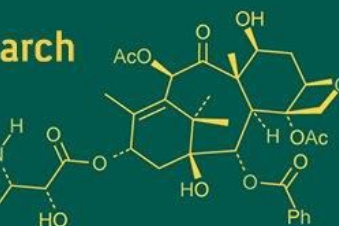
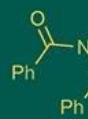


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Effect of irrigation levels and mulching on yield and productivity of mango (*Mangifera indica* L.) cv. Banganpalli

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Abstract

A field experiment was carried out at Fruit Research Station, Sangareddy, Telangana State during the year 2015- 2017 to study the effect of different irrigation levels*i.e.*, I₁ - One time per day, I₂ - Three pulses per day, I₃ - Farmer's practice and mulching on production, productivity, quality and W.U.E. of mango (*Mangifera indica* L.) cv. Banganpalli in Factorial Randomized Block Design with two factors, first factor with three irrigation levels and factor two with four different mulching materials *i.e.*, M₁ - Black polyethylene mulch (100 μ), M₂ - Paddy straw (10 cm thickness), M₃ - Saw dust (5 cm thickness), M₄ - Control (No mulch). The experiment results revealed that application of irrigation as three pulses per day (80% of total volume) with black polyethylene mulch (I₂M₁) has recorded the maximum number of fruits per tree at the time of harvest (195.05), fruit weight (501.09 g), yield per tree (97.7 kg), per unit (m³) canopy volume (1.22 kg) and per ha (15.27 t) due to maximum available soil moisture (%) at all observed soil depths (10,20,30,40,60 and 100 cm) during the observation period of January, February, March and April respectively.

Keywords: Irrigation scheduling, pulse irrigation, mulching, black polyethylene mulch, water use efficiency

Introduction

Mango (*Mangifera indica* L.) belongs to the family Anacardiaceae considered as one of the most important fruits of the tropical and subtropical countries. India occupies the top position among mango growing countries of the world and produces 40.1% of the total world production. It is the premier and choicest fruit of India and undoubtedly one of the best fruits of the world. It is known as 'King of Fruits' due to its captivating flavour, irresistible taste and sweetness. Very aptly, Indians designated this fruit as the 'National Fruit' of the country. Mango is a highly nutritive fruit. It plays an important role in balancing the human diet by providing about 64-86 calories per 100 grams of ripe fruits (Rathore *et al.* 2007) [40]. It is a good source of vital protective nutrients like vitamins A, B, and C, niacin and is also rich in minerals including calcium, potassium and iron.

Telangana is a semi-arid area and has a predominantly hot and dry climate. Summer starts in March and reaches a peak in May with an average high temperature of 42 °C (108 °F) range. The monsoon arrives in June and lasts till September with about 755 mm (29.7 inches) of rainfall. With the global climate changes, water becomes an increasingly limiting factor for agricultural crop production. Drip irrigation is the most efficient water and nutrient delivery system for growing crops. It delivers water and nutrients directly to the plant's roots zone, in the right amounts, at the right time, so each plant gets exactly what it needs, when it needs to grow optimally. Under South Indian condition, the flower bud differentiation starts at the end of December and fruits come to maturity by May (Bhagwan *et al.* 2013) [6] which coincides with severe summer. The peak water requirement of mango is during fruit development stage which coincides with March and April months in Telangana. These months experience severe water shortage in bore wells due to increased temperatures and depleting ground water. Hence, the Telangana farmers provide drip irrigation every two day in their orchards due to shortage of water which ultimately results in fruit drop and low yield. Water shortage

during critical period of fruit development was earlier reported by Adak *et al.*, 2012^[4] in mango.

Drip irrigation system minimizes water loss through percolation and provides optimum water supply to the roots and helps in maintaining soil moisture in the rhizosphere which ultimately reduces the plant water stress (Zuazo *et al.*, 2011)^[57]. Keeping this in view, the Government of India has been implementing PMKSY encouraging farmers to adopt micro-irrigation to expand cultivable areas under assured irrigation, improve on-farm water use efficiency, reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop). Recognizing the importance of micro-irrigation, the Telangana State government has been providing micro-irrigation systems to farmers on huge subsidies (80-100%) compared to other states under the PMKSY-TSMIP programme. This led to the adoption of drip irrigation by most of the farmers for irrigating crops especially the mango growing farmers of Telangana. But there is no standardized irrigation and fertigation schedules for mango crop in Telangana and still, the majority of farmers are practicing soil application of fertilizers.

The irrigation requirement of mango trees mainly depends on agronomic and climatic factors of the particular zone (Naor *et al.*, 2012)^[31]. In addition to this, the water requirement during the summer season is more than the winter season (Tejero *et al.*, 2010)^[54]. Further, the flowering and fruiting season coincides with summer in mango. Therefore, the shortage of water during flowering and fruit development stages may result in flowering and fruit dropping (Pavel and De Villiers 2004)^[35]. Various studies reported that fruit yield was more with drip irrigation system as the fruit parameters (length, diameter, number of fruits, and weight of fruit etc), were significantly affected by irrigation quantities (Levin *et al.*, 2017)^[26]. In limited water conditions, deficit irrigation can improve water use efficiency because water is allocated properly (Spreer *et al.* 2009)^[52]. Deficit irrigation is defined as the application of water below full crop-water requirements (evapotranspiration) and is an important tool to reduce irrigation water use. Deficit irrigation is an optimization strategy in which irrigation is applied during drought-sensitive growth stages of a crop. In this context, applying small quantities of water in pulses at frequent intervals through a drip which is known as pulse irrigation permits greater control and precision of irrigation timing and the amount of water applied. Pulse irrigation refers to the practice of irrigating for a short period then waiting for another short period and repeating this on-off cycle until the entire irrigation water is applied (Eric *et al.*, 2004)^[17]. In addition, a proper water conservation technique like mulching when coupled with this water management practice further provides an effective and efficient way to utilize applied irrigation water through soil moisture conservation. Mulches not only conserve soil moisture but along with modification of soil temperature also check the weed density (Kavino and Kaundal 2009)^[20], which ultimately increase the total and early yield (Pande *et al.* 2005)^[32]. The practice of applying a layer of dead vegetative waste mulch on soil surface such as straw mulch and polyethene mulches to conserve soil moisture has been prevalent for a very long time in many areas (Das *et al.* 2010)^[9]. Drip irrigation and mulching offer great savings of water on account of precise and direct application of water

to the root zone of plant and soil moisture conservation, respectively.

Material and Methods

The present investigation was carried out during two succeeding seasons *i.e.*, 2015-16 and 2016-17 at Fruit Research Station, Sangareddy, SKLTSHU, Telangana State. The material used and methods adopted during the investigation are presented under the following heads. The climate of Sangareddy is tropical, semi-arid and dry. Ten years old bearing trees of mango cv. Banganpalli, having uniform vigor and health were selected mango orchard. Trees were spaced 8×8 m and received uniform pruning and cultural operations. Seventy two selected trees were subjected to twelve treatments combinations

1. I₁ M₁ - One time per day (80% volume of PE) + Black polyethene mulch (100 µ)
2. I₁ M₂ - One time per day (80% volume of PE) + Paddy straw (10 cm thickness)
3. I₁ M₃ - One time per day (80% volume of PE) + Saw dust (5 cm thickness)
4. I₁ M₄ - One time per day (80% volume of PE) + Control (No mulch)
5. I₂ M₁ - Three pulses per day (80% volume of PE) + Black polyethene mulch (100 µ)
6. I₂ M₂ - Three pulses per day (80% volume of PE) + Paddy straw (10 cm thickness)
7. I₂ M₃ - Three pulses per day (80% volume of PE) + Saw dust (5 cm thickness)
8. I₂ M₄ - Three pulses per day (based on 80% volume of PE) + Control (No mulch)
9. I₃ M₁ - Farmer's practice + Black polyethene mulch (100 µ)
10. I₃ M₂ - Farmer's practice + Paddy straw (10 cm thickness)
11. I₃ M₃ - Farmer's practice + Saw dust (5 cm thickness)
12. I₃ M₄ - Farmer's practice + Control (No mulch)

Water requirement calculation of mango

Water requirement for mango crop (WR), is a function of surface area covered by plants, evaporation rate and infiltration capacity of the soil. The daily water requirement for fully grown plants was calculated as under. The average value of six years of corresponding months was taken into account and the daily water requirement for experimental plants was calculated as suggested by Shukla *et al.* (2001)^[48]

$$V = E_p \cdot K_p \cdot K_c \cdot S_p \cdot S_r \cdot W_p$$

Where,

- V = Volume of water required (litre day⁻¹ plant⁻¹),
- E_p = Pan evaporation as measured by Class-A pan evaporimeter mm day⁻¹.
- K_c = Crop co-efficient [co-efficient during fruit development stage 0.85 (Singh *et al.*, 2003)^[58]]
- K_p = Pan co-efficient (0.7)
- S_p = Plant to plant spacing (m)
- S_r = Row to row spacing (m)
- W_p = Fractional wetted area, which varies with different growth stage (0.3 for wider spaced crops).

