

**PHYSIOLOGICAL AND GENETICAL INVESTIGATION
FOR DROUGHT TOLERANCE IN TOMATO
(*Solanum lycopersicum* L.) GENOTYPES**

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Thesis submitted to the

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By

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CERTIFICATE

This is to certify that the thesis entitled “**PHYSIOLOGICAL AND GENETICAL INVESTIGATION FOR DROUGHT TOLERANCE IN TOMATO (*Solanum lycopersicum* L.) GENOTYPES**” submitted in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **BIOTECHNOLOGY AND CROP IMPROVEMENT** to the University of Horticultural Sciences, Bagalkot, is a record of bonafide research work carried out by **Mr. PRAKASH G.** under my guidance and supervision and that no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

Place: Arabhavi

Date: DECEMBER, 2015

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ARABHAVI
AUGUST, 2016

(PRAKASH G.)

**Affectionately Dedicated to
My Beloved Parents and
Family Members**

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1. INRODUCTION

Tomato (*Solanum lycopersicum* L.) which belongs to the family *Solanaceae* is an extremely popular and widely grown vegetable in the world. It is grown for its edible fruits, which can be consumed either fresh as salads or consumed after cooking or utilized in the preparation of range of processed products like paste, puree, soup, sauce, juice, ketchup, whole canned fruit and drinks. Unripe green fruits are used for preparation of pickles and chutney *etc.*, in our country. In many countries it is considered as “poor man’s orange” because of its attractive appearance and nutritive value. Tomato tops the list of processed vegetables and is a very good source of lycopene (an antioxidant), ascorbic acid and β -carotene and valued for its colour and flavour. Tomato seed contain 24 per cent oil which is used as a salad oil and in manufacture of margarine. Tomato is also rich in medicinal value. The pulp and juice are digestible, mild aperients, promote gastric secretion and blood purifiers. Tomato has antiseptic properties against intestinal infections. It is useful against cancer of the mouth and sour mouth.

Tomato is grown throughout the country; both under rainfed and irrigated conditions and ranks second among vegetables next to potato in area and production. It occupies an area of 6.34 lakh hectares with an annual production of 124.33 lakh metric tonnes accounting to an average productivity of 15.9 tonnes per hectare contributing 7.7 per cent of the total vegetable production. In Karnataka, tomato ranks third in area and second in production of among the vegetables with an area of 48.3 thousand hectares and annual production of about 15.8 lakh tonnes and an average productivity of 20.91 tonnes per hectare (Anon, 2014).

Tomato is native of Peru-Ecuador region (Rick, 1969). The genus *Solanum* consists of annual or short lived perennial herbaceous plants. Tomato has chromosome number $2n = 24$. Tomato is a typical day neutral plant and it is mainly self-pollinated, but five percentage of cross pollination also occurs. It is warm season crop reasonably tolerant to heat and drought and grows under wide range of soil and climatic conditions. Considering the potentiality of this crop, there is plenty of scope for its improvement. Many new cultivars have been developed to meet the diverse need and varied climatic conditions under which the tomato crop grown. Recent trend has been towards development of cultivars to meet specific uses rather than

multipurpose cultivars to meet several needs. Though some work has been done to improve tomato yield in India, yet the potential is far from exhausted. This is evident from the fact that a huge gap exists between the national average yield of India and that of the important tomato growing nations.

A water deficit or drought is, globally, the most common stress condition and it is increasingly of concern worldwide (Mahajan and Tuteja, 2005). Plant productivity is predominantly influenced by water availability. Tomatoes are very sensitive to drought stress, initially during vegetative development and, later, when the tomato is reproductive (Wudiri and Henderson, 1985). Several studies have investigated the effect of water deficit on individual aspects of tomato morphology, physiology and biochemistry (Liu et al., 2010). However, there are very few studies on the effects of severe drought stress through the critical developmental stages (early vegetative growth, flowering and fruiting stage) of tomato plants.

