PRD 50% ETc applied to alternating sides of the root system	4.20	6.30	8.44	10.41	10.24	9.51	8.183
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	4.28	6.65	8.53	10.56	10.31	9.69	8.337
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	4.44	6.92	8.71	10.74	10.39	9.77	8.495
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.27	7.43	9.08	10.96	10.44	9.83	8.835
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.36	7.83	9.31	11.10	10.89	10.40	9.148
T_{10}	No Irrigation	3.08	5.22	6.54	8.82	8.29	7.38	6.555
Mean		4.115	6.347	8.090	10.191	9.873	9.075	
CD 0.05(A)	**0.0631**							
CD 0.05 (B)	**0.0489**							
CD 0.05 (AxB)	**0.155**							

Table 56: Effect of different irrigation regimes and fertigation on non reducing sugar (%) of mango cv. Dashehari during storage in the year 2018

Treatments		Storage (No. of days)						
		0 day	2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	3.26	5.42	6.87	8.96	8.52	7.76	6.798
T_2	RDI 75% ETc evenly applied under the canopy	3.52	5.74	7.51	10.00	9.65	8.47	7.482
T_3	PRD 75% ETc applied to alternating sides of the root system	3.75	5.86	7.69	10.16	9.87	8.61	7.657
T_4	RDI 50% ETc evenly applied under the canopy	4.07	6.18	8.29	10.28	10.19	9.41	8.070
T_5	PRD 50% ETc applied to alternating sides of the root system	4.21	6.32	8.46	10.43	10.26	9.53	8.202
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	4.30	6.67	8.55	10.58	10.32	9.71	8.355
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	4.46	6.94	8.73	10.76	10.41	9.79	8.515
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.30	7.45	9.10	10.98	10.46	9.85	8.857
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	5.38	7.85	9.33	11.12	10.91	10.42	9.168
T_{10}	No Irrigation	3.10	5.24	6.56	8.84	8.31	7.40	6.575
Mean		4.135	6.367	8.109	10.211	9.890	9.095	
CD 0.05(A)	**0.1073**							
CD 0.05 (B)	**0.0831**							
CD 0.05 (AxB)	**0.263**							

Table 57: Effect of different irrigation regimes and fertigation on total sugar (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	4.95	8.24	10.78	15.25	14.33	13.40	11.158
T_2	RDI 75% ETc evenly applied under the canopy	5.24	8.96	12.03	16.52	16.05	14.39	12.198
T_3	PRD 75% ETc applied to alternating sides of the root system	5.53	9.21	12.30	16.77	16.53	15.09	12.572
T_4	RDI 50% ETc evenly applied under the canopy	5.93	9.63	13.30	17.02	16.96	15.99	13.138
T_5	PRD 50% ETc applied to alternating sides of the root system	6.14	9.96	13.73	17.44	17.07	16.18	13.42
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	6.65	11.11	13.10	18.17	17.40	16.43	13.81
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	6.84	11.72	14.62	18.49	17.72	16.74	14.355
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	8.23	13.49	16.68	19.09	18.32	17.41	15.537
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	8.59	14.04	17.02	19.42	18.98	18.06	16.018
T_{10}	No Irrigation	4.74	7.61	9.92	14.68	13.93	12.85	10.622
Mean		6.284	10.397	13.348	17.285	16.729	15.654	
CD 0.05(A)	**0.60**							
CD 0.05 (B)	**0.47**							
CD 0.05 (AxB)	**N.S.**							

Table 58: Effect of different irrigation regimes and fertigation on total sugar (%) of mango cv. Dashehari during storage in the year 2018

Treatments		**Storage (No. of days)**						
		0 day	2^{nd} day	4^{th} day	6^{th} day	8^{th} day	10^{th} day	Mean
T_1	100% ETc	4.99	8.28	10.81	15.29	14.37	13.44	11.197
T_2	RDI 75% ETc evenly applied under the canopy	5.28	9.01	12.07	16.56	16.08	14.43	12.238
T_3	PRD 75% ETc applied to alternating sides of the root system	5.57	9.25	12.34	16.81	16.56	15.13	12.61
T_4	RDI 50% ETc evenly applied under the canopy	5.97	9.67	13.34	17.06	17.00	16.03	13.178
T_5	PRD 50% ETc applied to alternating sides of the root system	6.17	10.00	13.77	17.48	17.12	16.23	13.462
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	6.69	11.15	14.22	18.21	17.43	16.47	14.028
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	6.88	11.76	14.66	18.53	17.76	16.78	14.395
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	8.38	13.53	16.72	19.13	18.37	17.45	15.597
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	8.63	14.08	17.06	19.46	19.02	18.10	16.058
T_{10}	No Irrigation	4.78	7.65	9.96	14.72	13.97	12.89	10.662
Mean		6.334	10.438	13.495	17.325	16.768	15.695	
CD 0.05(A)	**0.66**							
CD 0.05 (B)	**0.51**							
CD 0.05 (AxB)	**N.S.**							

Table 59: Effect of different irrigation regimes and fertigation pectin (%) of mango cv. Dashehari during storage in the year 2017

Treatments		Storage (No. of days)						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.441	0.327	0.268	0.112	0.052	0.021	0.204
T_2	RDI 75% ETc evenly applied under the canopy	0.444	0.333	0.272	0.117	0.060	0.025	0.209
T_3	PRD 75% ETc applied to alternating sides of the root system	0.447	0.339	0.276	0.123	0.067	0.032	0.214
T_4	RDI 50% ETc evenly applied under the canopy	0.451	0.346	0.281	0.135	0.081	0.037	0.222
T_5	PRD 50% ETc applied to alternating sides of the root system	0.456	0.360	0.286	0.152	0.090	0.043	0.231
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.502	0.411	0.327	0.206	0.102	0.049	0.266
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.509	0.423	0.345	0.213	0.111	0.052	0.276
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.511	0.446	0.356	0.224	0.117	0.060	0.286
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.521	0.463	0.359	0.233	0.123	0.066	0.294
T_{10}	No Irrigation	0.438	0.323	0.266	0.105	0.047	0.017	0.199
Mean		0.472	0.377	0.304	0.162	0.085	0.040	
CD 0.05(A)	**0.03**							
CD 0.05 (B)	**0.02**							
CD 0.05 (AxB)	**N.S.**							

Table 60: Effect of different irrigation regimes and fertigation pectin (%) of mango cv. Dashe

Treatments		**Storage (No. of days)**						
		0 day	2nd day	4th day	6th day	8th day	10th day	Mean
T_1	100% ETc	0.443	0.329	0.270	0.114	0.054	0.023	0.206
T_2	RDI 75% ETc evenly applied under the canopy	0.446	0.335	0.274	0.119	0.062	0.027	0.211
T_3	PRD 75% ETc applied to alternating sides of the root system	0.449	0.341	0.278	0.125	0.069	0.034	0.216
T_4	RDI 50% ETc evenly applied under the canopy	0.453	0.348	0.283	0.137	0.083	0.039	0.224
T_5	PRD 50% ETc applied to alternating sides of the root system	0.458	0.362	0.288	0.154	0.092	0.045	0.233
T_6	RDI 75% ETc evenly applied under the canopy + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%)	0.504	0.413	0.329	0.208	0.104	0.051	0.268
T_7	PRD 75% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$(1%)	0.511	0.425	0.347	0.215	0.113	0.054	0.278
T_8	RDI 50% ETc evenly applied under the canopy + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.513	0.448	0.358	0.226	0.119	0.062	0.288
T_9	PRD 50% ETc applied to alternating sides of the root system + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%)	0.523	0.465	0.361	0.235	0.125	0.068	0.296
T_{10}	No Irrigation	0.440	0.325	0.268	0.107	0.049	0.019	0.201
Mean		0.474	0.379	0.306	0.164	0.087	0.042	
CD 0.05(A)	**0.025**							
CD 0.05 (B)	**0.019**							
CD 0.05 (AxB)	**N.S.**							

Chapter-5

Discussion

CHAPTER V

DISCUSSION

The present investigation was focused on the study of water and nutrient management in mango cultivar Dashehari under Jammu sub-tropics. The experimental results presented in previous chapter provided a detail of effect of different irrigation treatments on mango cultivar dashehari. In this chapter, the significant experimental findings during the course of investigations have been discussed to offer possible explanations and evidences with a view to find out the effect amongst various treatments with regard to various attributes studied.