The total number of fruits harvested at different intervals was added to calculate the number of fruits per tree, Yield

(kg tree⁻¹), Days taken for fruit maturity (From fruit set to harvest) (Vijay Krishna, 2019) ^[56]. The length of each fruit from stalk end to style end and the fruit girth was measured with the help of digital verniercallipers, Average fruit weight was recorded by using the digital electronic balance in each treatment and expressed in gram (g). The canopy volume (from the root base of a tree to maximum spreading) was measured using tape (fastened on a bamboo stick) and calculated by the formula suggested by Samaddar and Chakrabarti (1988) ^[42].

$$\text{Canopy volume (m}^3\text{)} = 4/3 \pi(r2h)$$

where r = diameter/2, h= height of the plant. The canopy diameter was measured in both the direction (NS and EW) of the canopy. Plant height (m) was measured from graft union to the top of the tree by measuring tape (fixed on a bamboo stick). The design adopted was a randomized block design with the factorial concept. The data were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985) ^[34].

Results and Discussion

Available Soil moisture (%)

The data obtained for the available soil moisture was presented in Table 1 to 4. The analysis of pooled data revealed that different irrigation levels and mulching have shown wide variation in soil moisture (%) available at different depths (10, 20, 30, 40, 60 and 100 cm) during different months (January, February, March and April) in mango cv. Banganpalli.

Regarding the effect of different irrigation levels, significantly maximum soil moisture (%) was recorded with three pulses per day (based on 80% of the volume of water) (I₂) whereas the minimum was recorded with 3 h. irrigation at 2 days interval (I₃) at all recorded depths viz., at 10, 20, 30, 40, 60 and 100 cm during the entire observation period from January to April.

During January, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 6.40, 14.27, 27.73, 36.55, 51.90 and 74.55%, respectively with three pulses per day (I₂) whereas the minimum soil moisture (%) was recorded as 5.69, 11.64, 21.78, 28.17, 37.25 and 54.46 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively with 3 h. irrigation at 2 days interval (I₃). Further, when the mean available soil moisture in active root zone area (10-60 cm) between best treatment (pulse irrigation) (I₂) and farmer's practice (control) (I₃) was compared, the available soil moisture in farmers practice (I₃) was 20.91% whereas it was found as 27.37% in pulse irrigation treatment (I₂) which is 1.31 times to that of I₃ (Fig 1).

During February, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 3.04, 11.59, 19.82, 30.54, 40.75 and 66.83%, respectively with three pulses per day (I₂) whereas the minimum soil moisture (%) was recorded as 0.70, 8.96, 13.87, 22.15, 26.10 and 46.74 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively with 3 h. irrigation at 2 days interval (I₃). Further, when the mean available soil moisture in active root zone area (10-60 cm) between pulse irrigation (I₂) and farmer's practice (I₃) was compared, the mean available soil moisture in farmers practice (I₃) was 14.36 % whereas it was

found as 21.15 % in pulse irrigation treatment (I₂) which is 1.47 times to that of I₃ (Fig 1).

During March, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 2.63, 8.50, 14.82, 20.64, 34.22 and 55.83 %, respectively with three pulses of irrigation per day (I₂) whereas the minimum soil moisture (%) was recorded as 0.97, 5.87, 8.87, 12.25, 19.57 and 35.74% at 10, 20, 30, 40, 60 and 100 cm depths, respectively with 3 h. irrigation at 2 days interval (I₃). Further, when the mean available soil moisture in active root zone area (10-60 cm) between pulse irrigation (I₂) and farmer's practice (I₃) was compared, the mean available soil moisture in farmers practice (I₃) was 9.51 % whereas it was found as 16.16 % in pulse irrigation treatment (I₂) which is 1.70 times to that of I₃ (Fig 1).

During April, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 0.48, 3.00, 7.98, 16.37, 29.00 and 48.33 %, respectively with three pulses per day (I₂) whereas the minimum soil moisture (%) was recorded as 0.02, 0.37, 2.03, 7.99, 14.35 and 28.24 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively with 3 h. irrigation at 2 days interval (I₃). Further, when the mean available soil moisture in active root zone area (10-60 cm) between pulse irrigation (I₂) and farmer's practice (I₃) was compared, the mean available soil moisture in farmers practice (I₃) was 4.95 % whereas it was found as 11.37 % in pulse irrigation treatment (I₂) which is 2.30 times to that of I₃ (Fig 1).

When the available soil moisture content in active root zone area (10-60 cm) during different months was compared, higher moisture availability was found during January (mean temperature 22 °C) and with the progression of the time, the soil moisture content decreased comparatively during February (mean temperature 26 °C) and March (mean temperature 29 °C) where the lowest was recorded during April (mean temperature 33 °C), irrespective of treatments. This can be attributed to the increased temperatures during the summer months and when the decreasing pattern of soil moisture availability within irrigation levels (I₃ and I₂) was observed, the decrease was 31.32% from January to February in I₃ whereas it is 22.73% in I₂. From February to March, the decrease was 33.77 % in I₃ whereas it is 23.56 % in I₂ and from March to April, the decrease was 47.95 % in I₃ whereas it is 29.64 % in I₂ (Fig 1).

The active feeder root zone area spreads up to a depth of 60 cm in mango (Bojappa and Singh, 1974) ^[7]. The distribution of water in the soil occurs along the hydraulic gradient between the wet and the dry soil, laterally using capillary action and vertically due to gravitation (Mahgoub *et al.*, 2017) ^[28]. In the case of treatment I₂, water was applied in smaller quantities at three intervals due to which a lower hydraulic gradient was created and the percolation was slow into the soil. This resulted in higher availability of soil moisture at all depths. In the case of treatment I₃, with the application of bulk volume of water per irrigation with a long gap between the irrigation intervals, a greater hydraulic gradient was created, which resulted in more rapid downward movement of water recording less soil moisture content comparatively, at all studied depths. These results are in agreement with the findings of Eid *et al.* (2013) ^[13] who reported increased soil moisture in the root zone of soybean with pulse drip irrigation by applying daily water requirements in eight pulses compared to applying daily

water requirements at one time. With an increase in the number of pulses, soil moisture distribution increases in the root zone which in turn increased wetted soil volume, thus the volume of available water in the root zone was more. A similar increase in moisture content in the root zone and wetted soil volume with increased irrigation pulses was also reported in orange (Abdelraouf *et al.*, 2019)^[3], soybean (Eid *et al.*, 2013)^[13] and potato (Abdelghany, 2009)^[2].

Regarding the effect of different mulching's, significantly maximum soil moisture (%) was recorded with black polyethylene mulch (100 μ) (M_1) whereas the minimum was recorded in control (no mulch) (M_4) at all recorded depths viz., at 10, 20, 30, 40, 60 and 100 cm during entire observation period from January to April.

During January, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths were recorded as 6.65, 14.54, 29.73, 38.37, 55.08 and 79.73 %, respectively with black polyethylene mulch (M_1) whereas the minimum soil moisture (%) was recorded in control (M_4) as 5.67, 11.31, 20.80, 25.95, 37.46 and 50.20 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively. When the mean available soil moisture in active root zone area (10-60 cm) between best treatment (black polythene mulch) (M_1) and no mulch (control) (M_4) was compared, the mean available soil moisture under no mulch (M_4) was 20.24 % whereas it was found as 28.87% under black polythene mulch (M_1) which is 1.43 times to that of M_4 (Fig 1).

During February, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 3.51, 11.86, 21.81, 32.35, 43.93 and 72.01 %, respectively with black polyethylene mulch (M_1) whereas the minimum soil moisture (%) was recorded as 0.00, 8.62, 12.89, 19.93, 26.31 and 42.49 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively in control (M_4). When the mean available soil moisture in active root zone area (10-60 cm) between black polythene mulch (M_1) and no mulch (M_4) was compared, the mean available soil moisture under no mulch (M_4) was 13.55 % whereas it was found as 22.69 % under black polythene mulch (M_1) which is 1.67 times to that of M_4 (Fig 1).

During March, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 3.20, 8.77, 16.81, 22.45, 37.40 and 61.01 %, respectively with black polyethylene mulch (M_1) whereas the minimum soil moisture (%) was recorded as 0.00, 5.54, 7.89, 10.03, 19.78 and 31.49% at 10, 20, 30, 40, 60 and 100 cm depths, respectively in control (M_4). When the mean available soil moisture in active root zone area (10-60 cm) between black polythene mulch (M_1) and no mulch (M_4) was compared, the mean available soil moisture under no mulch (M_4) was 8.65 % whereas it was found as 17.73 % under black polythene mulch (M_1) which is 2.05 times to that of M_4 (Fig 1).

During April, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 0.65, 3.27, 9.98, 18.18, 32.18 and 53.51 %, respectively with black polyethylene mulch (M_1) whereas the minimum soil moisture (%) was recorded as 0.00, 0.04, 1.05, 5.77, 14.56 and 23.99 % at 10, 20, 30, 40, 60 and 100 cm depths, respectively in control (M_4). When the mean available soil moisture in active root zone area (10-60 cm) between black polythene mulch (M_1) and no mulch (M_4) was compared, the mean available soil moisture under no mulch (M_4) was 4.28 %

whereas it was found as 12.85 % under black polythene mulch (M_1) which is three times to that of M_4 (Fig 1). Further, the decrease in soil moisture availability from January to February was 33.05 % in M_4 whereas it is 21.41 % in M_1 . From February to March, the decrease was 36.16 % in M_4 whereas it is 21.86 % in M_1 and from March to April, the decrease was 50.52 % in M_4 whereas it is 27.52 % in M_1 (Fig 1).