Many of the areas where tomatoes are cultivated are arid or semi-arid, suffering water deficiency and ground water salinity (Romero-Aranda et al., 2001). When the guard cells of stomata lose turgor, the stomata close and gas exchange slows down leading to decreased photosynthesis, thus decreased growth rate. Absciscic acid (ABA) is a plant hormone which accumulates during drought periods and plays a key role in osmotic stress tolerance by regulating stomatal closure (Hayashi and Kinoshita, 2011). Stomatal conductance is controlled by light and drought directly or mediated through abscisic acid.

The dynamic concept of stress denotes that the organism under stress passes through a sequence of characteristic phases. The impact of stress factors destabilizes vital structures inducing an alarm phase, in which functional declines occur (stress reaction). Stress reactions are offset by counter-reactions (restitution), which may lead to over-compensation (hardening). Under ongoing exposure to constant stress, a higher degree of resistance is developed and this may result in re-stabilization (adjustment). If the organism is overstrained by stress (exhaustion), irreversible damage occurs. If the impairment was temporary, damage may be repaired in a phase of regeneration (Larcher, 2003).

The first and most sensitive response to water deficiency within cells is a decrease in turgor and therefore a decrease of growth (cell elongation) is the result. A much lower water potential is required for stomatal closure, which is followed by

effects on photosynthesis (repression) and respiration (activation) since these processes depend on the flow of O_2 and CO_2 . Furthermore intercellular space is decreasing (Larcher, 2003) and permeability of membranes is changing because of displacement of membrane proteins, which contributes to a loss of membrane integrity, selectivity, disruption of cellular compartments, and loss of membrane-based enzyme activity. The high concentration of cellular electrolytes due to the dehydration of the protoplasm may also cause disruption of the cellular metabolism (Shinozaki and Yamaguchi-Shinozaki, 2007).

Plants which tolerate moderate stress at low tissue water potential may do so by virtue of several dehydration tolerance mechanisms like maintenance of membrane integrity, osmotic adjustment and chloroplast integrity (Edward, 1989). Although tomato is generally grown under irrigated conditions, its cultivation as a rainfed crop has gained importance particularly in semi-arid regions.

In view of this, the present investigation was planned to identify variability in different drought adaptive mechanisms among different tomato genotypes with the following objectives.

1. To screen the tomato germplasm for drought tolerance under field condition.
2. To find out the physiological traits associated with drought tolerance mechanism among the selected genotypes for yield.
3. To study the genetic variability for growth, earliness, physiological and yield parameters under drought condition.
4. To confirm the drought tolerance of tomato genotypes through molecular markers.

2. REVIEW OF LITERATURE

Harsh environmental stresses of multifarious types significantly reduced growth, metabolism and yield of plants (Ashraf, 2012). Drought, salinity, extremes of temperature, pollutants, flooding and radiation are chief abiotic stress factors limiting crops productivity and production (Rahman *et al.*, 2006). India is also one of the country, which have agriculture system challenged with climate change. Acute shortage of irrigation water is adversely affecting the crop production in general and vegetable production in particular.

Drought is one of the most important factors for yield reduction in the majority of the cultivated areas, affecting 40 to 60 per cent of the world's agriculture lands (Mollasadeghi *et al.*, 2011). Among the different crops, understanding of physiological mechanisms that enable plants to adapt to water deficit and maintain growth and productivity during stress period could help in screening and selection of tolerant genotypes and using this trait in breeding programmes (Zaharieva *et al.*, 2001). Since water is essential for plant growth, it is axiomatic that water stress, depending on its severity and duration, will affect plant growth, yield and quality.

The present investigations were carried out to study the effects of water stress on physiological and genetics of tomato and to understand the physiological, biochemical and molecular mechanisms and genetical aspects of tolerance to water stress and also to explore the possible ways of mitigation of stress effects through hormonal manipulation, thereby, minimizing the yield loss in tomato.