5.1 Effect of deficit irrigation on phenological characteristics of mango fruit

5.2 Effect of deficit irrigation on tree growth characteristics of mango fruit

5.3 Effect of deficit irrigation on physiochemical characteristics of mango fruit

5.5 Effect of deficit irrigation on fruiting characteristics of mango fruit

5.5 Irrigation water productivity of mango fruit

5.6 Soil and plant water characteristics

5.7 Economic

5.8 Effect of deficit irrigation on shelf life of mango fruit

5.1 Effect of deficit irrigation on phenological characteristics of mango fruit

The flowering in mango evaluated under the present study showed variation in the commencement of flowering, date of appearance of panicle, full bloom, duration of flowering, date of maximum fruit set and date of harvest mango was noticed. Date of appearance of panicle, full bloom, date of maximum fruit set and date of harvest was recorded earlier in plants when deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\ \%\ ETc}$) and in T_3 (PRD $_{75\ \%\ ETc}$) whereas date of appearance panicle, full bloom was recorded to be delayed when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) and in T_5 (PRD $_{50\ \%\ ETc}$). However, the date of appearance of panicle, full bloom was recorded earlier (13th February, 6th March, respectively) in the treatments T_6 i.e (RDI $_{75\%\ ETc}$ + F) as compared to the treatments not subjected to fertigation i.e both T_2 (RDI $_{75\%\ ETc}$), T_3 (RDI $_{75\%\ ETc}$), T_4 (RDI $_{75\%\ ETc}$) and T_5 (RDI $_{75\%}$

$_{ETc}$) whereas, panicle appearance and full bloom was last (100 % ETc) i.e 19th February, 11th March, respectively) in plants treated with full irrigation (T_1) as compared both fertigated and non feritgated plants while during the second year (2018), the date of panicle appearance, full bloom, was recorded earlier (15th February, 8th March, respectively) in the treatments receiving fertigation i.e T_6 (RDI $_{75\%\ ETc}$ + F) as compared to the treatments not subjected to ferigation i.e both T_2 (RDI $_{75\%\ ETc}$) , T_3 (RDI $_{75\%\ ETc}$), T_4 (RDI $_{75\%\ ETc}$) and T_5 (RDI $_{75\%\ ETc}$) whereas, panicle appearance, full bloom, was last (21st February, 15th March, respectively) in plants treated with full irrigation T_1 (100 % ETc) as compared both fertigated and non feritgated plants.

The date of maximum fruit set and date of harvest was recorded earlier (22nd March and 14th June, respectively) in the treatments T_6 i.e (RDI $_{75\%\ ETc}$ + F) as compared to the treatments T_2 (RDI $_{75\%\ ETc}$), T_3 (RDI $_{75\%\ ETc}$), T_4 (RDI $_{75\%\ ETc}$) and T_5 (RDI $_{75\%\ ETc}$) whereas, date of maximum fruit set and date of harvest was last (100 % ETc) i.e, 29th March and 20th June, respectively in plants treated with full irrigation(T_1) as compared both fertigated and non feritgated plants while during the second year (2018), the date of maximum fruit set and date of harvest was recorded earlier (24th March and 15th June, respectively) in the treatments T_6 (RDI $_{75\%\ ETc}$ + F) as compared to the treatments not subjected to ferigation i.e both T_2 (RDI $_{75\%\ ETc}$), T_3 (RDI $_{75\%\ ETc}$), T_4 (RDI $_{75\%\ ETc}$) and T_5 (RDI $_{75\%\ ETc}$) whereas, date of maximum fruit set and date of harvest was last (30th March and 22nd June, respectively) in plants treated with full irrigation T_1 (100 % ETc) as compared both fertigated and non feritgated plants. Sharma *et al.,* 2015 found that under water stress condition the initiation of flowering is earlier and this might be due to accumulation of maximum photosynthesis favoring fast growth in tomato. These results are supported by findings of Cuevas *et al.,* 2008 who reported that more severe the water stress was, the earlier the blooming resulted. Similarly in mango, water stress also advance bloom date (Nunez-Elisea and Davenport, 1994; Lu and Chacko, 2000). Sidhu and Bal (2009) reported that ber plants irrigated at stress condition (cumulative Epan 150 mm) were first to flower, attain full bloom and first to complete flowering phase as compared to the plants which were irrigated at 50, 75, 100 and 125 pan cumulative evaporation. Early flowering under drip fertigation had been documented by Prabhakar *et al.* (2001), Meenakshi and Vadivel (2003) and Kavitha (2005) in tomato.

This indicated that nutrient availability at regular intervals in water soluble form and judicious water availability might have helped early flowering and harvesting of the crop.

In the present studies, potassium nitrate showed a very positive effect on the panicle emergence. The higher per cent of panicle appearance in KNO_3-1% treated trees might be due to the fact that KNO_3 acts as a bud dormancy breaking agent (Tongumpai *et al.,* 1989). Davenport and Nunez-Elisea (1997) opined that KNO_3 stimulated flowering in mango is mediated by increased levels of endogenous ethylene. Potassium nitrate is a universal rest-breaking agent in deciduous fruit trees (Erez and Lavee, 1974) that may simply hasten flower emergence of a differentiated, but dormant, mango bud.

Longest duration of flowering was recorded treatments receiving fertigation i.e T_6 (RDI $_{75\%\ ETc}$ + F) on (25 and 27 days) during both the years 2017 and 2018 as compared to the treatments not subjected to fertigation ,whereas ,shortest duration of flowering was recorded in T_{10} i.e no irrigation. So far as the start of flowering as well as its duration is concerned with KNO_3- 1% flowered earlier and thus reduced the duration of flowering period. Early initiation of panicle, flowering and lesser duration in these processes are in line with Ubale and Banik (2017a) who observed shortest flowering duration in the trees treated with KNO_3 2% (14 days) whereas longest (20 days) was perceived with T_7 (Control - water spray) and T_8 (Control, without water), respectively. Earlier flowering in mango promoted by foliar spray of KNO_3, which promotes ethylene biosynthesis has also been reported by Mosqueda-Vazquez and Avila-Resendiz (1985).

Panicle length and breadth was recorded maximum under T_7 comprising of PRD $_{75\%\ ETc}$ + F) and minimum panicle length and breadth was recorded under T_{10} i.e no irrigation. Results are in line with Sarker and Rahim (2013) who reported that there were significant differences in terms of terminal shoot length, number of leaves per terminal shoot, leaf area, length and breadth of panicle and number of secondary branches per panicle as influenced by different irrigation treatments and this might be due to the uptake of sufficient nutrient elements from the soil. Kumar and Jaiswal (2004) stated that possible cause of difference in panicle length and width may be due to environmental conditions. The results were in accordance with the findings of

Majumder *et al.* (2011) and Kundu *et al.* (2009). Garad *et al.* (2013) who stated that the maximum panicle length (34.41 cm) was observed by spraying of KNO_3 1 %.

5.2 Effect of deficit irrigation on tree growth characteristics of mango

Growth and development of tree is a consequence of excellent coordination of several processes operating during the growing stages of crop. Tree height and tree spread are two important phenotypic characters which not only decide the growth in terms of vigour but also have direct influence on yield by increasing canopy spread and number of fruits. Hence, an understanding of plant growth parameters on quantitative terms is essential to increase crop yield in mango.

During the present course of investigation it was observed that during both the years of investigation higher tree height and spread were recorded in the treatments receiving fertigation as compared to the treatments not subjected to fertigation. It was also observed that the treatments receiving deficit irrigation at 75 % ETc recorded higher tree height and spread as compared to treatments receiving irrigation at 50 % ETc and no irrigation. The optimum and continuous availability of water to the plants under 75% ETc drip irrigation treatments may be accounted for better vegetative and reproductive growth of plants. Tree height and spread was higher in case of full irrigation i.e 100 % ETc (T_1) followed by T_7 (PRD $_{75\ \%\ ETc}$ + F) However, lowest tree height and spread was recorded under no irrigation (T_{10}). These results are in conformity with those of Yuan *et al.* (2004), who obtained significantly higher plant growth attributes and more number of leaves with increasing the amount of irrigation water from Ep 0.75 to Ep 1.25 in strawberry. Similar results were obtained by Kumar *et al*. (2012) in strawberry, who found that irrigation at 1.0 IW/CPE ratio, significantly increased crown height, plant spread, than other irrigation levels. Further, they also observed that limited water availability decreased plant growth attributes. The plants irrigated at 50% ETc and no irrigation attained less vegetative growth than those of 75 % ETc. The plants irrigated at 50% ETc through drip attained less vegetative growth in terms of plant height, during both the years of study. Irrigation at 50% ETc results into water stress condition in the soil during the active growing period due to more evaporation of water and limited application of irrigation water which resulted in the reduction of uptake of nutrients and may have accounted for poor vegetative and reproductive growth. These results are in agreement with the findings of Rolbiecki *et al*. (2004), who observed significant reduction in vegetative growth of strawberry under no irrigation treatments. Further they concluded that reduction in vegetative growth of strawberry under no irrigation treatment was due to water stress condition in the soil during active growing period.

Different fertilization methods gave a variable impact on vegetative growth characteristic of mango. The maximum vegetative growth in terms of tree height, tree spread were observed in plants fertigated with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%) The increased nutrients content might have increased the rate of various physiological and metabolic processes in the plant system, ultimately resulted in higher vegetative growth parameters. These results are in accordance with the findings of Martinsson *et al*. (2006). The higher growth parameters recorded under these fertigation treatments may be due to increased nutrient use efficiency by minimizing the leaching losses through drip. Also there was a continuous supply of nutrients in fertigation treatments as the fertilizers were applied during the growth period of the plants, which might have helped in meeting the requirements of nutrients during the critical period of growth. These results are in accordance with the findings of Raina *et al.* (2005) in apricot, Chauhan and Chandel (2008) in kiwifruit, who also observed that higher vegetative growth under fertigation treatments than with conventional soil application.