The results revealed that all mulching treatments have recorded higher soil moisture content than control treatment without mulch (M_4). The greater moisture content under mulch treatments compared to control was due to reduced soil surface evaporation and weed intensity due to mulching. However, black polythene mulch (M_1) has resulted in the highest available soil moisture at all recorded depths than other mulches paddy straw (M_2) and saw dust (M_3). This high moisture retention ability of plastic mulches could be due to limited evaporation from the soil compared to paddy straw and saw dust mulches which are inherently porous and hygroscopic. Further, the water vapors that evaporate from the soil surface were trapped on the lower side of polythene sheet, it gets condenses and drips down again into the soil surface thus increasing the soil moisture content (Khan *et al.* 2015)^[22]. A similar increase in soil moisture content due to black polythene mulch followed by paddy straw and paddy husk was reported by Das and Dutta (2018)^[10] in mango cv. Himsagar. Improvement in soil moisture content with mulching was also reported in several other tropical fruits such as Nagpur mandarin (Shirgure *et al.* 2003)^[46], mango cv. Himsagar (Ghosh and Bauri, 2003)^[19] and guava cv. L-49 (Dutta and Majumder, 2009)^[12].

Regarding the interaction effect, the treatment irrigation as three pulses per day (based on 80% of volume of water) with black polyethylene mulch (100 μ) (I_2M_1) has recorded the highest soil moisture (%) at all recorded depths viz., at 10, 20, 30, 40, 60 and 100 cm during entire observation period from January to April whereas lowest soil moisture was recorded by the treatment three hours irrigation at two days interval (Farmer's practice) with no mulch (I_3M_4) mostly.

During January, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 7.84, 18.17, 36.65, 47.59, 68.36 and 97.14 %, respectively with the treatment of three pulses of irrigation per day with black polyethylene mulching (I_2M_1). At 10 cm soil depth, minimum soil moisture (5.67 %) was recorded by all three irrigation levels combination with no mulch (I_1M_4 , I_2M_4 and I_3M_4) whereas at 20 cm soil depth the minimum soil moisture (%) was recorded as 11.27 % in the treatment three pulses irrigation per day with no mulch (I_2M_4). Further, at 30 cm soil depth, minimum soil moisture (%) was recorded as 20.67 % in the treatment one-time irrigation per day with no mulch (I_1M_4). At 40, 60 and 100 cm depths lowest soil moisture was recorded as 24.46, 34.04 and 48.75 %, respectively in the treatment three hours irrigation at two days intervals with no mulch (I_3M_4). Further, when the mean available soil moisture in the active root zone area (10-60 cm) between best treatment (pulse irrigation with black polythene mulch) (I_2M_1) and farmer's practice of irrigation with no mulch (control) (I_3M_4) was compared, the mean available soil moisture in I_3M_4 was 19.25% whereas it was found as 35.72% in I_2M_1 which is 1.86 times to that of I_3M_4 (Fig 1).

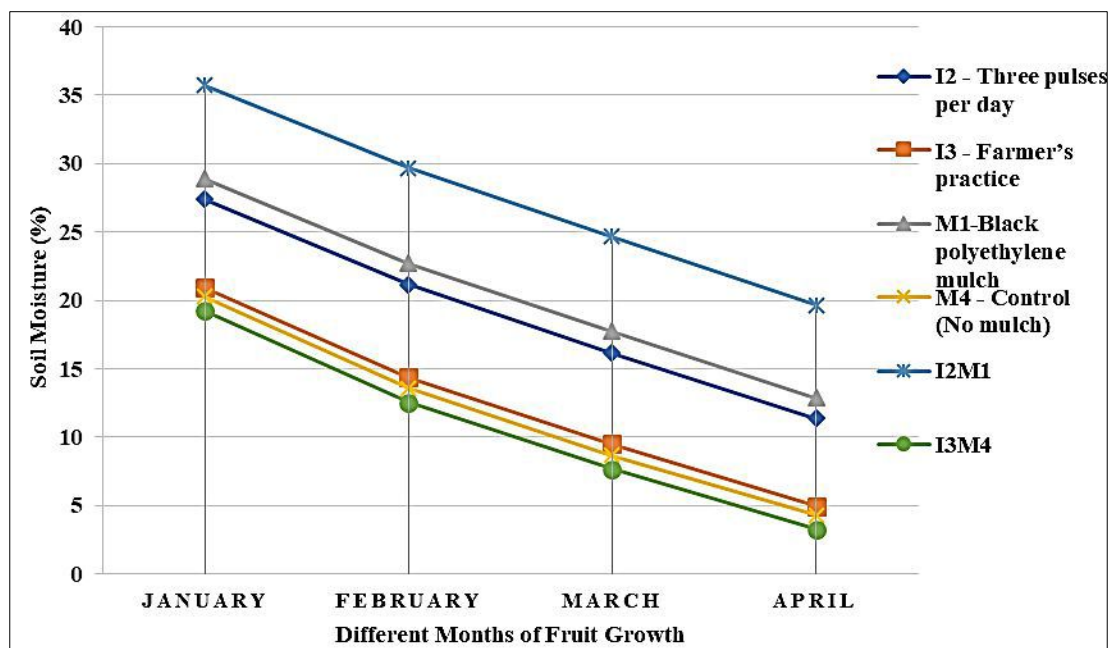


Fig 1: Comparison of mean available soil moisture in the active root zone area (10-60 cm depth) in best treatment and control during fruit growth and development period in mango cv. Banganpalli

During February, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 5.25, 15.49, 28.74, 41.58, 57.21 and 89.42 %, respectively with the treatment of three pulses of irrigation per day with black polyethylene mulching (I_2M_1). At 10 cm soil depth, no soil moisture (0.00 %) was recorded by all three irrigation levels combination with no mulch (I_1M_4 , I_2M_4 and I_3M_4) whereas at 20 cm soil depth the minimum soil moisture (%) was recorded as 8.59 % in the treatment three pulses irrigation per day with no mulch (I_2M_4). Further, at 30 cm soil depth, minimum soil moisture (%) was recorded as 12.76 % in the treatment one-time irrigation per day with no mulch (I_1M_4). At 40, 60 and 100 cm depths lowest soil moisture was recorded as 18.44, 22.89 and 41.03 %, respectively in the treatment three hours irrigation at two days interval with no mulch (I_3M_4). Further, when the mean available soil moisture in active root zone area (10-60 cm) between pulse irrigation with black polythene mulch (I_2M_1) and farmer's practice of irrigation with no mulch (I_3M_4) was compared, the mean available soil moisture in I_3M_4 was 12.56 % whereas it was found as 29.65 % in I_2M_1 which is 2.36 times to that of I_3M_4 (Fig 1).

During March, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 4.78, 12.41, 23.74, 31.68, 50.68 and 78.42 %, respectively with the treatment of three pulses of irrigation per day with black polyethylene mulching (I_2M_1). At 10 cm soil depth, no soil moisture (0.00 %) was recorded by all three irrigation levels combination with no mulch (I_1M_4 , I_2M_4 and I_3M_4) whereas at 20 cm soil depth the minimum soil moisture (%) was recorded as 5.51 % in the treatment three pulses irrigation per day with no mulch (I_2M_4). Further, at 30 cm soil depth, minimum soil moisture (%) was recorded as 7.76 % in the treatment one-time irrigation per day with no mulch (I_1M_4). At 40, 60 and 100 cm depths lowest soil moisture was recorded as 8.54, 16.35 and 30.03 %, respectively in the treatment three hours irrigation at two days intervals with no mulch (I_3M_4). Further, when the mean available soil moisture in the active root zone area (10-60 cm) between pulse irrigation with black polythene mulch (I_2M_1) and

farmer's practice of irrigation with no mulch (I_3M_4) was compared, the mean available soil moisture in I_3M_4 was 7.65 % whereas it was found as 24.66 % in I_2M_1 which is 3.22 times to that of I_3M_4 (Fig 1).

During April, maximum soil moisture (%) available at 10, 20, 30, 40, 60 and 100 cm depths was recorded as 1.45, 6.91, 16.90, 27.41, 45.46 and 70.92 %, respectively with the treatment of three pulses of irrigation per day with black polyethylene mulching (I_2M_1). At 10 cm soil depth, no soil moisture (0.00 %) was recorded by all three irrigation levels combination with no mulch (I_1M_4 , I_2M_4 and I_3M_4) whereas at 20 cm soil depth the minimum soil moisture (%) was recorded as 0.01 % in the treatment three pulses irrigation per day with no mulch (I_2M_4). Further, at 30 cm soil depth, minimum soil moisture (%) was recorded as 0.92 % in the treatment one-time irrigation per day with no mulch (I_1M_4). At 40, 60 and 100 cm depths lowest soil moisture was recorded as 4.28, 11.14 and 22.53 %, respectively in the treatment three hours irrigation at two days intervals with no mulch (I_3M_4). When the mean available soil moisture in the active root zone area (10-60 cm) between pulse irrigation with black polythene mulch (I_2M_1) and farmer's practice of irrigation with no mulch (I_3M_4) was compared, the mean available soil moisture in I_3M_4 was 3.29 % whereas it was found as 19.63 % in I_2M_1 which is 5.96 times to that of I_3M_4 (Fig 1). Further, the decrease in soil moisture availability from January to February was 34.75 % in I_3M_4 whereas it is 16.99 % in I_2M_1 . From February to March, the decrease was 39.09 % in I_3M_4 whereas it is 16.83 % in I_2M_1 and from March to April, the decrease was 56.99 % in I_3M_4 whereas it is 20.40 % in I_2M_1 .