2.1 Effect of water stress on morphological parameters

2.1.1 Effect of water stress on plant height

It has been established that drought stress is a very important limiting factor at the initial phase of plant growth and establishment. It affects both elongation and expansion growth (Shao *et al.*, 2008). Subramanian *et al.* (1993) reported that moisture stress imposed at different growth intervals resulted in significant reduction in the plant height in brinjal. Water deficit in the early stages of tomato showed a greater effect on reduction in plant height as observed by Gladden *et al.* (2012).

Rad and Padma (1991) reported that moisture stress at all stages of growth reduced the plant height significantly in tomato. A greater reduction in plant height and stem diameter was also noticed with increasing level of water stress in maize (Khan *et al.*, 2001).

In chilli, Thakur *et al.* (2000) recorded that a maximum reduction in plant height under 75 per cent water deficit compared to control. Yadav *et al.* (2003), however, noticed a significant difference in the plant height at cumulative pan evaporation (CPE) of 100 mm in potato cv. Kufri Sutlej. Upreti *et al.* (2000) reported that in pea cultivars, the reduction in plant height was more pronounced at vegetative stage than at flowering stage. The reduction in plant height could be attributed to decline in the cell enlargement and more leaf senescence in the plant under water stress (Manivannan *et al.*, 2007a). Under severe water deficiency, cell elongation of plants can be inhibited by interruption of water flow from the xylem to the surrounding elongating cells (Nonami, 1998). Drought caused impaired mitosis, cell elongation and expansion resulted in reduced growth and yield traits (Hussain *et al.*, 2008). Bhatt and Rao (2005), reported that, in the reduction in plant height was associated with a decline in the cell enlargement and more leaf senescence in okra under water stress.

2.1.4 Effect of water stress on pubescence

Leaf hairs are ecologically important to plants, in both negative and positive ways, Plant leaf hairs play important physiological and ecological roles. They are often implicated in plant protection from abiotic stresses.

Chavan *et al.* (2010) reported that, stress level increases with increase in pubescence. Pubescence count was more than eight times greater on the abaxial than adaxial leaf surface under the drought condition as reported by Ratnayak and Kincaid (2005) in *Tinnevelly senna* and *Cassia agnustifolia*. Olive cultivars showed highly significant variation for trichome density (TD). This variability can be attributed to efficacy of the defense mechanisms used by these cultivars. The cultivars which were tolerant to drought stress found to increase TD to 25 per cent when exposed drought stress.

2.2 Effect of water stress on growth and growth parameters

Leaf is a functional area and where photosynthesis will takes of cell expansion and is again depends upon turgidity of cell. Development of optimal leaf area is important for effective light interception and CO₂ fixation. Water deficit stress mostly reduced leaf growth and in turn the leaf areas in many species of plants like *Populus* (Wullschlegel *et al.*, 2005) and many other species (Farooq *et al.*, 2009).

Meenakumari *et al.* (2004) mentioned that drought led to substantial impairment of growth-related traits of maize in terms of plant height, leaf area, number of leaves / plant, cob length, shoot fresh and dry weight.

Drought tolerance was prominently noticed in those pigeonpea genotypes which had more number of leaves per stem. These genotypes were reported to have narrower leaves with more waxy coating on them, compared to the other non-tolerant genotypes. This was attributed that these morphological adjustments enabled those genotypes to lose more heat and reduce transpirational losses (Narina *et al.*, 2014).

In brinjal, severe water stress reduced the relative leaf expansion rate up to 75 per cent, besides reducing the plant height by 46 per cent, stem diameter by 51 per cent, total dry weight by 43 per cent. Bhagavanthagoudra and Rokhade (2002) reported that as the irrigation frequency increased, there was increase in leaf area in cabbage. Upreti *et al.* (2000) indicated that water stress treatments lead to significant reduction in leaf area in all the cultivars of pea and the decline was greater with stress at flowering than at vegetative stage.