Tree response to various irrigation levels in terms of stock girth, scion girth and stock scion ratio was studied during the present study wherein maximum stock girth and scion girth was recorded in plants treated with 100% ETc (T_1) followed by plant treated with PRD $_{75\%\ ETc}$ + Fertigation (T_7), whereas, lowest value was recorded under plants treated with no irrigation (T_{10}). The reduction in trunk girth either due to deficit or surplus water availability to the plants in the present study can be attributed to the fact that the reduced water potential might have resulted in low uptake of water and nutrients. The observations made during the present study are in conformity with the findings of Bhardwaj *et al.* (2010) who reported that apple tree had 12 per cent increased trunk girth and 92 per cent increased shoot growth under drip irrigation, whereas in basin irrigation trunk girth increased only up to 6 per cent and shoot growth up to 32 per cent as compared to plant grown under rainfed conditions. Dolker *et al.* (2017) also that reported maximum plant height, stock girth, scion girth and plant volume were recorded under plants supplied with RDI at 100% ETc whereas, the minimum value were with plants treated with no irrigation and this might be due to the fact that plants grown under rainfed conditions or water stress conditions might have saturated the root zone, thereby reduced the oxygen level and respiration rate resulting into low uptake of nutrients and inhibited proper growth and vigour of plants. The similar type of observations were also recorded in the earlier studies on irrigation scheduling in Nagpur mandarin (Shirgure *et al.,* 2014), kinnow mandarin by Panigrahi *et al.* (2014) and Nagpur mandarin by Shirgure *et al.* (2016). Mills *et al.* (1996) also reported that the higher trunk girth obtained with availability of water might be due to higher absorption of water and nutrient from soil, better translocation of assimilates and production of harmones from roots and better unloading through phloem.

5.3 Effect of deficit irrigation on physiochemical characteristics of mango

The beneficial effect of water soluble fertilizers in enhancing the fruit size, weight and volume could also be observed in the present study. The fruit size, weight and volume of mango were significantly influenced by different irrigation treatments during both the years. During the present course of investigation it was observed that the treatments receiving deficit irrigation at 75 % ETc both RDI and PRD recorded higher fruit size, weight and volume as compared to treatments receiving irrigation at 50 % ETc RDI and PRD and also in T_{10} (no irrigation) . However, fruit size, weight and volume was higher in case of full irrigation i.e 100 % ETc (T_1) than plants treated at 50% ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) and in T_5 (PRD $_{50\ \%\ ETc}$) during both the years.

It was also observed that maximum fruit size, weight and volume were recorded in the treatments receiving fertigation as compared to the treatments not subjected to fertigation.

According to Marscher (1995), a balanced supply of nutrients promoted the carbohydrate assimilation and its efficient translocation for the fruit development processes, which would directly influence the enhancement of fruit weight. The increased fruit weight under fertigation might be ascribed to better utilization of water, minimum losses of water through percolation and evaporation, and excellent soil-water-air relationship with higher oxygen concentration in the root zone and higher uptake of nutrients. These results are in agreement with the findings of Gornet *et al*. in cucumber (1973) and Bafna *et al*. in tomato (1993). Appreciable improvement in fruit weight by borax application had been also reported by Dutta

(2004) in mango cv. Himsagar. Boron facilitates sugar transport within the plant and it was also reported that borate react with sugar to form a squgar-borate complex (Gauch and Dugger, 1953). Increase in fruit weight with the application of borax has been also observed by Raychaudhary *et al.* (1992) in guava.

The higher fruit size and weight under 75 % ETc (RDI and PRD) with fertigation and also in 100% ETc through drip irrigation treatments may be attributed to optimum soil moisture content maintained by frequent irrigations and better nutrients availability during the entire growth period. These results are in line with the findings of Yuan *et al*. (2004), who found that the size and weight of strawberry fruit increased with the increase in amount of irrigation water from Ep 0.75 to Ep 1.25. Similarly, Sharma *et al.* (2005) also noticed significant increase in strawberry fruit size and weight under drip irrigation. They emphasized that increase in size and weight of fruits may be due to availability of optimum soil moisture content throughout entire growth period because of frequent irrigation coupled with better nutrient supply. The possible reason for higher fruit weight under T_7 may be due to water deficit in root zone under this treatment suppressed the vegetative growth of the plants without bringing much effect on leaf photosynthesis rate and the mango plants invested higher quantity of photosynthates towards reproductive growth (fruiting) than vegetative growth. Similarly, Proietti and Antognozzi (1996) in olive reported that larger fruit size was primarily the result of a larger number of cells and the positive effect of water availability on the cell division rather than cell expansion.

Fertigation with nutrients registered a significant higher size and weight of fruits. This may be ascribed to the increased synthesis of metabolites due to higher nutrient levels and their translocation to the fruits. These results are in accordance with the findings of Shirgure *et al*. (2001) in Nagpur mandarin, Thakur and Singh (2004) in mango cv. Amarpalli and Mahalakshmi *et al.* (2001) in banana, who observed significant increase in fruit size and weight with Fertigation. Similarly, Peterson (1998) observed better fruit size and overall quality in fertigated plot than the non-fertigated strawberry plants. Martinsson *et al.* (2006) also observed better size and weight of strawberry under fertigation compared to common soil application.

Application of 75 per cent of water along with nutrients recorded higher in fruit size, weight and volume over conventional method of fertilizer application. These results stand in conformity with the findings of Yadav and Singh (1991), Loccascio and Smajstrla (1992) in tomato, Salvadore *et al.* (1997) in tomato, and Alva *et al.* (1998) in Valencia orange.

Lower fruit size, weight and volume was recorded at 50 per cent ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) and in T_5 (PRD $_{50\ \%\ ETc}$) than plants treated with fertigation (T_6, T_7, T_8 and T_9). This was attributed to low soil moisture during the growing season under 50% ETc drip irrigation treatment, hence, the fruits failed to attain normal size and weight due to low availability of soil moisture as such fruit size is directly related to the availability of soil moisture (Hsiao, 1973). These results are in conformity to the findings of Kumar *et al.* (2012), who recorded better fruit size and weight of strawberry at 1.0 IW/CPE ratio irrigation levels than at 0.6 IW/CPE ratio of irrigation. Berman and Dejong (1996) also postulated that fruit growth depend on the accumulation of large quantities of osmotically active solutes and massive cell expansive growth and these processes require carbohydrates and its restriction under water-stressed crop decrease ability to accumulate water. Thus, the results obtained in the present investigation are in line with their hypothesis. Behboudian and Lawes (1994) observed reduction in fruit weight of kiwi fruit in late stress conditions compared to the well watered tree. Differential response of mango fruit to different irrigation levels in terms of fruit volume may be attributed to the increase or decrease in length and diameter of fruits harvested under particular level of irrigation. Chalmars *et al.* (1985) also reported that peach fruit volume reduced under deficit irrigation compared to full irrigation. Hence, the differences in fruit volume observed under different levels of irrigation in the present study are in conformity with their findings. Different irrigation levels influenced the specific gravity of mango and it increased with increase in irrigation regime from no irrigation to deficit irrigation.. The present findings are in line with Kour *et al.* (2013) who reported that increase in specific gravity might be due to increase in fruit volume with higher fruit weight.

5.3.1 Fruit quality

The data on the quality characteristic of fruits reveals that different fertigation treatments significantly influenced the fruit quality during both the years of study. During both the year i.e. 2017 and 2018, it was observed that TSS was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$, T_3 i.e PRD $_{75\ \%\ ETc}$, T_4 i.e RDI $_{50\ \%\ ETc}$ and in T_5 i.e PRD $_{50\ \%\ ETc}$, as compared to 100 per cent ETc i.e T_1. However, highest total soluble solids were observed when deficit irrigation was supplemented with fertigation under treatment T_9 PRD $_{50\ \%\ ETc}$ + fertigation with K_2SO_4 (0.5%), H_3BO_3 (0.5%) and $Ca(NO_3)_2$ (1%) 20.42 ^oBrix and 20.50 ^oBrix in 2017 and 2018, respectively, whereas lowest TSS was recorded under no irrigation (T_{10}) 17.96 ^oBrix and 18.00 ^oBrix during first and second year of experimental trial. These results are in conformity with those of Crisosto *et al.* (1994) who reported that deficit irrigation increased total soluble solids at harvest in 'O' Henry peaches as compared to optimum or fully irrigated trees. Similar effect was noticed by Crisosto *et al.* (1997), wherein deficit irrigation increased total soluble solids at harvest in 'O' Henry peaches. The more total soluble solids were recorded in relatively higher water stress conditions over 100% ETc, it may be due to reduced fruit water content and greater hydrolysis of starch into sugars (Kramer, 1983). This might have contributed towards an increase in TSS at lower irrigation levels. These findings were conformed to Torrecillas *et al.* (2000) in apricot; Pérez-Pastor *et al.* (2007) in apricot. They found that deficit irrigation applied during fruit growth stages in peaches and apricots induced a higher soluble solid content. On the other hand, boron may be associated with the cell membrane where it forms complex with sugar molecules and facilitates its passage across the membrane that might be the reason of increased total soluble solids. Similar results were found by Bhowmick and Banik (2011); Nehete *et al.* (2011) and Bhowmick *et al*. (2012) in mango, Meena *et al.* (2006) in ber.

Lower acid content in fruits harvested from plants treated with PRD $_{50\%\ ETc}$ + F was probably caused by enhanced transformation of acids to sugars in dehydrated juice sac, which is required to maintain the osmotic pressure of fruit cells under mild water deficit condition prevailed under these treatments (Huang *et al.*, 2000). Thus, the results obtained in present study are in conformity with the findings of Panigrahi *et al.* (2012) who reported that Nagpur mandarin trees irrigated DI at 80 % Ecp and 60 % Ecp recorded lower acidity than under DI at 40 % Ecp. Lower level irrigation applied during fruit growth stages in mango induced low titratable acidity. These results were in agreement with those obtained by Torrecillas *et al.,* 2000; Pérez-Pastor *et al.,* 2007 in apricot. Acidity was reduced in trees that received calcium chloride and boric acid fertigation. On the other hand maximum acidity was registered with untreated fruits. The results are in accordance with those of Bhat and Farooqui (2004) who reported that acidity of apple cv. Red Delicious decreased with combined application of calcium chloride and boric acid.