Irrigation as three pulses per day along with black polyethylene mulch (I_2M_1) has enhanced available soil moisture content due to the synergistic effect of mulching and irrigation treatment. The higher available soil moisture in the soil layers under pulse drip irrigation may be attributed to the fact that daily water requirement was met by the application of smaller quantities of water in three pulses due to which more moisture was confined in the upper layers of soil. The higher available soil moisture by

pulse irrigation was further retained without any evaporation loss from the soil surface due to the presence of polythene mulch which has resulted in more soil moisture content in I_2M_1 than other treatments. This higher moisture content under mulch treatments may be ascribed to reduced evaporation during the daytime which is the main reason for the diurnal cycle in the bare soil. Furthermore, under the plastic mulch, the evaporated moisture condenses on the lower side of the polythene sheet and drip down again on the soil surface, consequently eliminating the diurnal cycling process of the bare soil. These observations are in accordance with the findings of Raina *et al.* (1998) [38] and Singh *et al.* (2004) [49]. Further, these results are in agreement with the findings of Eid *et al.* (2013) [13] who reported the increased soil moisture content due to the synergistic effect of irrigation as 8 pulses/day along with black polythene mulch in soybean. The pulse irrigation increased water movement in the horizontal direction than vertical direction hence improved soil moisture distribution and wetted soil volume in root zone and black polythene mulch decreased from evaporation process rate from the soil surface. Under control treatment, a higher hydraulic gradient was created owing to the application of bulk volume of water per irrigation with quite wider irrigation intervals, which resulted in more rapid downward movement of water reducing the available soil moisture.

Number of Fruitlets per Panicle at the Time of Fruit Set

The data obtained for the number of fruitlets per panicle at the time of fruit set was presented in Table 5. The perusal of pooled data revealed that different irrigation levels and mulching have shown a varied effect on the number of fruitlets per panicle at the time of fruit set in mango cv. Banganpalli.

Regarding the effect of different irrigation levels, the maximum number of fruitlets per panicle (7.71) at the time of fruit set was recorded with the application of three pulses of irrigation per day (I_2) whereas the minimum (5.98) was recorded with three hours irrigation at two days interval (I_3). Through pulse irrigation, water was applied in precise amounts at frequent intervals, directly in the root zone. Nutrient uptake requires live, healthy roots to transport the nutrients from the soil environment into the tree. A good supply of soil water, usually from irrigation or rain, is required to support the uptake processes and ensure that nutrients are available in the solution. In addition to the role of a good water supply in the uptake process, the proliferation and branching of the fine roots will be encouraged in moist soil. This further improves the capacity of the tree to intercept and take up nutrients from the soil. In mango, the active root zone area of superficial feeder roots spreads up to a depth of 60 cm (Bojappa and Singh, 1974) [7]. The fruit set occurs during January in mango. In the present investigation, pulse drip irrigation (I_2) treatment has resulted in maximum available soil moisture (27.37%) in the active root zone (10- 60 cm depth) which is 1.31 times more than that of control (20.91%) during January (Table 1). This increased soil moisture during the time of fruit set might have helped in the solubility of mineral nutrients and mobilization of nutrients in the soil leading to efficient utilization of available nutrients. As plants receive optimum amount of water and nutrients, it directly improves cell permeability which enhances photosynthetic process and results in more number of leaves, flowers (Shah *et al.*, 2018)

[44] and increased fruit set thus producing more number of fruitlets per panicle. A similar increase in the number of fruits due to pulse irrigation was also reported in mango (Shah *et al.*, 2018) [44], orange (Abdelraouf *et al.*, 2019) [3] and tomato (Elshamly *et al.*, 2016) [16]. Similar results were obtained by Larson *et al.* (2008) [25] for peach, who reported that the number of flowers per panicle was highly influenced by different levels of irrigation through drip irrigation.

Regarding the effect of different mulching, the maximum number of fruitlets per panicle (7.71) at the time of fruit set was recorded with the application of black polythene mulching (M_1) which was at par with the number of fruitlets per panicle (7.36) recorded with application of Paddy straw (10 cm thickness) mulching (M_1) whereas the minimum number (5.29) was recorded in treatment with no mulch (M_4). During January, the mean available soil moisture in the active root zone area (10-60 cm) under no mulch (M_4) was 20.24 % whereas it was found as 28.87% under black polythene mulch (M_1) which is 1.43 times that of M_4 (Table 1). Mulching with black polythene has conserved more soil moisture which was essential for the biological and physiological process of the plant such as transporting nutrients from the soil via the root and translocation of assimilating to the sink from the source (Teame *et al.*, 2017) [53]. This better translocation of assimilates to the sink have resulted in increased fruit set recording more number of fruitlets per panicle over other mulches and no mulch treatment. Furthermore, the increased available soil moisture has reduced the water stress that induces ABA synthesis which is responsible for fruit abscission (Mishra *et al.*, 2016) [30]. This increased soil moisture availability and better uptake of nutrients under the black polythene and paddy straw mulch might have promoted synthesis of auxin and cytokinin like substances along with reduced ABA synthesis and has ultimately resulted in increased fruit set in the present investigation. In addition to this, better weed control was obtained under the influence of mulch and pulse irrigation provided higher soil moisture, which might have synergistically reduced the competition for soil moisture and nutrients thus, leading to better fruit retention in the present investigation. A similar increase in fruit set in black polythene mulch was reported in strawberry (Sharma and Goel, 2017) [45] and Nagpur mandarin (Shrigure, 2012) [47]. Regarding the interaction effect of different irrigation levels and mulching, no significant difference was found between the treatments in the number of fruits per panicle.

Number of Days Taken For the Maturity of the Fruit

The data for the number of days taken for the maturity of fruit was presented in Table 6. The analysis of pooled data revealed that the individual factors *i.e.*, different levels of irrigation (I) and different mulching (M) have variably affected the number of days taken for fruit maturity of mango cv. Banganpalli.

Regarding the effect of irrigation levels (I), the application of irrigation as three pulses per day (I_2) has recorded the minimum number of days for fruit maturity (98.68 days) whereas the maximum number of days (108.47 days) was recorded with farmer's practice with three hours irrigation at two days interval (I_3). Regarding the effect of different mulching (M), mulching with black polythene (M_1) has recorded the minimum number of days for fruit maturity (98.30 days) whereas control (no mulch) (M_4) has recorded

the maximum number of days for fruit maturity (108.15 days). In the present investigation black polythene mulching treatment has resulted in almost 14 days earlier fruit maturity as compared to no mulch and pulse irrigation treatment has resulted in almost 10 days earlier fruit maturity as compared to farmer's practice. In Telangana conditions, mango fruit set and fruit development occur during January to May months (Vijay Krishna *et al.*, 2019) [56]. When the decreasing pattern of soil moisture availability between I_3 and I_2 was observed, the decrease was 31.32% from January to February in I_3 whereas it is 22.73% in I_2 . From February to March, the decrease was 33.77 % in I_3 whereas it is 23.56 % in I_2 and from March to April, the decrease was 47.95 % in I_3 whereas it is 29.64 % in I_2 . Further, the decrease in soil moisture availability from January to February was 33.05 % in M_4 whereas it is 21.41 % in M_1 . From February to March, the decrease was 36.16 % in M_4 whereas it is 21.86 % in M_1 and from March to April, the decrease was 50.52 % in M_4 whereas it is 27.52 % in M_1 . This means, in pulse irrigation treatment (I_2), as the water was applied in precise amounts in three pulses in a day directly in the root zone and there was increased soil moisture availability in the root zone throughout the fruit development phase from January to May months (Table 1 to 4) compared to control and under black polythene mulch (M_1), more moisture was conserved without much loss compared to no mulch (M_4). As plants receive optimum amount of water and nutrients throughout fruit growth period, it directly improves cell permeability which enhances photosynthetic process and results in more number of leaves, flowers (Shah *et al.*, 2018) [44] and increased fruit set and early fruit development without any hindrance. Further, with black polythene mulch, there was better conservation of soil moisture that helped in the solubility of mineral nutrients and mobilization of nutrients in the soil leading to efficient utilization of available nutrients throughout different growth stages of fruit (701, 703, 705 and 709 stages of BBCH scale). This might have increased the metabolic activity and translocation of food material from source (leaves) to sink (fruits) resulting in the early development of fruits and early harvesting recording less number of days taken for the maturity of fruit in different phenological stages (701, 703, 705 and 709 stages of BBCH scale) of fruit development compared to control treatment. Further, the mulching treatment reduced the weed competition through smothering and increased the nutrient solubility through better soil condition, microflora and avoided fixation and leaching of applied nutrients (Thirupathiah and Shirol 2019) [55] which ultimately leads to better nutrient use efficiency in the present investigation. This increased rate of translocation of synthesized food from leaves to fruits might have resulted in early fruit maturity with mulching in the present investigation. These results conform with the findings with Aassouline *et al.* (2006) [1], who reported proportional relation between pulse irrigation and days taken for the maturity of fruits, as high pulse irrigation gave early maturity in capsicum. A similar report of minimum numbers of days for fruit maturity with pulse irrigation was also made by Arshad (2017) [5] in cucumber. Similar findings of early fruit maturity of fruits with mulching were earlier reported in guava cv. Allahabad Safeda (Prasanna *et al.*, 2018) [37] and strawberry cv. Chandler (Singh *et al.*, 2005) [50].

However, no significant difference was found among the treatments in the number of days taken for fruit maturity with the interaction effect of different levels of irrigation and mulching ($I \times M$) in mango cv. Banganpalli.

Number of Fruits per Tree at the Time of Harvest

The results obtained for the number of fruits at the time of harvest were presented in Table 5. Regarding the individual effect of factors, it was found from the pooled data that the application of different mulching (M) and different levels of irrigation (I) has variably affected the number of fruits at the time of harvest in mango cv. Banganpalli.