Naidu *et al.* (2001) indicated that leaf area of all genotypes of green gram was reduced drastically under drought stress. Total leaf area in stress imposed plants of tomato was lower than well-watered plants as observed by Tahi *et al.* (2008). Water deficit diminishes leaf size, longevity, and number of leaves per plant in tomato (Shao *et al.*, 2008)

The productivity of the crop may be related to physiological attributes such as Net Assimilation Rate (NAR), Leaf Area Index (LAI) and Relative Growth Rate (RGR). Higher NAR and RGR lead to better growth and development which in turn

depends on leaf area. Rapid early growth and maintenance of LAI at reasonably higher level with higher NAR during reproduction phase have greater influence on yield (Haloi and Baldev, 1986).

A reduction in LAI, NAR and RGR was noticed at all the growth stage as the stress increased from 1.2 to 0.4 IW/CPE ratio, whereas, per cent light transmission was increased in tomato (Chavan *et al.*, 2010). Chowdhury and Varma (1998) noticed a significant decline in CGR at IW/CPE ratio of 0.2 at both 60 and 90 days after planting in sweet potato. Irrigation water applied to mustard at flowering and pod development stage increased the CGR compared to unirrigated crop (Panda *et al.*, 2004). Patel *et al.* (2012) showed that the leaf area per plant was decreased significantly by drought stress in chickpea. Singh and Singh (1994) studied the RGR in sugarcane under the moisture stress and reported that maintenance of higher RGR under stress condition showed its greater ability of drought tolerance and also studied the NAR in sugarcane under the moisture stress and reported that NAR increased steadily with the age of plants grown under normal moisture condition. Under stress condition, it declined up to five months of age.

Higher plants, which are continuously exposed to intense or moderate water deficit, uses morphological, cellular and molecular adaptive mechanisms to survive (Pedrol *et al.*, 2000). In tobacco plant responses to drought include changes of growth intensity in shoots and roots, and an acceleration of the plant development. In addition, drought has been demonstrated to be extremely negative at the reproductive stage of plant development (Ma *et al.*, 2006). Therefore, plants tend to avoid dangerous periods by changing the intensity of the physiological processes and the position of organs, or by leaf rolling (Saglam *et al.*, 2008). Singh and Singh (2000) suggested that leaf rolling is one of the visible physiological responses to plant water deficit. It is an adaptive response to water deficit which helps in maintaining favorable water balance within plant tissues with resultant benefit to plants under conditions of water scarcity and depleting soil moisture in rice.

Kadioglu and Rabiye (2007) reported that the plants have several defense mechanisms against unfavorable environmental conditions. One of these mechanisms is leaf rolling. Leaf rolling is a response to water deficit stress and activities of some

enzymes and changes in osmotic substances. Beena *et al.* (2012) stated that significant variation was observed for leaf rolling and leaf drying in inbred lines of rice under water stress condition.

2.2.1 Total dry matter production

A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production (Zhao *et al.*, 2006). Milton *et al.* (1992) in an experiment on the effect of soil moisture on tomato indicated that decrease in watering frequency decreased the dry weight of leaf, stem and root. When tomato plants were irrigated biweekly, there was significant reduction in dry weight of leaf, stem and root (1.52, 0.78 and 1.02 g respectively) when compared to daily irrigation (6.30, 4.58 and 2.45 g, respectively).

Rao and Bhatt (2000) concluded that the dry weight of stem and leaf of the stressed and mepiquat chloride treated tomato plants were similar to those of irrigated control. However, in stressed tomato plant, the decrease in the stem and leaf dry weight varied between 18-36 per cent. Molla *et al.* (2003) studied water stress at different phenological stages of tomato and found that biomass production was less when stress was imposed during flowering and fruit ripening.

Kirnak *et al.* (2001) noticed that 57 per cent reduction in total dry weight, when plants were irrigated with 40 per cent of pot capacity and minimum reduction was observed under irrigation with 80 per cent of pot capacity (95 per cent) compared to control in egg plant. Similarly, there was 48 and 57 per cent reduction in shoot and root dry weight when plants were irrigated with 40 per cent of pot capacity compared to control. Bhagavanthagoudra and Rokhade (2002) reported that as the irrigation frequency increased, there was an increase in dry matter production in cabbage. Significantly higher dry matter production per head was recorded at the IW/CPE ratio of 1.6 (81.67 g) and minimum dry matter was observed at IW/CPE ratio of 1.0 (49.56 g). Bhagavanthagoudra (2000) showed that scheduling of irrigation at 1.6 IW/CPE ratio recorded significantly higher dry matter production per head (81.678 g) compared to irrigation scheduled at 1.0 IW/CPE ratio (49.56 g) in cabbage.