Highest total sugars, reducing and non reducing sugars were recorded in treatment T_9 i.e PRD $_{50\%\ ETc}$ + F (15.27 %,3.72 % and 10.99 %) followed by T_8 i.e RDI $_{50\%\ ETc}$ + F as compared to no irrigation T_{10} (12.13 per cent, 2.19 per cent and 9.44 per cent). However, it was observed that total sugar, reducing and non reducing was higher in plants treated with deficit irrigation ETc 75 % and ETc 50 % (T_2, T_3, T_4 and in T_5) as compared to 100 per cent ETc i.e T_1 during 2017. Fruit quality, in terms of sugars were improved at lower water application levels over the higher water application levels at final harvest. This may be due to increase in total soluble solids associated with reduced fruit water content and greater hydrolysis of starch into sugars (Kramer, 1983). These results are in agreement with findings of Stoll *et al*. 2000 in grapvines, Dos Santos *et al.* 2003 in grepevines. The accumulated water stress produced active accumulation of glucose, fructose and sucrose, contributing to fruit osmotic adjustment, and consequently, more total and reducing sugar than in full irrigated fruits. The fruits harvested from plants under surplus water level had minimum sugar content due to increased water flow into fruit, which led to dilution of sugars in fruits. The results obtained in the present study were similar as reported by Yakushiji *et al.*(1996) who found that the total sugar content of the well watered Satsuma mandarin fruits and moderately drought stressed fruits was higher as compared to severely drought stressed ones. The increased sugar contents in treatment T_9 PRD $_{50\%\ ETc}$ + F might be due to the presence of potassium and boron which plays a very important role in the translocation of sugars from other parts into developing fruits. Similar findings were also observed by Sarker and Rahim (2013) who reported that total sugars and reducing sugars of mango fruit are significantly influenced by the foliar application of potassium on mango trees. Increase in sugar content may also be attributed to translocation of sugars which is enhanced with boron (Davenport and Peryea, 1990).

5.3.2 Nutrient status

During the present course of investigation it was observed that during both the years of investigation higher nutrient status of mango leaves with respect to Boron, potassium and calcium were recorded in the treatments receiving fertigation (Table 15 and 16) as compared to the treatments not subjected to fertigation. It was also observed that the treatments receiving deficit irrigation at 75 per cent recorded higher leaf nutrients status with respect to boron, potassium and calcium as compared to treatments receiving irrigation through full irrigation or no irrigation at all. Overall highest leaf boron, potassium and calcium (19.84 ppm and 20.16 ppm) boron, (0.28 % and 0.30 %) potassium and (1.79 % and 1.81 %) calcium, during 2017 and 2018, respectively, was recorded in T_7 i.e PRD $_{75\ \%\ ETc}$ + F, whereas, minimum leaf boron, potassium and calcium (13.83 ppm and 13.94 ppm) boron, (0.20 % and 0.21 %) potassium and (1.70 % and 1.72 %) calcium, during 2017 and 2018, respectively, were recorded in T_{10} (no irrigation). The increased level of leaf nutrient status with fertigation can be due to the combined effect of applied nutrients. Present findings are in agreement with the findings of Sankar *et al.* (2013) who also observed that the fertigation with boric acid and calcium nitrate on mango cv. Alphanso significantly influenced the status of N, P, K, Ca and B in leaves after fruit harvest. The results are also in line with the results of Taha *et al*. (2014) who reported that potassium application on mango trees increased the status of N, P and K in leaves after harvest and also attributed that the increase in leaf N, P and K content in fertigation treatments to be a consequence of better nutrient use efficiency through fertigation as compared to conventional method of fertilizer application. Furthermore, the periodical application of nutrients in solution reduced nutrient losses due to leaching and fixation besides provided a continuous supply of nutrients in readily available forms, all this might have lead in higher leaf nutrient status in these treatments as reported by Kachwaya *et al.* (2018) in strawberry. These results can also be corroborated with reports of Murthy *et al*. (2001) who also recorded highest mean macro and micro elements in leaf petiole of grapes with higher doses of water soluble fertilizers through drip irrigation. Dangler and Locascio, (1990) and Fontes *et al.*, 2000 also reported that fertigation technique provides consistent moisture regimes in the soil due to which roots remain active throughout the season resulting in optimum availability of nutrients in leaves. Fontes *et al.* (2000) and Dangler and Lacascio (1990) opined that application of K through drip irrigation increased the yield by the way of maximizing the mobility of nutrients around the root zone. Similarly, the higher leaf K, Ca and B content in drip fertigated plants might be attributed to the fact that fertigation helps in better uptake of nutrients due to frequent and timely application of fertilizers directly to the feeder root zone. Thus, results in better nutrient uptake by the plants and eventually improved nutrient use efficiency resulting into higher leaf nutrient content of plants subjected to fertigation. These findings were in close conformity with Kuchanwar *et al.* (2017) in Nagpur mandarin, Naik *et al*. (2016) in banana cv. Grand Naine and Haneef *et al.* (2014) in pomegranate.

5.3.3 Proline

In the present investigation highest proline content in mango leaves was recorded under no irrigation i.e T_{10} followed by plants subjected to T_5 i.e PRD 50% ETc + fertigation. Proline content in Treatment T_6 (RDI $_{75\ \%\ ETc}$ +F) was significantly low then all other treatments. However, it was observed that proline content was higher in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$, T_3 i.e PRD $_{75\ \%\ ETc}$, T_4 i.e RDI $_{50\ \%\ ETc}$ and in T_5 i.e PRD $_{50\ \%\ ETc}$ as compared to 100 per cent ETc i.e T_1 during 2017 and 2018. The present results showed that proline decreased in response to $Ca(No_3)_2$ treatments. In this respect, Jaleel *et al.* (2007) reported that drought stressed plants treated with $CaCl_2$ led to decrease the proline concentration, the negative impact of $CaCl_2$ on the proline may be ascribed to expanded level of proline corrupting protein and diminishing the proline synthesizing enzyme by the exogenous use of $CaCl_2$.

These results are in agreement with those obtained by Abdel-Razik and Abd-Raboh (2007), who found that mango plants produced more proline in leaves as a result of high water stress. Zaharah and Razi (2009), who studied “Chok Anan” mango trees under water stress, reported that leaf proline content increased under water stress and water stress with root restriction but decreased after re-watering. Similarly, in a comparative study in “Chok Anan” and “Khieo Sawoei” mango trees under water stress, it was found that leaf proline content was increased during withholding water and decreased in a few days after rewatering, while “Chok Anan” had higher leaf proline content than “Khioe Sawoei”, as the first is more resistant to drought stress (Elsheery and Cao. 2008). Proline accumulation under water stress helps the plant to resist drought (Paul *et al*. 2006). The increased accumulation of proline content within cell tissue appears to maintain osmotic pressure within cell tissue and is considered a response to drought stress (Claussen, 2002).

5.3.4 Pectin methylesterase

Pectin methylesterase activity of mango cv. Dashehari was significantly influenced by different irrigation levels. The PME activity of mango was increased under treatment T_{10} (no irirgation) whereas, activity decreased progressively under treatment T_8 RDI $_{50\%\ ETc}$ + F. However, it was observed that pectinmethyl esterase activity was lower in plants treated with deficit irrigation T_2 i.e RDI $_{75\ \%\ ETc}$, T_3 i.e PRD $_{75\ \%\ ETc}$, T_4 i.e RDI $_{50\ \%\ ETc}$ and in T_5 i.e PRD $_{50\ \%\ ETc}$ as compared to 100 per cent ETc i.e T_1. The decrease in activity of PME enzymes upon $Ca(No_3)_2$ application is understandable as calcium is reported to be in reducing the rate of fruit ripening and senescence (Ferguson, 1984), and these processes are normally accelerated by higher activities of PG and PME. Calcium treatments can change polygalacturonase activity by reducing enzyme export in the apoplast and slowing down the production of pectin degrading enzymes (Rigney and Wills, 1981). Calcium treatments also increase cell turgor and maintain tissue firmness (Zocchi and Mignani, 1995). The present results are in accordance with the earlier work of Nunes *et al.* (2005) who also observed that treatment of 'Premier' peach fruits with 1.0 per cent calcium chloride led to less solubilization of pectins and lower pectin methyl esterase and polygalacturonase activities. The PME activity remained low on fruits treated with Ca and B. PME is responsible for the de-esterification of pectin required before PG starts the depolymerization of pectins associated with fruit softening (Mc Cready *et al.,* 1955).

The level of PME activity decreased under water stress conditions. The lowest PME activity under the 50% watering regime, indicating its high resistance to weight loss due to cell wall degradation. These results are also confirmed by the PME/dry matter ratio values (Wood and Siddiqui 1971; Spagna *et al.,* 2003).