Mulching with black polythene (M_1) treatment has recorded the maximum number of fruits (177.72) whereas control (no mulch) (M_4) has recorded the minimum number of fruits (139.13) at the time of harvest. This is due to more number of fruitlets per panicle at the time of fruit set (Table 5) obtained with black polythene mulching. The soil under mulching treatments retained more moisture during the fruit growth period as compared to bare soil without mulch, which in turn might have attributed to improvement in fruit retention thus increased the number of harvestable fruits. The increased availability of water and nutrients to the plant throughout the crop growth period might have helped in increased photosynthesis, reduced respiration and production of other essential plant metabolites which in turn might have boosted up the metabolic activity of the tree, which increasing the fruit set (Table 5) and reducing fruitlet abscission (Ram, 1992) [39], leading to the increased total number of fruits per tree in the present investigation. These results are in line with the findings of Das *et al.* (2010) [9] and Polara *et al.* (2013) [36] who also reported improvement in the number of fruits of guava and custard apple, respectively due to better conservation of soil moisture following mulching. A similar increase in the number of fruits with mulching treatment was also reported by Panigrahi *et al.* (2010) [33] in mango cv. Dashehari.

Among the different irrigation treatments (I) applied, irrigation with three pulses per day (I_2) has recorded the maximum number of fruits (178.11) while the minimum number of fruits (149.87) was recorded in farmer's practice with three hours of irrigation at two days interval (I_3). This is due to more number of fruitlets per panicle at the time of fruit set (Table 5) obtained with irrigation with three pulses per day (I_2). The favourable effects of pulse drip irrigation on the growth and fruit yield of mango may be attributed to the fact that water was applied in precise amounts and at frequent intervals. It thus resulted in uniform moisture distribution in the root zone and also maintained the moisture content near the field capacity during the entire growth period, thereby leading to more favourable soil conditions for better plant growth. Further, pulse irrigation might have provided a consistent moisture regime in the soil due to which roots remain active throughout the fruit growing period has resulted in increased soil moisture availability (Table 1 to 4), better uptake of nutrients leading to increased fruit set (Table 5) bearing more number of fruits per tree in the present investigation. A similar increase in the number of fruits due to pulse irrigation was also reported in Nagpur mandarin (Shirgure, 2012) [47] and orange (Abdelraouf *et al.*, 2019) [3].

Regarding the interaction effect of factors ($I \times M$), the interaction of irrigation as three pulses per day with black polythene mulch (I_2M_1) has recorded the maximum number

of fruits per tree (195.05) which was on par with the interaction effect of irrigation as three pulses per day with paddy straw mulch (I_2M_2) (189.40). A minimum number of fruits (132.93) was recorded by the interaction of three hours irrigation at two days intervals with no mulch (I_3M_4) in mango cv. Banganpalli.

The synergistic effect of mulching which acts as a surface barrier against evaporation and also checks weed growth helps in reducing competition for soil moisture (Thirupathaiah and Shirol 2019) [55] and pulse irrigation which provided a consistent moisture regime in the soil has enhanced available soil moisture content (Table 1 to 4) for longer duration which resulted in more uniform soil-water distribution due to which roots remain active leading to better uptake of nutrients throughout the fruit growing period. This increased availability of water and nutrients led to proper translocation of food materials and nutrients throughout the fruit growth period. These increased plant physiological activities, fruit set, reduced fruit drop per cent with better availability and uptake of nutrients has resulted in the increased number of fruits per plant in the present investigation. Similar results were reported in orange (Abdelraouf *et al.*, 2019) [3]. Eid *et al.* (2013) [13] also reported increased yield due to the synergistic effect of irrigation as 8 pulses/day along with black polythene mulch in soybean.

Fruit Length (Cm) and Fruit Breadth (Cm) At the Time of Harvest

The data for fruit length (cm) and fruit breadth (cm) at the time of harvest were presented in Tables 6 respectively. From the analysis of pooled data, it was found that the application of different levels of irrigation (I) and different mulching (M) have variably affected the fruit length and fruit breadth recorded at the time of harvest in mango cv. Banganpalli.

Among the different irrigation treatments (I) applied, irrigation with three pulses per day (I_2) has recorded maximum fruit length (12.01 cm) which was on par with fruit length recorded in treatment one-time irrigation per day (I_1) (11.59 cm) whereas minimum fruit length (11.16 cm) was recorded in farmer's practice with three hours irrigation at two days interval (I_3). Regarding fruit breadth, irrigation with three pulses per day (I_2) has recorded maximum fruit breadth (10.02 cm) which was on par with fruit breadth recorded in treatment one-time irrigation per day (I_1) (9.69 cm) while minimum fruit breadth (9.36 cm) was recorded in farmer's practice with three hours irrigation at two days interval (I_3). In the case of pulse irrigation (I_2), there was more available soil moisture content for longer durations and it also maintained optimal soil temperature in I_1 and I_2 treatments compared to control. Mango requires an ample amount of water during fruit growth. Cell enlargement and division need adequate water during the fruit growth and development period, while lack of water inhibits fruit growth and development (Liu *et al.*, 2007) [27]. With the availability of more available soil moisture in I_1 and I_2 treatments, proper cell enlargement and cell division took place resulting in the improved size of fruits with the increase in fruit length and breadth. These results are coinciding with findings of El-Kosary *et al.* (2011) [14] for mango, who reported that plants that do not get the required amount of water produce undersized and deformed fruits. Similar results of increased fruit length were reported in

mango with twice application of water comprised of (62.5 minutes) longer duration by using 4 drippers (flow rate 16 LPH) (Shah *et al.*, 2018) [44], and also in cucumber (Arshad, 2017) [5] and greenbeans (El-Mogy *et al.*, 2012) [15].

Regarding the effect of different mulching (M), mulching with black polythene (M_1) has recorded maximum fruit length (12.02 cm) which was on par with the application of Paddy straw mulch (M_2) (11.84 cm) and Sawdust mulch (M_3) (11.67 cm) whereas control (no mulch) (M_4) has recorded minimum fruit length (10.82 cm) at the time of harvest. Further, mulching with black polythene (M_1) has recorded maximum fruit breadth (10.02 cm) which was on par with the application of Paddy straw mulch (M_2) (9.89 cm) and Sawdust mulch (M_3) (9.76 cm) whereas control (no mulch) (M_4) has recorded minimum fruit breadth (9.09 cm) at the time of harvest. From the results, it is evident that all mulching treatments recorded an increase in fruit length and fruit breadth compared to control. These results are in agreement with the findings of Borthakur and Bhattacharya (1992) [8] in guava who reported that the mulching treatment significantly increases the growth of plants which subsequently increase the fruit physical characters. In the present investigation, mulching reduced the evapotranspiration losses from the soil maintaining improved soil moisture availability (Table 1 to 4) for a longer duration. This might have maintained optimal soil temperature resulting in better translocation of nutrients which is congenial for better plant growth thus the mulched plants have produced fruits with good physical properties. Such an improvement in soil hydrothermal regime and fruit length and diameter with mulching was also reported by Kiranshankar *et al.* (2019) [23] in mango cv. Alphonso, Samant *et al.* (2017) [43] in mango hybrid 'Amrapali', Panigrahi *et al.* (2010) [33] in mango cv. Dashehari and Dutta and Majumder in guava cv. L-49.

However, the interaction effect of different levels of irrigation and mulching ($I \times M$) has shown no significant difference in fruit length and fruit breadth recorded at the time of harvest among the treatments in mango cv. Banganpalli.

Fruit Weight (G) at the Time of Harvest

The data obtained for fruit weight (g) at the time of harvest was presented in Table 6. The analysis of pooled data revealed that a significant difference was found in fruit weight recorded at the time of harvest by the individual effect of different levels of irrigation (I) and mulching (M) in mango cv. Banganpalli.

Regarding the effect of different irrigation treatments (I) applied, irrigation with three pulses per day (I_2) has recorded maximum fruit weight (461.73 g) while minimum fruit weight (395.71 g) was recorded in farmer's practice with three hours of irrigation at two days interval (I_3). Through pulse irrigation, water was applied in precise amounts at frequent intervals, directly in the root zone which led to the increased soil moisture content in the root zone (Table 1 to 4). This increased soil moisture might have helped in the solubility of mineral nutrients leading to greater mobility of major nutrients to the developing fruits which acted as a strong metabolic sink and stimulated the synthesis of chlorophyll and increased photosynthetic activity which resulted in increased stored food material in the tissue (Singh and Rajput, 1977) [51] resulting in good size of fruits with increased fruit length and breadth (Table 6)

contributing to increased fruit weight in the present investigation. A similar increase in fruit weight with different drip irrigation regimes was also reported by Khalifa (2018) ^[21] in two mango cultivars Ewais and Tommy Atkins, Kumar *et al.* (2008) ^[24] in mango hybrid ArkaAnmol, Shirgure (2012) ^[47] in Nagpur mandarin and Marathe *et al.* (2018) ^[29] in pomegranate.