Shubhra *et al.* (2003) noticed a significant reduction in the leaf, stem and root dry weights of cluster bean at all the growth stages due to moisture stress. Garg *et al.* (2004) noticed a reduction in dry matter production due to drought at vegetative stage than at flowering stages in all the genotypes of moth bean. Same trend was observed by Vyas *et al.* (2001) in cluster bean.

Mukesh *et al.* (2007), screened 50 tomato genotypes for drought tolerance based on the per cent reduction in 0.4 over 1.2 IW/CPE. Results of pooled analysis indicated that, under the severe moisture stress of 0.4 IW/CPE ratio, was noticed biomass production was significantly higher in the genotypes L-10 (P), S-22 and L-30 at all the growth stages as compared to local check Arka Meghali and other susceptible genotypes.

Patel *et al.* (2012) showed that total dry weight of the plant was decreased significantly by drought stress in chickpea. Greater plant fresh and dry weights under water limited conditions are desirable characters. A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production (Farooq *et al.*, 2009). Plant productivity under drought stress is strongly related to the processes of dry matter partitioning and temporal biomass distribution (Kage *et al.*, 2004). Diminished biomass due to water stress was observed in almost all genotypes of sunflower (Tahir and Mehid, 2001). However, some genotypes showed better stress tolerance than the others.

2.3 Biophysical parameters

2.3.1 Transpiration rate

Mingchi *et al.* (2010) reported that the stomatal conductance, transpiration rate and photosynthetic rate were reduced under simulated drought stress in tomato. Kudoyarova *et al.* (2007) showed that the partial root zone drying decreased the whole plant transpiration rate by 22 per cent in tomato plants.

Pirjo *et al.* (1999) also recorded a low transpiration rate of 3.3 mol H₂O /m² /s in drought stressed tomato plant compared to control (3.8 mol H₂O/m²/s). While observing the influence of various stress levels on transpiration rate of egg plants, Kirnak *et al.* (2001) reported that transpiration rate was highest in the mid day for the

treatment 80 per cent of pot capacity irrigation. However, irrigation of 60 and 40 per cent of pot capacity treatments, it remained low throughout the day.

Meenakumari *et al.* (2004) reported that there was a significant reduction in transpiration rate in maize lines under severe stressed condition compared to control. Ravindrakumar and Robinson (2003) recorded a significantly higher transpiration rate in the rice variety Mahamay ($2.68 \text{ mmol /m}^2 \text{ /s}$) when drought was induced at flowering and minimum transpiration rate was recorded in the variety Indira A-9 ($1.02 \text{ mmol /m}^2 \text{ /s}$).

2.3.2 Photosynthetic rate and stomatal conductance

Considering the past literature as well as the current information on drought-induced photosynthetic responses, it is evident that stomata close progressively with increased drought stress. It is well known that leaf water status always interacts with stomatal conductance and a good correlation between leaf water potential and stomatal conductance always exists, even under drought stress. It is now clear that there is a drought-induced root-to-leaf signaling, which is promoted by soil drying through the transpiration stream, resulting in stomatal closure. The "non-stomatal" mechanisms include changes in chlorophyll synthesis, functional and structural changes in chloroplasts, and disturbances in processes of accumulation, transport, and distribution of assimilates.

Environmental stresses have a direct impact on the photosynthetic apparatus, essentially by disrupting all major components of photosynthesis including the thylakoid electron transport, the carbon reduction cycle and the stomatal control of the CO_2 supply (Allen and Ort, 2001).