5.5 Effect of deficit irrigation on fruiting characteristics of mango

5.5.1 Yield attributes

The various irrigation and fertigation levels exhibited a significant influence on yield of mango cv. Dashehari. During both the years, it was observed that fruit yield, fruits per tree and fruit set was higher in plants treated with deficit irrigation at 75% ETc both in RDI and PRD i.e T_2 (RDI $_{75\ \%\ ETc}$), T_3 (PRD $_{75\ \%\ ETc}$), whereas, fruit yield was lower when deficit irrigation was provided at 50% ETc i.e T_4 (RDI $_{50\ \%\ ETc}$) and in T_5 i.e (PRD $_{50\ \%\ ETc}$). The better size and weight of fruits under treatment T_7 (PRD 75% ETc + Fertigation) may be due to higher availability of water which accounted for higher total yield in the T_7 (47.02 and 97.11 kg/tree) during both years 2017 and 2018 respectively. These results are in accordance with the findings of Minami *et al.* (1982), Tekinel *et al*. (1989) and Yuan *et al*. (2004), who also recorded significant increase in fruit yield of strawberry under higher level of drip irrigation and they attributed it due to optimum soil moisture condition owing to frequent, precise and direct application of water to root zone. The possible reason for higher fruit yield under treatment (T_7) may be due to water deficit in root zone which suppressed the vegetative growth of the plants without bringing much effect on leaf photosynthesis rate and the mango plants invested higher quantity of photosynthates towards reproductive growth then vegetative growth. A comparison of data among different levels revealed that, the plants irrigated at 50% ETc through drip produced minimum yield during both the years of study. This may be attributed due to the fact that under this level of drip irrigation less amount of irrigation water was applied in each irrigation, which might have resulted in the development of water stress conditions and further reduced the uptake of nutrients. Water stress conditions have been found to interfere in cell division and cell enlargement (Hsiao, 1973) thereby reduced the size of fruits and ultimately the yield. These results are in line with Kim *et al*. (2009). Panigrahi *et al.* (2012) also observed highest yield of Nagpur mandarin under DI at 80% Ecp followed by 100Ecp. Peterson (1998) found that the fruit size and overall fruit quality of fertigated plants was considerably better as compared to that of the non-fertigated plants. It seems that uniform distribution of nutrients, coupled with its confinement in the root zone under fertigation, might have led to the increased nutrient uptake. Similarly, Martinsson *et al*. (2006) found that fertigation with full nutrient package increased yield (186.6 g/plant) as compared to common practice (113.8 g/plant). The increased nutrients content might have increased the rate of various physiological and metabolic processes in the plant system, ultimately resulted in higher vegetative growth parameters. The increased fruit set could be possibly attributed to large reduction in the extent of fruit drop with increased moisture regimes.

More fruit number per plant was observed in PRD $_{75\%\ ETc}$ + F (T_7) over the other deficit irrigation treatments. Possible reason for this is that roots under drought stress produce ABA as a hormonal signal to the shoot to reduce stomatal aperture (Hartung *et al*., 2002). In higher concentrations, root-borne ABA is involved in shedding of leaves (Gomez-Cadenas *et al*., 1996). ABA is involved in fruit drop in the early stages of mango development. PRD at 75% could have a less relative water stress and consequently lesser amount of ABA synthesis could have taken place, which resulted in more fruits to retain on trees till maturity.

5.1.13 Number of fruits according to size classes

The fruits harvested in all the treatments were similar in size and weight. The fruits harvested from trees under all the treatments weighed between 166.60 – 208.29 g, hence could not be differentiated into different grades. Only the fruits under T_7 (206.45 g and 208.29 g) during both years 2017 and 2018 respectively, recorded fruit size above 200gm thus can be grouped in grade (A). Lower fruit size of mango cv. Dashehari have been attributed to low soil moisture during the growing season under 50% ETc drip irrigation treatment, hence, the fruits failed to attain normal size and weight due to low availability of soil moisture as such fruit size is directly related to the availability of soil moisture (Hsiao, 1973).

5.5 Irrigation water productivity of mango

In the present investigation the higher water productivity was attributed to the higher yield accompanied with less amount of irrigation water used. Under rainfed conditions the water productivity was lowest of about 4.07 kg m^{-3} and 13.05 kg m^{-3} during both the years. This lower water productivity resulted from the lower yield and without any supplemental irrigation. Partial root zone drying ($PRD_{75\ \%\ ETc}$) along with fertigation exhibited higher water productivity on account of the fact that along with irrigation the plant has got access to the required nutrition for its growth and hence the treatment with fertigation exhibited the maximum water productivity. The increase in water use efficiency in drip fertigation treatments over no irrigation treatment was mainly due to considerable saving in irrigation water and increased yield. Corroborative results also made by Arunadevi *et al.* (2007) in mulberry.

5.6 Soil and plant water attributes

5.6.1 Soil moisture

The data presented in Table 22 and 23 revealed that the average soil moisture during first year (2017) of investigation at different depths during the crop growth period of mango cv. Dashehari was found to be maximum under treatment T_1 (100 % ETc) at 0-20 cm of soil depth the where average soil moisture was recorded as 20.2 and it increased with increase in depth at 20-40 cm of soil depth it was recorded (22.4), 40-60 cm of soil depth (22.8) and 60-100 cm of soil depth (23.1). The soil moisture was recorded minimum under treatment T_{10} no irrigation, at different soil depth 0-20 cm, 20-40 cm, 40-60 cm and 60-100 cm soil moisture was recorded 16.4, 16.8, 17.3 and 18.2. During second year of second year of investigation, maximum soil moisture was recorded under treatment T_1 (100 % ETc) at different depths 0-20 cm, 20-40 cm, 40-60 cm and 60-100 cm soil moisture was recorded as 22.2, 22.8, 23.4 and 24.4. The soil moisture was recorded minimum under treatment T_{10} no irrigation, at different soil depth 0-20 cm, 20-40 cm, 40-60 cm and 60-100 cm soil moisture was recorded as 15.4, 17.3, 17.6 and 18.8. These results suggested that under drip irrigation, the moisture content was higher in soil surface as compared to no irrigation. The higher soil moisture in the surface may be attributed to the fact that, under drip irrigation water was applied at regular intervals in smaller quantities, which remained confined in the upper layer only. Whereas, under no irrigation, higher hydraulic gradients was created owing to application of bulk volume of water per irrigation with quite wider irrigation frequency, which results in more rapid downward movement of water. These results are in close conformity with the findings of Kumar *et al*. (2011), who also recorded higher soil moisture content in drip irrigation at 1.0 V volume of water as compared to surface irrigation in strawberry.

5.6.2 Soil water potential

The data presented in Table 24 and 25 revealed that the average soil water potential during first year of investigation at different depth during the crop growth period of mango cv. Dashehari was found maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (52 kPa), at 60 cm depth it was recorded (60 kPa) in month of March and it was found minimum under treatment T_1 (100 % ETc). In month of April the average water potential was found maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (54kPa), at 60 cm depth it was recorded (62 kPa) and it was found minimum under treatment T_1 (100 % ETc) whereas in month in May the average water potential was found maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (52 kPa), at 60 cm depth it was recorded (60 kPa) and it was found minimum under treatment T_1 (100 % ETc). During second year of investigation the soil water potential was recorded maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (52 kPa), at 60 cm depth it was recorded (60 kPa) in month of March and it was found minimum under treatment T_1 (100 % ETc). In month of April the average water potential was found maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (52 kPa), at 60 cm depth it was recorded (60 kPa) and it was found minimum under treatment T_1 (100 % ETc) whereas in month in May the average water potential was found maximum under treatment T_{10} (no irrigation) under 20-40 cm of soil depth (54 kPa), at 60 cm depth it was recorded (60 kPa) and it was found minimum under treatment T_1 (100 % ETc), the values are reduced within the treatments reflecting the drying of the soil, the demand increasing by the atmosphere, and the high vapor saturation deficit reported by Cotrim *et al.* 2011.

5.6.3 Leaf temperature

Data pertaining to the leaf temperature as recorded for various treatments for the two consecutive years (2017 and 2018) are depicted in Table 26 and 27. During both the years of investigation average air temperature in month of March was recorded to be (25.5 ^{0}C and 28.2 ^{0}C, 2017 and 2018, respectively and leaf temperature was recorded to be maximum under treatment T_{10} (no irrigation) i.e 29.8 ^{0}C and 31.5 ^{0}C, 2017 and 2018 respectively whereas minimum canopy temperature was recorded under treatment T_1 (100% ETc) (24.0 ^{0}C and 27.8 ^{0}C, 2017 and 2018, respectively). In case of deficit irrigation i.e both 75 % and 50 % RDI and PRD treated plants the average leaf temperature was higher then full irrigation i.e T_1 (100 % ETc). In the month of April the average air temperature was recorded as (33.6 ^{0}C and 35.4 ^{0}C, 2017 and 2018, respectively) whereas maximum leaf temperature was recorded to be 36.5 ^{0}C and 39.1 ^{0}C during 2017 and 2018, respectively and minimum leaf temperature was recorded 32.8 ^{0}C and 34.2 ^{0}C (2017 and 2018, respectively) while in case of deficit irrigation i.e both 75 % and 50 % RDI and PRD treated plants the average leaf temperature was higher then full irrigation i.e T_1 (100 % ETc). During the month of month of May air temperature was recorded as 40.5 ^{0}C and 38.8 ^{0}C (2017 and 2018, respectively whereas maximum leaf temperature was recorded 42.6 ^{0}C and 42.8 ^{0}C (2017 and 2018, respectively) minimum leaf temperature was recorded 38.5 ^{0}C and 38.5^{0}C (2017 and 2018) respectively and in case of deficit irrigation i.e both 75 % and 50 % RDI and PRD treated plants the average leaf temperature was higher than full irrigation i.e T_1 (100 % ETc). Direct measurement of leaf temperature has been related to crop water stress based on the fact that under stress-free conditions the water transpired by the plants evaporates and cools the leaves. Conversely, in a water-deficit situation, little water is transpired and the leaf temperature increases. This is also the dominant mechanism when the canopy is considered as a whole (Idso and Baker 1967).