Regarding the effect of different mulching (M), mulching with black polythene (M₁) has recorded maximum fruit weight (461.73 g) which was on par with the application of Paddy straw mulch (M₂) (448.61 g) whereas control (no mulch) (M₄) has recorded minimum fruit weight (369.33 g) at the time of harvest. Mulching treatments have recorded better fruit weight compared to control treatment. Mulching treatments resulted in a significantly higher level of leaf nitrogen content due to greater diffusion of nitrogen into the roots of a plant grown under mulching. As mulching reduced the loss of water from the soil surface and maintained a higher moisture regime, this reduced the shrinkage of roots and increased the contact surface between the roots and soil solution. A higher level of leaf nitrogen content produces extra protein by conversion of synthesized carbohydrates into amino acids in the leaf to enable them to grow larger to have a larger surface area for carbon assimilation and thus, probably might have resulted in better plant growth and better fruit size (Borthakur and Bhattacharyya, 1996) ^[8] with enhanced fruit length and breadth (Table 6) contributing to increased fruit weight in mulching treatments in the present investigation. A similar increase in fruit weight with mulching treatments was also reported by Das and Dutta (2018) ^[10] in mango cv. Himsagar, Panigrahi *et al.* (2010) ^[33] in mango cv. Dashehari, Kiranshankar *et al.* (2019) ^[23] in mango cv. Alphonso and in Nagpur mandarin by Shirgure *et al.* (2003) ^[46].

Regarding the interaction effect of factors (I × M), the interaction of irrigation as three pulses per day with black polythene mulch (I₂M₁) has recorded maximum fruit weight (501.09 g) which was on par with the interaction effect of irrigation as three pulses per day with paddy straw mulch (I₂M₂) (487.97 g). Minimum fruit weight (355.10 g) was recorded by the interaction of three hours irrigation at two days intervals with no mulch (I₃M₄) in mango cv. Banganpalli (Fig 8). This is due to the synergistic effect of pulse irrigation along with mulching, which led to the increased soil moisture content in the root zone, reduced soil temperature creating congenial conditions for better plant growth with increased availability and translocation of nutrients from source to sink resulting in good size fruits with increased fruit weight in the present investigation. These results are in agreement with findings of other workers who also reported increased fruit weight that includes Panigrahi *et al.* (2010) ^[33] in mango cv. Dashehari, Kiranshankar *et al.* (2019) ^[23] in mango cv. Alphonso and Shirgure *et al.* (2003) ^[46] in Nagpur mandarin.

Fruit Yield (Kg) per Tree and per Ha (t)

The data obtained for fruit yield (kg) per tree and ha (t) was presented in Table 7. The perusal of pooled data revealed that the individual factors *i.e.*, different levels of irrigation (I) and different mulching (M) have variably affected the fruit yield (kg) per tree and ha (t).

Regarding the effect of irrigation treatments (I) applied, irrigation with three pulses per day (I₂) has recorded

maximum fruit yield per tree (83.14 kg) fruit yield per ha. (12.99 t) whereas minimum fruit yield per tree (59.53 kg) and fruit yield per ha. (9.30 t) was recorded in farmer's practice with three hours irrigation at two days interval (I₃). This increased yield is due to an increase in the yield attributing characters like the number of fruits per tree (Table 5), fruit length and breadth (Table 6) and fruit weight (Table 6) which ultimately contributed to increased fruit yield per tree and fruit yield per ha. In I₂ treatment, water was applied in smaller quantities at three intervals due to which a lower hydraulic gradient was created and the percolation was slow into the soil. This resulted in higher availability of soil moisture in the root zone (Table 1 to 4). This increased soil moisture during the time of fruit set and fruit growth stages might have helped in the solubility of mineral nutrients and mobilization of nutrients in the soil leading to efficient utilization of available nutrients. As plants receive optimum amount of water and nutrients, it directly improves cell permeability which enhances photosynthetic process and results in more number of leaves, flowers (Shah *et al.*, 2018) ^[44] and increased fruit set thus producing more number of fruitlet per panicle with improved fruit size (fruit length and breadth) (Table 6) and weight (Table 6) ultimately contributing to increased fruit yield in the present investigation. A similar increase in fruit yield with different irrigation regimes was also reported by Khalifa (2018) ^[21] in two mango cultivars Ewais and Tommy Atkins, Kumar *et al.* (2008) ^[24] in mango hybrid Arka Anmol, Shirgure (2012) ^[47] in Nagpur mandarin and Marathe *et al.* (2018) ^[29] in pomegranate.

Regarding the effect of different mulching (M), mulching with black polythene (M₁) has recorded maximum fruit yield per tree (82.48 kg) and fruit yield per ha. (12.89 t) whereas control (no mulch) (M₄) has recorded minimum fruit yield per tree (51.38 kg) and fruit yield per ha. (8.03 t) (Fig 9). This increased yield is due to the increase in yield attributing characters like the number of fruitlets per panicle (Table 5), fruit length and breadth (Table 6) and fruit weight (Table 6) with black polythene mulching which ultimately contributed to increased fruit yield per tree and yield per ha. Since mulch acts as a surface barrier against evaporation, it checks weeds thereby helps in reducing competition for soil moisture and nutrients (Thirupathaiah and Shirol 2019) ^[55] and thus improved available soil moisture in the present investigation (Table 1 to 4). This increased availability of soil moisture and nutrients reduced competition for soil moisture by weeds has resulted in increasing the solubility of mineral nutrients thereby the mineral nutrients were efficiently utilized. This might have encouraged surface rooting of the crop and further reduced hydrothermal fluctuation in soil under mulching in turn reduced fixation of applied nutrients leading to higher nutrient uptake (Robinson and Hosegood, 1965) ^[41]. The increased availability of water and nutrients to the plant throughout the crop growth period might have helped in increased photosynthesis. The increased photosynthesis might have resulted in enhanced accumulation of photosynthates and auxins like substances which promoted the fruit physical parameters (like length, diameter and weight) (Table 6) and the total number of fruits per tree (Table 5), which contributed to the overall increased fruit yield per plant and per ha in the present investigation. A similar increase in fruit yield of the plant under black polythene mulch was also reported in mango cv. Alphonso (Kiranshankar *et al.*, 2019)

^[23], guava (Dutta and Majumdar, 2009) ^[12], bael (Ghosh *et al.*, 2020) ^[18] and strawberry (Sharma and Goel, 2017) ^[45].

Regarding the interaction effect of factors ($I \times M$), the interaction of irrigation as three pulses per day with black polythene mulch (I_2M_1) has recorded maximum fruit yield per tree (97.71kg) and fruit yield per ha. (15.27 t) (Plate 6) which was on par with the interaction effect of irrigation as three pulses per day with paddy straw mulch (I_2M_2) (92.43kg) (14.44 t ha⁻¹). Minimum fruit yield per tree (47.15kg) and fruit yield per ha. (7.37) was recorded by the interaction of three hours irrigation at two days interval with no mulch (I_3M_4) in mango cv. Banganpalli. This increase in fruit yield is due to the synergistic effect of pulse irrigation along with mulching which resulted in increased available soil moisture (Table 1 to 4). The increased availability of water and nutrients to the plant throughout the crop growth period might have helped in increased photosynthesis with enhanced accumulation of photosynthates and auxins like substances which promoted the increased number of fruits per tree (Table 5) and fruit weight (Table 6) contributing to increased fruit yield per tree and yield per ha in the present investigation. These results are in agreement with the findings of Panigrahi *et al.* (2010) ^[33] in mango and Samant *et al.* 2017 ^[43] in mango hybrid 'Amrapali'.

Fruit Yield (Kg) Per M³ Canopy Volume of Tree

The data obtained for fruit yield (kg) per m³ canopy volume of the tree was presented in Table 7. The analysis of pooled data revealed that there was a significant difference among different levels of irrigation (I), different mulching (M) and their interaction effect with respect to fruit yield (kg) per m³ canopy volume of tree in mango cv. Banganpalli.

Regarding the effect of irrigation treatments (I) applied, irrigation with three pulses per day (I_2) has recorded maximum fruit yield per m³ canopy volume of the tree (1.03 kg) whereas minimum fruit yield per m³ canopy volume of the tree (0.75 kg) was recorded in farmer's practice with three hours irrigation at two days interval (I_3). This is due to the increased soil moisture through pulse irrigation (Table 1 to 4) helped in the solubility of mineral nutrients leading to greater mobility of major nutrients to the developing fruits which acted as a strong metabolic sink and stimulated the synthesis of chlorophyll and increased photosynthetic activity which resulted in increased stored food material in the tissue (Singh and Rajput, 1977) ^[51] improving the fruit set (Table 5), the number of fruits per tree (Table 5) size (fruit length and breadth (Table 6), fruit weight (Table 6) thus increasing the overall fruit yield per m³ canopy volume of tree in the present investigation. A similar increase in fruit yield with pulse irrigation was earlier reported by Kumar *et al.* (2008) ^[24] in mango hybrid ArkaAnmol,

Shirgure (2012) ^[47] in Nagpur mandarin and Marathe *et al.* (2018) ^[29] in pomegranate.

Regarding the effect of different mulching (M), mulching with black polythene (M_1) has recorded maximum fruit yield per m³ canopy volume of the tree (1.03 kg) and control (no mulch) (M_4) has recorded minimum fruit yield per m³ canopy volume of the tree (0.67 kg). Further, mulching with black polythene might have increased phosphate uptake by crop, mainly because it encouraged surface rooting of the crop, kept the surface soil moist for a longer time with more available soil moisture in the root zone (Table 1 to 4). This might have avoided fixation of applied nutrients leading to higher uptake by roots especially phosphate uptake from surface soil by surface rooting under mulches (Robinson and Hosegood, 1965) ^[41]. Phosphorous is an essential constituent of biologically active macromolecules (nucleic acids, co-enzyme NAD, NADP, ATP *etc.*), is an integral part of important plant processes like photosynthesis, glycolysis, respiration, fatty acid synthesis *etc.* contributing to the overall better performance of a plant (Devlin, 1969) ^[11]. Hence the increased level of phosphorous uptake under mulched conditions might have possibly increased the fruit yield of the plant (Das *et al.*, 2010) ^[9]. Further, the black polythene mulch mitigates negative effects of water stress, enhanced the concentrations of nutrients resulting in improved fruit set (Table 5), number of fruits per tree (Table 5) size (fruit length and breadth (Table 6), fruit weight (Table 6) thus increasing the overall fruit yield per m³ canopy volume of the tree.