Transpiration is important trait for assessment of drought tolerance, and is widely affected by environmental stress conditions. Higher transpiration rate were observed in control plants (100% FC) at all the stages compared to water deficit stress condition (50% FC) in tomato all the genotypes (Sivakumar, 2014). The ability of crop plants to acclimate to different environments is directly or indirectly associated with their ability to acclimate at the level of photosynthesis, which in turn affects biochemical, physiological processes and, consequently, the growth and yield of the whole plant (Chandra, 2003). Stomatal conductance and intercellular CO_2

concentration showed parallel course under drought in tomato. There was rapid decline in stomatal conductance from 0.160 to 0.015 mole $\text{H}_2\text{O}/\text{m}^2/\text{s}$ which leads to decrease in internal CO_2 from 230 to 112 $\mu\text{L}/\text{L}$ (Haupt-Herting and Heinrich, 2000a). Bhatt *et al.* (2002) showed that water stress affected the rate of photosynthesis and the effect was more in non-grafted than grafted plants and it varied between 1.3 to 5.0 $\mu\text{mole}/\text{m}^2/\text{s}$ in grafted and 3.4 to 6.2 $\mu\text{mol m}^{-2}\text{s}^{-1}$ in non-grafted plants. Haupt-Herting and Heinrich (2000b) reported that lowering leaf water potential from -0.6 MPa in control to -1.8 MPa in severely stressed plants decreased net photosynthetic rate in tomato.

Mukesh (2007). Reported that, in drought was imposed 15 days after transplanting to all the tomato genotypes in both the IW/CPE ratio of 0.40 and 1.20 treatments. Irrigation was given when the pan evaporation reaches 41.66 mm (1.20 IW/CPE ratio) and 125 mm (0.40 IW/CPE ratio). Photosynthetic rate was found comparably higher in the genotypes L-30, IIHR 2274 and L-40-3 which are drought tolerant compared to genotypes L-17 and L-28. Where are drought susceptible due to higher photosynthetic rate and heat tolerance the genotypes L-30, IIHR 2274 and L-40-3 able to tolerate drought and produce more yield per plant compared to the genotype L-17 and L-28.

The decrease in photosynthetic rate (35 per cent) in the stressed plants compared to control was observed by Rao and Bhatt (2000). Thakur *et al.* (2000) observed that in *Capsicum annum*, the photosynthetic rate declined with increasing levels of water deficit and maximum reduction in photosynthetic rate was observed at 75 per cent water deficit.

Vyas *et al.* (2001) reported that when cluster bean plants were induced water stress at different growth stages, pronounced reduction in photosynthetic rate was observed when the plants were stressed at vegetative and flowering stage compared to pod formation stage. Decrease in plant water status was associated with significant decline in net photosynthetic rate in the moth bean genotypes in both vegetative and reproductive stages (Garg *et al.*, 2004).

Many studies have shown the decreased photosynthetic activity under drought stress due to stomatal or non-stomatal mechanisms (Del Blanco *et al.*, 2000; Samarah

et al., 2009). Stomata are the entrance of water loss and CO₂ entry and stomatal closure is one of the first responses to drought stress which result in declined rate of photosynthesis. Stomatal closure deprives the leaves of CO₂ and photosynthetic carbon assimilation is decreased in favour of photorespiration.

Similarly, Rao *et al.* (2000) stated that maximal drop of the rate of photosynthesis (53.1%) occurred during anthesis in tomato cultivars subjected to drought stress. Shah *et al.* (2010) showed that the moisture stress reduced the net photosynthetic rate from 25.42 to 19.44 mmol CO₂/m²/s in *Withania somnifera*. Chavan *et al.* (2010) reported that the stomatal conductance, transpiration rate and photosynthetic rate were significantly decreased under stress condition compared to control in tomato. Sanadhya *et al.* (2012) reported that the water stress reduced the photosynthetic rate with increased levels of stress in mung bean. Choudhury *et al.* (2010) showed that the transpiration rate significantly affected by the water stress in french bean.