5.7 Economics

Maximum benefit: cost ratio was obtained with irrigation scheduled with PRD $_{75\%\ ETc}$ + F (T_7) followed by T_6 (RDI $_{75\%\ ETc}$ + F), T_8 (RDI $_{50\%\ ETc}$ + F), T_9 (PRD $_{50\%\ ETc}$ + F) whereas, minimum was obtained with no irrigation T_{10}. This may be due to the fact that the cost of cultivation increased with the increase in application of irrigation level and due to increased production. The present results are in conformity with the findings of Bhattacharya (2010) found that the benefit cost ratio was the highest in treatment combination of drip irrigation at 0.75 EpR and fertigation with 75 per cent recommended dose of N and K which was closely followed by treatment combination of drip irrigation at 0.75 EpR and fertigation with 100 per cent recommended dose of N and K through drip in banana cv. Barjahaji (AAA) and Qin *et al.* 2018 reported that PRD produced 3.1% higher net benefit than DI.

Sujatha and Haris (2006) indicated that, drip irrigation resulted in realizing a net return of `68,581 ha-1. Similarly the net return per rupee investment was also higher with drip fertigation system in arecanut.

5.8 Effect of deficit irrigation on shelf life of mango

5.8.1 Physiological loss in weight

Physiological loss in fruit weight during storage is mainly due to evaporation of water, respiration and degradation processes during pre harvest handling and is also influenced by storage. In the present investigation the physiological loss in weight increased with increase in storage period. On mean value basis maximum PLW was recorded in T_{10} (no irrigation) (21.06 %) throughout the storage period whereas, minimum PLW (12.8 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) throughout the storage period. The present results are in agreement with those obtained by Rathore *et al.* 2007, who found that weight loss in mango fruits proportionally increased with increasing number of days. The authors reported that the increase in fruit weight loss may be due to respiration and transpiration of water through fruit peel tissue and to some biological changes occurring in fruits. Mahajan and Sharma (2000) stated that reduction in weight loss in peach fruits as a result of calcium application may possibly be due to the action of $CaCl_2$ in lowering the respiration rate and protecting the cell membrane from disintegration thereby leading to delay in senescence. These findings substantiate the earlier reports on the aspects by Singh *et al.* (1982) in peaches; Gupta and Mehta (1988) in ber; Singh and Chauhan (1993) in guava.

5.8.2 Decay loss

The data on decay loss in mango cv. Dashehari during storage presented in Table 34 and 35 shows that decayed fruits could not be detected for 4 days. The percentage of decayed fruits increased with increase in storage period. The minimum decay loss was obtained in T_7 i.e PRD $_{75\%\ ETc}$ + F. The considerable decrease in decay loss due to calcium application might be due to its anti-senescence property. The reduction in fruit decay with calcium may possibly be due to its beneficial effect on firmness of fruit tissues by retarding the rate of respiration and prevent the cellular disintegration by maintaining protein synthesis, which leads to delay in senescence. These results corroborate with the findings of Singh *et al.* (1987) in mango, Siddiqui *et al.* (1989) in ber. Abdel-Razik (2012) reported that the reduction in irrigation water from 100% to 70% ETc decreased the decayed fruit percentage in storage. The increase in number of days under storage increased the decayed fruit percentage. It seems that after reaching ripening stage in storage, the percentage of decayed fruits increased drastically.

5.8.3 Fruit moisture

The results in Table 36 and 37 clearly show that percent fruit moisture decreased with increase in storage period in both the years. On mean value basis maximum percent fruit moisture content was recorded in T_7 (PRD $_{75\ \%\ ETc}$ + F) throughout the storage period whereas, minimum fruit moisture was recorded in T_{10} (no irrigation) throughout the storage period. The reduction in moisture content may be due to fruit skin transpiration and to some extent to fruit respiration as reported by Rathore *et al.* (2007). The present results are also similar with the finding of Proietti and Antognozzi (1996), who reported that with increasing irrigation regime, pulp water content of olive was increased.

5.8.4 Firmness

A perusal of data during the first year of investigation reveals that with advancement of storage life, the fruit firmness decrease. On mean value basis maximum fruit firmness content was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) (21.62 lb/in^2) throughout the storage period whereas, minimum fruit firmness content was recorded in T_{10} (no irrigation) (14.61 lb/in^2) throughout the storage period. On mean value basis maximum fruit firmness content was recorded on 0 day of storage (24.56 lb/in^2) which decreased significantly and continuously up to 10th the day of storage (10.80 lb/in^2). However, interaction between treatments and storage were observed to be non significant. Firmness is a criterion often used to evaluate fruit quality as it is directly related to fruit development, maturity, ripening and storage potential. It is also related to the likelihood of bruising when fruits are subjected to impact during handling (Lesage and Destain, 1996). Fruit firmness is also an important quality in fruit production that can decide which fruit will be harvested, transported, stored, or marketed. The results of this study showed an increase in fruit firmness with reduction in water application. The firmness of fruits and vegetables is mainly influenced by their moisture contents. Thus the higher the moisture content the lower the firmness and vice versa. Hosakote *et al*.(2006) also observed that softening in fruit texture from unripe to ripe stage of mango was a result of a decrease in starch content, pectin, cellulose and hemicelluloses. This result is in agreement with the findings of Proietti and Antognozzi, (1996) on olive and Abdel-Razik, (2012) on mango fruit who reported that increasing irrigation water decreased the fruit firmness and vice versa. The difference in firmness may be due to differences in their pectin composition (Billy *et al*., 2008). In other words, the reduction in irrigation water should slow down fruit ripening under storage.

5.8.5 Total soluble solids

During first year of investigation, percent total soluble solid of mango cv. Dashehari revealed that with the advancement of storage life, the per cent TSS increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage. On mean value basis maximum TSS content was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) (17.41 %) throughout the storage period whereas, minimum TSS content was recorded in T_{10} (no irrigation) (13.91 %) throughout the storage period. On mean value basis minimum TSS in mango fruits showed a significant increasing trend from

0 day (10.08 %) to 6th day of storage (19.28 %) and showed a significant and continuous decrease thereafter and was recorded to 17.20 % at on 10th day of storage i.e. at the end of storage period. However, interaction between treatments and storage were observed to be non significant. TSS was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar increase with increase in storage period as in 2017. These results correspond with those obtained by Zheng *et al.* (2012) who reported that TSS increased in the juice of mango fruit during storage. The increase in TSS might be due to the breakdown of the complex form of carbohydrates into simple sugars during storage period. According to Rathore *et al.* (2007) the increase in TSS is directly correlated with hydrolytic changes in starch and conversion of starch to sugar being an important index of ripening process in mango.

Abdel-Razik (2012) showed that TSS increased with the reduction of irrigation water given to the orchard and the maximum increase was recorded at 70% of ETc. The increase in TSS up to certain period signified the period of active synthesis of carbohydrates in fruits, while declining trend in TSS followed thereafter, indicated the degradation and fermentation of sugars signaling the onset of senescence stage (Ryall and Pentzer, 1974).

5.8.6 Total acidity

During first year of investigation, percent total acidity of mango cv. Dashehari revealed that with the advancement of storage life, the per cent total acidity decreased significantly upto10th day of storage. On mean value basis maximum total acidity content was recorded in T_{10} (no irrigation) (0.23 %) throughout the storage period whereas, minimum total acidity content was recorded in T_9 (PRD 50% + F) (0.15 %) throughout the storage period. On mean value basis minimum total acidity in mango fruits showed a significant decreasing trend from 0 day (0.24 %) to 10th day of storage (0.13 %) i.e. at the end of storage period. However, interaction between treatments and storage were observed to be non significant. Total acidity was higher in the year 2018 as compared to year 2017 irrespective of treatments and showed similar decrease with increaseing in storage period as in 2017. Similar changes were reported by Rathore *et al.* (2007) in mango that titratable acidity showed a decreasing trend during 15 days of storage period. They added that the decrease in acidity may be attributed to the increase in activity of citric acid glyoxylase during ripening; the reduction in acidity also may be due to their conversion into sugars and their further utilization in metabolic process in the fruit. The role of calcium in reducing the fruit acidity has been reported by various workers in many fruit crops (Sharma *et al.,* 1991 in guava, Bhat *et al.,* 1997 in cherry).