Regarding the interaction effect of factors ($I \times M$), the interaction of irrigation as three pulses per day with black polythene mulch (I_2M_1) has recorded maximum fruit yield (1.22 kg) per m³ canopy volume of the tree which was on par with yield recorded by the interaction of irrigation as three pulses per day with paddy straw mulch (I_2M_2) (1.13 kg). Minimum fruit yield (0.60 kg) per m³ canopy volume of the tree was recorded by the interaction of three hours irrigation at two days interval with no mulch (I_3M_4) (2.14 kg) in mango cv. Banganpalli. This increase in yield can be attributed to the synergistic effect of pulse irrigation along with mulching which resulted in increased soil moisture availability in the root zone (Table 1 to 4). This improved the nutrient availability in soil solution and enabled the better uptake of nutrients by active roots enhancing the fruit growth and development with an increase in yield attributing characters like the number of fruits per tree (Table 5) and fruit weight (Table 6) contributing to increased fruit yield per m³ canopy volume of the tree. These results are in agreement with the findings of Panigrahi *et al.* (2010) ^[33] in mango and Samant *et al.* 2017 ^[43] in mango hybrid 'Amrapali'.

Table 1: Effect of different irrigation levels and mulching on soil moisture (%) available at different depths during January month of mango cv. Banganpalli

Soil moisture (%) available at different depth during January month																								
	10 cm depth				20 cm depth				30 cm depth				40 cm depth				60 cm depth				100 cm depth			
Treatments	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	6.43 ^b	7.84 ^a	5.69	6.65 ^a	13.45 ^c	18.17 ^a	11.99	14.54 ^a	28.45 ^b	36.65 ^a	24.09 ^c	29.73 ^a	34.59 ^c	47.59 ^a	32.92 ^c	38.37 ^a	51.81 ^b	68.36 ^a	45.06 ^c	55.08 ^a	76.53 ^b	97.14 ^a	65.52 ^c	79.73 ^a
M ₂	5.82 ^c	6.25 ^b	5.72	5.93 ^b	12.94 ^c	15.73 ^b	11.72	13.46 ^b	24.27 ^c	28.88 ^b	21.49	24.88 ^b	32.33 ^c	38.40 ^b	28.51	33.08 ^b	44.52 ^d	49.75 ^b	35.89	43.39 ^b	62.19	78.95 ^b	54.16	65.10 ^b
M ₃	6.13 ^b	5.82	5.7	5.89 ^b	12.53 ^c	11.9	11.51	11.98 ^c	23.28 ^c	24.38 ^c	20.84	22.83 ^c	29.73	33.57 ^c	26.79	30.03 ^c	40.24	47.33 ^c	34.03	40.54 ^c	56.74	69.50 ^c	49.41	58.55 ^c
M ₄	5.67	5.67	5.67	5.67 ^b	11.31	11.27	11.34	11.31 ^d	20.67	21.02	20.72	20.80 ^d	26.74	26.66	24.46	25.95 ^d	36.19	42.17	34.04	37.46 ^d	49.26	52.61	48.75	50.20 ^d
Mean of I	6.01 ^b	6.40 ^a	5.69 ^c	6.03	12.56 ^b	14.27 ^a	11.64 ^c	12.82	24.17 ^b	27.73 ^a	21.78 ^c	24.56	30.85 ^b	36.55 ^a	28.17 ^c	31.86	43.19 ^b	51.90 ^a	37.25 ^c	44.12	61.18 ^b	74.55 ^a	54.46 ^c	63.39 ^b
	S.Em±	C.D.at 5%			S.Em±	C.D. at 5%			S.Em±	C.D.at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D.at 5%		
I	0.1	0.28			0.21	0.6			0.19	0.56			0.31	0.88			0.41	1.19			0.82	2.36		
M	0.11	0.32			0.24	0.69			0.22	0.64			0.31	0.88			0.41	1.19			0.82	2.36		
I X M	0.19	0.55			0.42	1.2			0.39	1.11			0.36	1.02			0.48	1.37			0.95	2.72		

*Each data point is average of two years *Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 2: Effect of different irrigation levels and mulching on soil moisture (%) available at different depths during February month of mango cv. Banganpalli

Soil moisture (%) available at different depth during February month																								
	10 cm depth				20 cm depth				30 cm depth				40 cm depth				60 cm depth				100 cm depth			
Treatments	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	3.84 ^b	5.25 ^a	1.44	3.51 ^a	10.77 ^c	15.49 ^a	9.31	11.86 ^a	20.53 ^b	28.74 ^a	16.17 ^c	21.81 ^a	28.58 ^c	41.58 ^a	26.90 ^c	32.35 ^a	40.66 ^b	57.21 ^a	33.91 ^d	43.93 ^a	68.81 ^b	89.42 ^a	57.80 ^c	72.01 ^a
M ₂	3.23 ^c	3.67 ^b	0.65	2.51 ^b	10.26	13.05 ^b	9.04	10.78 ^b	16.35 ^c	20.96 ^b	13.57	16.96 ^b	26.31	32.39 ^b	22.5	27.06 ^b	33.37	38.60 ^b	24.74	32.24 ^b	54.48	71.23 ^b	46.45	57.38 ^b
M ₃	3.55	3.23 ^c	0.7	2.49 ^b	9.85	9.22	8.83	9.30 ^c	15.36	16.46 ^c	12.93	14.92 ^c	23.72	27.55 ^c	20.78	24.01 ^c	29.09	36.18 ^c	22.88	29.39 ^c	49.03	61.78 ^c	41.69	50.83 ^c
M ₄	0	0	0	0.00 ^c	8.63	8.59	8.66	8.62 ^d	12.76	13.1	12.8	12.89 ^d	20.72	20.64	18.44	19.93 ^d	25.04	31.02	22.89	26.31 ^d	41.54	44.89	41.03	42.49 ^d
Mean of I	2.65 ^b	3.04 ^a	0.70 ^c	2.13	9.88 ^b	11.59 ^a	8.96 ^c	10.14	16.25 ^b	19.82 ^a	13.87 ^c	16.64	24.83 ^b	30.54 ^a	22.15 ^c	25.84	32.04 ^b	40.75 ^a	26.10 ^c	32.97	53.46 ^b	66.83 ^a	46.74 ^c	55.68 ^b
	S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%		
I	0.1	0.29			0.05	0.15			0.17	0.48			0.34	0.96			0.37	1.06			0.75	2.16		
M	0.1	0.29			0.05	0.15			0.17	0.48			0.34	0.96			0.37	1.06			0.75	2.16		
I X M	0.12	0.34			0.06	0.17			0.19	0.55			0.39	1.11			0.43	1.22			0.87	2.49		

*Each data point is average of two years *Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 3: Effect of different irrigation levels and mulching on soil moisture (%) available at different depths during March month of mango cv. Banganpalli

Soil moisture (%) available at different depth during March month																								
	10 cm depth				20 cm depth				30 cm depth				40 cm depth				60 cm depth				100 cm depth			
Treatments	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	3.26	4.78	1.56	3.20 ^a	7.69 ^c	12.41 ^a	6.23	8.77 ^a	15.53 ^b	23.74 ^a	11.17 ^c	16.81 ^a	18.68 ^c	31.68 ^a	17.00 ^c	22.45 ^a	34.13 ^b	50.68 ^a	27.38 ^d	37.40 ^a	57.81 ^b	78.42 ^a	46.80 ^c	61.01 ^a
M ₂	2.65	3.09	1.2	2.31 ^b	7.17 ^d	9.96 ^b	5.95	7.70 ^b	11.35 ^c	15.96 ^b	8.57	11.96 ^b	16.41	22.49 ^b	12.6	17.16 ^b	26.84 ^d	32.07 ^b	18.21	25.70 ^b	43.48	60.23 ^b	35.45	46.38 ^b
M ₃	2.96	2.65	1.12	2.24 ^b	6.77 ^e	6.13	5.74	6.21 ^c	10.36	11.46 ^c	7.93	9.92 ^c	13.82	17.65 ^c	10.88	14.11 ^c	22.56	29.65 ^c	16.35	22.85 ^c	38.03	50.78 ^c	30.69	39.83 ^c
M ₄	0	0	0	0	5.54	5.51	5.57	5.54 ^d	7.76	8.1	7.8	7.89 ^d	10.82	10.74	8.54	10.03 ^d	18.51	24.48	16.35	19.78 ^d	30.54	33.89	30.03	31.49 ^d
Mean of I	2.22 ^b	2.63 ^a	0.97 ^c	1.94	6.79 ^b	8.50 ^a	5.87 ^c	7.06	11.25 ^b	14.82 ^a	8.87 ^c	11.64	14.93 ^b	20.64 ^a	12.25 ^c	15.94	25.51 ^b	34.22 ^a	19.57 ^c	26.43	42.46 ^b	55.83 ^a	35.74 ^c	44.68 ^d
	S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%			S.Em±	C.D.at 5%		
I	0.12	0.36			0.07	0.2			0.17	0.49			0.2	0.58			0.38	1.1			0.76	2.18		
M	0.12	0.36			0.07	0.2			0.17	0.49			0.2	0.58			0.38	1.1			0.76	2.18		
I X M	0.14	0.41			0.08	0.24			0.2	0.57			0.23	0.67			0.44	1.27			0.88	2.52		