5.8.7 Carotenoids

During first year of investigation, carotenoids content in mango fruits was found to increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage. The maximum carotenoids was reported in T_{10} (no irrigation) during 0th, 2nd, 4th and 6th day of storage i.e 2.28, 6.45, 6.48 and 12.95 mg/100g pulp respectively and later on decreased during 8th and 10th day of storage i.e 11.78 and 10.60 mg/100g pulp and minimum carotenoids was reported in T_9 (PRD $_{50\%\ ETc}$ + F) i.e 0.97 mg/100g pulp on 0th day of storage, 3.99 mg/100g pulp on 2nd day of storage, 4.03 mg/100g pulp on 4th day of storage, 10.14 mg/100g pulp on 6th day of storage, 9.00 mg/100g pulp on 8th day of storage, 8.84 mg/100g pulp on 10th day of storage. The findings of second year revealed that with the advancement of storage life, the carotenoid content in mango fruits was found to increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage. The maximum carotenoids was reported in T_{10} (no irrigation) during 0th, 2nd, 4th and 6th day of storage i.e 2.30, 6.47, 6.50 and 12.97 mg/100g pulp respectively and later on decreased during 8th and 10th day of storage i.e 11.80 and 10.62 and minimum carotenoids was reported in T_9 (PRD 50% ETc + F) i.e 0.99 mg/100g pulp on 0th day of storage, 4.01 mg/100g pulp on 2nd day of storage, 4.05 mg/100g pulp on 4th day of storage, 10.16 mg/100g pulp on 6th day of storage, 9.02 mg/100g pulp on 8th day of storage, 8.86 mg/100g pulp on 10th day of storage. Haribabu and Krishamurthy (1993) in Alphonso mango and Ramkrishna *et al.* (2001) in papaya who reported that the rate of increase in total carotenoids was more in the control fruits as compared to fruits sprayed with higher concentration of calcium chloride and calcium nitrate. It was observed that the carotenoids content of the pulp increased steadily as the storage period increased. The increase in the carotenoids of the pulp maybe attributed to the concurrent increase of pigment synthesis in the pulp as the storage advanced and does not just involve a simple unmasking of carotenoids (Kays, 1991; Fennema 1996). Similar result was reported in mango cultivar Dashehari by Periyathambi (2013).

5.8.8 Nutrients status

Results related to nutrient content of fruit pulp in present experiment shown in Table 46, 47, 48, 49, 50 and 51 depict that nutrient content of fruit pulp decreased with corresponding increase in storage period. Results of present experiment depict that nutrient content of fruit pulp decreased with corresponding increase in storage period. On mean value basis maximum nutrient content was recorded in T_7 (PRD $_{50\ \%\ ETc}$ + F) throughout the storage period whereas, minimum nutrient content was recorded in T_{10} (no irrigation) throughout the storage period. Thus, results in better nutrient uptake by the plants and eventually improved nutrient use efficiency resulting into higher fruit nutrient content of plants subjected to fertigation. These findings were in close conformity with Kuchanwar *et al.* (2017) in Nagpur mandarin, Naik *et al*. (2016) in banana cv. Grand Naine and Haneef *et al.* (2014) in pomegranate.

5.8.9 Reducing sugar

The data on reducing sugar in mango cv. Dashehari during storage presented in Table 52 and 53 shows that the per cent reducing sugar increased significantly upto 6th day of storage and then decrease on 8th and 10th day of storage during both the years (2017 and 2018). During first year of investigation (2017), maximum reducing sugar (7.74 %) was recorded under fertigated plants in T_9 (PRD $_{50\%\ ETc}$ + F) on 6th day of storage and was followed by T_8 (RDI $_{50\%\ ETc}$ + F) (7.56 %) on 6th day of storage whereas, minimum reducing sugar (5.09%) was observed in T_{10} (no irrigation) on 10th day of storage. During storage reducing sugar in mango fruits showed a significant increasing trend from 0 day (1.95 %) to 6th day of storage (6.56 %) and showed a significant and continuous decrease thereafter and was recorded to be 6.10 % on 10th day of storage i.e. at the end of storage period. During second year of experimental study the per cent non reducing sugar of mango during storage period followed trend similar to preceding year of investigation. Kahlon and Uppal (2005) suggested that conversion of starches and polysaccharides into simple sugar with the advancement of storage was responsible for the increase of reducing sugar, and onward decline was due to the utilization of sugar in evapotranspiration and other biochemical activities. The increase in sugar may be due to break down of complex polymers in to simple substances by hydrolytic enzymes. Boron facilitated sugar transport within the plant and it was also reported that borate react with sugar to form a sugarborate complex (Gauch and Dugger, 1953).

5.8.10 Non reducing sugar

The data depicted in table 54 and 55 pertaining to non reducing sugar of mango cv. Dashehari under different treatments shows that during first year of investigation (2017), maximum non reducing sugar was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) on 6^{th} day of storage (11.10 %) and was followed by T_9 (10.96 %) on 6^{th} day of storage whereas, minimum non reducing sugar was observed in T_{10} (no irrigation) on 10^{th} day of storage (7.38 %). During storage non reducing sugar in mango fruits showed a significant increasing trend from 0 day (4.11 %) to 6^{th} day of storage (10.91 %) and showed a significant and continuous decrease thereafter and was recorded to 9.07 % on 10^{th} day of storage i.e. at the end of storage period. During second year of experimental study the per cent non reducing sugar of mango during storage period followed trend similar to preceding year of investigation.

It was observed that the proportion of reducing sugar content was less as compared to non reducing sugar both at ripe and at the end of shelf life supporting the findings of Sudhavani and Ravisankar (2002) . The increase in sugar may also be due to break down of complex polymers in to simple substances by hydrolytic enzymes. Boron facilitated sugar transport within the plant and it was also reported that borate react with sugar to form a sugarborate complex (Gauch and Dugger, 1953). The data showed that the fruits treated with potassium nitrate exerted highest non reducing sugars. It might be possible due to the reason that potassium treatment could be attributed to enhance photosynthetic efficiency of the leaves and a possible increase in translocation of assimilates into the fruit (Singh *et al.,* 1982). These findings are in conformity with several workers along with Kumar and Reddy (2008), Sarker and Rahim (2013), Baiea *et al.,* (2015) in mango fruit.

5.8.11 Total sugar

The results depicted in Table 56 and 57 clearly show that percent fruit total sugar increased significantly upto 6^{th} day of storage and then decreased on 8^{th} and 10^{th} day of storage during both the years (2017 and 2018). On mean value basis maximum total sugar content (16.01 %) was recorded in T_9 (PRD $_{50\%\ ETc}$ + F) throughout the storage period whereas, minimum total sugar content (10.62 %) was recorded in T_{10}

(no irrigation) throughout the storage period. The data showed that the fruits treated with potassium nitrate exerted highest total sugars. It might be possible due to the reason that potassium treatment could be attributed to enhance photosynthetic efficiency of the leaves and a possible increase in translocation of assimilates into the fruit (Singh *et al.*, 1982). Boron facilitated sugar transport within the plant and it was also reported that borate react with sugar to form a sugarborate complex (Gauch and Dugger, 1953).

5.8.12 Pectin

Results of present experiment depict that pectin content of fruit pulp decreased with corresponding increase in storage period during both the year 2017 and 2018 respectively. On mean value basis maximum pectin content was recorded in T_9 (PRD $_{50\ \%\ ETc}$ + F) 0.294 per cent and 0.296 per cent during 2017 and 2018 respectively whereas, minimum pectin content (0.199 per cent 0.201 per cent) during both the years was recorded in T_{10} (no irrigation) throughout the storage period. The fall in total pectin during storage was observed to be associated with the occurrence of slight mealiness in the fruit, presumably through the degradation of polygalacturonic acid chains since, the viscosity of extracted pectin was found to decrease in fruits (Eggenberger, 1949; Mc Cready, 1954 and Mc Comb, 1955).

Chapter-6

Summary and Conclusion

CHAPTER VI

SUMMARY AND CONCLUSION

The present investigations entitled "Studies on water and nutrient management in mango (***Mangifera indica*** **L.)** cultivar Dashehari under Jammu subtropics" were carried out at the farmer's field Akhnoor, Jammu during 2017 and 2018.

The salient results of the studies are summarized as under:

6.1 EFFECT OF IRRIGATION AND FERTIGATION

6.1.1 The data related to flowering behavior of mango cv. Dashehari experienced range of variability amongst the treatment. During first and second year of study date of appearance of panicle and date of full bloom was recorded earlier under T_7 (13th February and 15th February) during 2017 and 2018, respectively and (6th March and 8th March) during 2017 and 2018, respectively comprising of PRD $_{75\%\ ETc}$ + F. This was followed closely by the treatment T_6 having irrigation schedule with RDI $_{75\%\ ETc}$ + F and date of appearance of panicle and date of full bloom was recorded late in treatment T_1 (100 % ETc) i.e 19th February and 21st February during 2017 and 2018, respectively and 11th March and 15th March during 2017 and 2018, respectively.

6.1.2 Maximum increase in panicle length and breadth (25.87 cm and 12.90 cm) was observed under T_7 comprising of PRD $_{75\%\ ETc}$ + F followed by (24.04 cm and 12.56 cm) in RDI $_{75\%\ ETc}$ + F (T_6) while minimum increase in panicle length and breadth was recorded under no irrigation (T_{10}).

6.1.3 Duration of flowering was found maximum under treatment T_7 PRD $_{75\%\ ETc}$ + F (25 and 27 days), and minimum number of days were recorded under treatment T_{10} no irrigation (22 and 21 days) during both the years 2017 and 2018, respectively. During first and second year of the study, the fruit set was obtained from 22nd March and 24th March during 2017 and 2018, respectively under T_7 (PRD $_{75\%\ ETc}$ + F). Treatment T_1 (100% ETc) and T_5 (PRD $_{50\%\ ETc}$) were the last to come into fruit set (29th and 28th March). During the year 2017, the mango fruit were harvest first on 15th June under treatment T_6 (RDI $_{75\%\ ETc}$ + F), T_7 (PRD $_{75\%\ ETc}$ + F), T_{10} (no irrigation) followed by treatment T_8 (RDI $_{50\%\ ETc}$ + F) on 18th June. During 2018, mango fruit under treatment T_6 (RDI $_{75\%\ ETc}$ + F) and T_7 (PRD $_{75\%\ ETc}$ + F) were first to be harvested on (14th June) followed by treatment T_8 (RDI $_{50\%\ ETc}$) on (17th June), while treatment T_1 with 100% irrigation were last to be harvested on 20th of June and 22nd June during 2017 and 2018, respectively.

6.1.4 Treatment T_1 consisting of 100% ETc recorded the maximum tree height and tree spread of east-west and north-south direction of mango cv. Dashehari whereas, minimum tree height and tree spread of east-west and north-south direction was recorded under T_{10} i.e no irrigation.

6.1.5 Maximum in stock girth and scion girth (64.62 cm and 61.25 cm) was observed under T_1 comprising of 100% ETc while minimum stock girth and scion girth was recorded under no irrigation (T_{10}) whereas the plants applied with T_1 100% ETc showed maximum stock: scion ratio 0.947.

6.1.6 The results revealed that various treatments have significant effect on average fruit weight, fruit volume, fruit length and breadth which reached to maximum under treatment T_7 (PRD $_{75\%\ ETc}$ + F) and minimum fruit weight, fruit volume, fruit length and breadth was found in control T_{10} no irrigation. Maximum increase in specific gravity was observed under T_7 comprising of PRD $_{75\%\ ETc}$ + F while minimum specific gravity was recorded under (T_{10}) i.e no irrigation.

6.1.7 The plants applied with T_9 (PRD $_{50\%\ ETc}$ + F) showed maximum total soluble solids, titratable acidity and sugar acid ratio 20.43 ^{0}Brix, 0.27 per cent and 92.99 whereas minimum total soluble solids, titratable acidity and sugar acid ratio was recorded under no irrigation i.e T_{10}.

6.1.8 Highest total sugars, reducing sugar and non reducing sugar were recorded in fruits harvested from the plants receiving irrigation scheduled with PRD $_{50\%\ ETc}$ + F (T_9) whereas, lowest total sugar, reducing sugar and non reducing sugar was observed under no irrigation i.e (T_{10}).

6.1.9 The leaf potassium, calcium and boron was found maximum under treatment T_7 consisting of (PRD $_{75\%\ ETC}$ + F) and minimum leaf potassium, calcium and boron was recorded under (T_{10}) no irrigation.

6.1.10 The proline content was found to be maximum (36.21µg g–1 FW) in fruits obtained under treatment T_{10} (no irrigation) whereas minimum proline content 19.61 µg g–1 FW was recorded under T_6 (RDI $_{75\%\ ETc}$ + F).

6.1.11 Highest PME activity was recorded in fruits harvested from the plants receiving irrigation scheduled with no irrigation T_{10}. Whereas, lowest PME activity was observed under T_8 (RDI $_{50\% \text{ ETc}}$ + F).

6.1.12 Various irrigation level treatments exhibited a significant influence on yield, fruit set and number of fruits/tree of mango fruit and plants treated with PRD $_{75\% \text{ ETC}}$ + F (T_7) gave maximum yield of 72.06 kg/tree, 0.96 per cent and 346.5 while yield, fruit set and number of fruits/tree of mango fruit was minimum under plants treated with T_{10} (no irrigation). The per cent fruit drop was found maximum under treatment T_{10} consisting of no irrigation and minimum per cent fruit drop was recorded under T_7 (PRD $_{75\% \text{ ETc}}$ + F).

6.1.13 The mango fruits harvested from all the treatments were in same group 200-350 gram under treatment T_7 PRD 75% ETc applied to alternating side of root system + Fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%).

6.1.14 Treatment T_{10} (no irrigation) i.e 2.87 kg/m^{3}was recorded minimum water use efficiency whereas maximum water use efficiency was recorded under treatment T_9 (12.70 kg/m^3) during 2017. Maximum water use efficiency was recorded T_9 (26.27 kg/m^3) whereas minimum was recorded under treatment (T_{10}) during 2018.

6.1.15 The data related to average soil moisture during first and second year (2017 and 2018) at different depths (0-20 cm, 20-40 cm, 40-60 cm, 60-100 cm) during the crop growth period of mango cv. Dashehari was found to be maximum under treatment T_1 (100 % ETc) at whereas it was found minimum at T_{10} (no irrigation).

6.1.16 The data related to average soil water potential during first and second (2017 and 2018) year of investigation at different depths during the crop growth period of mango cv. Dashehari was found maximum under treatment T_{10} (no irrigation) whereas it was found minimum in T_1 (100 %ETc) during 2017 and 2018 respectively.

6.1.17 Data pertaining to the leaf temperature was recorded to be maximum under treatment T_{10} (no irrigation) whereas, minimum leaf temperature was recorded under treatment T_1 (100% ETc). In case of deficit irrigation i.e both 75 % and 50 % RDI and PRD treated plants the average canopy temperature was higher than full irrigation i.e T_1 (100 % ETc) during both the years 2017 and 2018 respectively.

6.1.18 The highest benefit cost ratio was recorded under treatment T_7 (PRD $_{75\% \text{ ETc}}$ + F) 1:2.30 which was closely followed by T_6 (RDI $_{75\% \text{ ETc}}$ + F), while lowest benefit cost ratio was observed under no irrigation (T_{10}) i.e 1:1.31 during 2017. During the year 2018 the highest benefit cost ratio was recorded under treatment T_7 (PRD $_{75\%\ ETc}$ + F) 1:4.87 while lowest benefit cost ratio was observed under no irrigation (T_{10}) i.e 1:3.23.

6.1.19 Highest physiological loss in weight (21.06% and 21.10%) and decay loss (51.00% and 52.20%) was recorded in fruits harvested from the plants receiving irrigation scheduled with no irrigation i.e (T_{10}) during 2017 and 2018 respectively. Whereas, lowest physiological loss in weight was observed under (PRD $_{50\%\ ETc}$ + F) T_9 (12.81% and 12.85%) and minimum per cent of decay loss was recorded under treatment T_7 (PRD $_{75\%\ ETc}$ + F) 32.33% and 33.33%.

6.1.20 During storage condition maximum increase in fruit moisture content was observed under T_7 comprising of PRD $_{75\%\ ETc}$ + F (77.46% and 77.72%) while minimum increase in fruit moisture content was recorded under no irrigation (T_{10}) 70.55% and 70.83% during 2017 and 2018.

6.1.21 The plants applied with T_9 (PRD $_{50\%\ ETc}$ + F) 21.622 lb/inch^2 and 22.476 lb/inch^2 showed maximum fruit firmness then those under no irrigation (T_{10}) during storage period during 2017 and 2018.

6.1.22 The plants applied with T_9 PRD $_{50\%\ ETc}$ + F showed maximum total soluble solids, titratable acidity, total sugar, reducing and non reducing sugar whereas minimum total soluble solids, titratable acidity, total sugar, reducing and non reducing sugar was recorded under no irrigation i.e T_{10} during storage period.

6.1.23 During storage condition carotenoids content was recorded maximum under no irrigation T_{10} (8.42 mg/100gm pulp and 8.44 mg/100gm pulp) while minimum increase was recorded under T_9 comprising of PRD 50% ETc + F (6.16 mg/100gm pulp and 6.18 mg/100gm pulp) during both the years 2017 and 2018.

6.1.24 The fruit potassium, calcium and boron content was found maximum under treatment T_7 consisting of PRD 75% ETc + F and minimum fruit potassium, calcium and boron content was recorded under T_{10} i.e no irrigation.

6.1.25 Throughout the storage pectin content was recorded maximum under T_9 comprising of PRD 50% ETc + F (0.294 and 0.296 %) while minimum was recorded under no irrigation T_{10} during both the years 2017 and 2018.

Conclusion

Out of different modes of irrigation scheduling the present investigation employed the weather based (Pan E based) irrigation scheduling. However, it was found that the owing to light texture and rocky soil, the field capacity of the soil was less and the value was about 20 cm^3 m^{-3} and permanent wilting point was 0.08 $cm^3 m^{-3}$ soil. Therefore, 75 % of water estimated by 100% ETc should be given to mango crop growing in kandi areas for best yield. The present investigation reveals that out of various deficit irrigation methods PRD mode of irrigation expresses the best result because of the fact that alternate drying and wetting induces water stress in response to which ABA is synthesized. This ABA synthesis in roots gives signal for slow transpiration. Thus PRD gave best results over RDI at same levels of irrigation. PRD also resulted in better fruit quality in terms of TSS and sugars. When PRD and RDI were supplemented with fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%) both yield and quality improved with same level of irrigation. Thus it is recommended that mango crop of cv. Dashehari growing in kandi areas should be irrigated at 75% of ETc in PRD mode once in a week supplemented by fertigation with K_2SO_4 (0.5%), H_3BO_3(0.5%) and $Ca(NO_3)_2$(1%).

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CERTIFICATE-IV

Certified that all necessary corrections as suggested by external examiner and the advisory committee have been duly incorporated in the thesis entitled **"Studies on water and nutrient management in mango (*Mangifera indica* L.) cultivar Dashehari under Jammu sub-tropics"** submitted by **Mrs Simrandeep Kour,** Registration No. **J-15-D-247-A.**

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