*Each data point is average of two years *Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 4: Effect of different irrigation levels and mulching on soil moisture (%) available at different depths during April month of mango cv. Banganpalli

Soil moisture (%) available at different depth during April month																								
	10 cm depth				20 cm depth				30 cm depth				40 cm depth				60 cm depth				100 cm depth			
Treatments	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	0.50 ^b	1.45 ^a	0.01	0.65 ^a	2.19 ^c	6.91 ^a	0.73	3.27 ^a	8.70 ^b	16.90 ^a	4.34	9.98 ^a	14.41 ^c	27.41 ^a	12.73 ^d	18.18 ^a	28.91 ^b	45.46 ^a	22.16 ^d	32.18 ^a	50.31 ^b	70.92 ^a	39.30 ^c	53.51 ^a
M ₂	0.1	0.39 ^c	0.03	0.17 ^b	1.67 ^d	4.46 ^b	0.45	2.20 ^b	4.52 ^c	9.13 ^b	1.74	5.13 ^b	12.15	18.22 ^b	8.33	12.90 ^b	21.62 ^d	26.85 ^b	12.99	20.49 ^b	35.98	52.73 ^b	27.95	38.88 ^b
M ₃	0.31 ^d	0.1	0.02	0.14 ^c	1.27 ^d	0.63	0.24	0.71 ^c	3.53	4.63 ^c	1.09	3.08 ^c	9.55	13.38 ^c	6.61	9.85 ^c	17.34	24.43 ^{bc}	11.13	17.64 ^c	30.53	43.28 ^c	23.19	32.33 ^c
M ₄	0	0	0	0.00 ^d	0.04	0.01	0.07	0.04 ^d	0.92	1.27	0.97	1.05 ^d	6.55	6.47	4.28	5.77 ^d	13.29	19.27	11.14	14.56 ^d	23.04	26.39	22.53	23.99 ^d
Mean of I	0.23 ^b	0.48 ^a	0.02 ^c	0.24	1.29 ^b	3.00 ^a	0.37 ^c	1.56	4.42 ^b	7.98 ^a	2.03 ^c	4.81	10.66 ^b	16.37 ^a	7.99 ^c	11.67	20.29 ^b	29.00 ^a	14.35 ^c	21.22	34.96 ^b	48.33 ^a	28.24 ^c	37.18 ^b
	S.Em±	C.D. at 5%			S.Em±	C.D.at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D.at 5%			S.Em±	C.D. at 5%		
I	0.01	0.02			0.04	0.11			0.11	0.31			0.20	0.58			0.38	1.09			0.76	2.18		
M	0.01	0.02			0.04	0.11			0.11	0.31			0.2	0.58			0.38	1.09			0.76	2.18		
I X M	0.01	0.02			0.04	0.13			0.13	0.36			0.23	0.67			0.44	1.26			0.88	2.52		

*Each data point is average of two years *Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 5: Effect of different irrigation levels and mulching on number of fruitlets per panicle at the time of fruit set, Number of days taken for maturity of the fruit and Number of fruits per tree at the time of harvest of mango cv. Banganpalli

Treatments	Number of fruitlets per panicle at the time of fruit set				Number of days taken for maturity of the fruit				Number of fruits per tree at the time of harvest			
	POOLED				POOLED				POOLED			
	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	7.71	8.74	6.67	7.71 ^a	96.72	98.68	99.51	98.30 ^a	176.94 ^{bc}	195.05 ^a	161.17	177.72 ^a
M ₂	7.36	8.4	6.33	7.36 ^a	110.43	97.56	99.8	102.60 ^a	172.46	189.40 ^{ab}	155.52	172.46 ^b
M ₃	7.02	8.05	5.98	7.02 ^{ab}	114.34	101.64	108.47	108.15	166.82	183.76 ^{ba}	149.87	166.81 ^c
M ₄	5.29	5.64	4.95	5.29 ^c	112.38	96.84	106.51	105.24 ^a	140.25	144.23	132.93	139.13 ^d
Mean of I	6.85 ^b	7.71 ^a	5.98 ^c	6.85	108.47 ^{bc}	98.68 ^a	103.57 ^{ab}	103.57	164.12 ^b	178.11 ^a	149.87 ^c	164.03
	S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%		
I	0.15	0.44			2.11	6.05			1.42	4.08		
M	0.18	0.5			2.43	6.99			1.64	4.71		
I X M	0.3	NS			4.22	NS			2.84	8.16		

*Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 6: Effect of different irrigation levels and mulching on fruit length (cm), Fruit breadth (cm) and Fruit weight (g) at the time of harvesting of mango cv. Banganpalli

Treatments	Fruit length (cm) at the time of harvesting				Fruit breadth (cm) at the time of harvesting				Fruit weight (g) at the time of harvesting			
	POOLED				POOLED				POOLED			
	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	12.02	12.53	11.5	12.02 ^a	10.02	10.42	9.62	10.02 ^a	461.73 ^{bc}	501.09 ^a	422.37	461.73 ^a
M ₂	11.84	12.36	11.33	11.84 ^a	9.89	10.29	9.49	9.89 ^a	448.61	487.97 ^a	409.25	448.61 ^a
M ₃	11.67	12.19	11.16	11.67 ^a	9.76	10.15	9.36	9.76 ^a	435.49	474.85 ^{ba}	396.13	435.49 ^{ba}
M ₄	10.82	10.99	10.65	10.82 ^b	9.09	9.23	8.96	9.09 ^b	369.89	383.01	355.1	369.33 ^c
Mean of I	11.59 ^a	12.01 ^a	11.16 ^b	11.59	9.69 ^a	10.02 ^a	9.36 ^b	9.69	428.93 ^b	461.73 ^a	395.71 ^c	428.79
	S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%		
I	0.15	0.44			0.13	0.37			4.12	11.83		
M	0.18	0.51			0.15	0.43			4.76	13.66		
I X M	0.31	NS			0.26	NS			8.24	23.66		

*Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Table 7: Effect of different irrigation levels and mulching on fruit yield (kg) per tree, Fruit yield (ton. /ha.), Canopy volume (m3) and Fruit yield (kg) per m3 canopy volume of mango cv. Banganpalli

Treatments	Fruit yield (kg) per tree				Fruit yield (ton. /ha.)				Canopy volume (m3)				Fruit yield (kg) per m3 canopy volume			
	POOLED				POOLED				POOLED				POOLED			
	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M	I ₁	I ₂	I ₃	Mean of M
M ₁	81.70 ^{cb}	97.71 ^a	68.01	82.48 ^a	12.77 ^{cb}	15.27 ^a	10.63	12.89 ^a	81.27	80.29	78.32	79.96	1.01 ^{cb}	1.22 ^a	0.87	1.03 ^a
M ₂	77.31	92.43 ^a	63.63	77.79 ^b	12.08	14.44 ^a	9.94	12.15 ^b	85.21	82.26	81.27	82.91	0.91	1.13 ^a	0.78	0.94 ^b
M ₃	72.56	87.20 ^{ba}	59.33	73.03 ^c	11.34	13.63 ^{ba}	9.27	11.41 ^c	78.32	83.24	82.26	81.27	0.93	1.05 ^{ba}	0.73	0.90 ^b
M ₄	51.77	55.2	47.15	51.38 ^d	8.09	8.63	7.37	8.03 ^d	76.35	77.33	78.32	77.33	0.68	0.72	0.6	0.67 ^c
Mean of I	70.84 ^b	83.14 ^a	59.53 ^c	71.17	11.07 ^b	12.99 ^a	9.30 ^c	11.12	80.29	80.78	80.04	80.37	0.88 ^b	1.03 ^a	0.75 ^c	0.89
	S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%			S.Em±	C.D. at 5%		
I	1.05	3.01			0.16	0.47			1.64	NS			0.02	0.05		
M	1.21	3.48			0.19	0.54			1.89	NS			0.02	0.05		
I X M	2.1	6.02			0.33	0.94			3.27	NS			0.03	0.1		

*Figures with same alphabet did not differ significantly

M ₁ - Black polyethylene mulch (100 µ)	I ₁ - One time per day (80% volume of PE)
M ₂ - Paddy straw (10 cm thickness)	I ₂ - Three pulses per day (80% volume of PE)
M ₃ - Saw dust (5 cm thickness)	I ₃ - Farmer's practice (3 hrs. irrigation @ 2 days interval)
M ₄ - Control (No mulch)	

Summary and Conclusions

The present study has indicated that the interaction effect of different mulching and irrigation levels on soil physical properties, the treatment irrigation as three pulses per day with black polyethylene mulch (I_2M_1) has recorded the highest soil moisture (%) at all recorded depths during the entire critical fruit growth and development period *i.e.*, from January to April. The synergistic effect of pulse irrigation along with black polyethylene mulch, which led to the increase in soil moisture content in the root zone reduce soil temperature created congenial conditions for better plant growth with which ultimately might have caused the mobilization of soluble carbohydrates and macro and micro nutrients which are essential during fruit growth and development. Hence, the interaction effect of different mulching and irrigation levels on yield characters, the treatment irrigation as three pulses per day with black polyethylene mulch (I_2M_1) has recorded the maximum number of fruits per tree at the time of harvest, fruit weight, maximum yield per tree and unit (m^3) canopy volume.

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