The foliar photosynthetic rate of higher plants is known to decrease as the relative water content and leaf water potential decreases (Lawlor and Cornic, 2002). However, whether drought mainly limits photosynthesis through stomatal closure or through metabolic impairment (Lawson *et al.*, 2003; Anjum *et al.*, 2003). Both stomatal and non-stomatal limitation was generally accepted to be the main determinant of reduced photosynthesis under drought stress (Farooq *et al.*, 2009).

Under drought or any abiotic stress, there will be a significant decrease in photosynthesis which consequently reduce the amount of metabolites and energy in hot pepper (Kulkarni and Phalke, 2009), which are needed for the proper development of both above and below ground biomass in coffee (Dias *et al.*, 2007).

Bhatt *et al.* (2002) reported that in grafted and 100 per cent stressed tomato plants, stomatal conductance varied from 0.09 to 0.12 mol/m²/s, while in non-grafted it was 0.4 to 0.12 mol /m²/s at the same level of water stress. Stomatal conductance can be considered as a good indicator of leaf water status as reported by Suresh *et al.* (2012).

Photosynthetic rate, stomatal conductance and transpiration rate were significantly declined by water stress, while the intercellular CO₂ concentration was

changed only slightly at the initiation of stress treatment as observed by Ohashi *et al.* (2006) in soybean. Reduced stomatal conductance and photosynthetic rate were observed under 50 per cent and 100 per cent water stress over control in tomato (Bhatt *et al.*, 2002). Photosynthetic and transpiration rate were reduced, whereas leaf temperature and stomatal resistance were increased by water stress in all cultivars of tomato (Hnilickova and Duffek, 2004).

2.3.4 Leaf Temperature

Due to different level of moisture stress, there was differential leaf temperature in the sweet potato varieties Sree Nandini and H 42 and maximum leaf temperature (35.20 and 36.86⁰C respectively) was recorded when the varieties were induced to stress level of 0.25 IW/CPE ratio (Indiramma, 1994). Meenakumari *et al.* (2004) while studying the drought tolerance in maize lines, observed that as transpiration rate decreased under severe stress, leaf temperature increased by 2-4⁰C. Genotypes having moderate transpiration rate had less increase in leaf temperature. Hybrids had more transpiration rate under severe stress but showed less increase in leaf temperature (0.5 to 1.0⁰C).

Ravindrakumar and Robinson (2003) studied the leaf temperature under drought condition during flowering stage in different varieties of rice and reported that Kranti and Mahamaya maintained lower leaf temperature than air temperature under drought condition, whereas other varieties showed increased leaf temperature. Kirnak *et al.* (2001) reported that the water deficits increased leaf temperature up to 3-4⁰C compared to the control in brinjal.

2.4 Effect of water stress on biochemical processes

2.4.1 Effect of drought on proline production

Plants accumulate different types of organic and inorganic solutes in the cytosol to lower the osmotic potential thereby maintaining cell turgor (Rhodes and Samaras, 1994). Under drought, the maintenance of leaf turgor may also be achieved by the way of osmotic adjustment in response to the accumulation of proline, sucrose, soluble carbohydrates, glycine, betaine, and other solutes in cytoplasm improving water uptake from drying soil. The process of accumulation of such solutes under

drought stress is known as osmotic adjustment which strongly depends on the rate of plant water stress.

Of these solutes, proline is the most widely studied because of its considerable importance in the stress tolerance. Proline accumulation is the first response of plants exposed to water-deficit stress in order to reduce injury to cells. Anjum *et al.* (2011a) showed that progressive drought stress induced a considerable accumulation of proline in water stressed maize plants. The proline content increase as the drought stress progressed and reached a peak as recorded after 10 days of stress, and then decreased after 15 days of stress (Anjum *et al.*, 2011b).

Under vegetative stage, drought stress increased proline content about tenfold, this increasing roles as an osmotic compatible and adjust osmotic potential which resulted in drought stress avoidance in chickpea (Mafakheri *et al.*, 2010). Proline accumulation is believed to play adaptive roles in plant stress tolerance (Verbruggen and Hermans 2008). Accumulation of proline has been advocated as a parameter of selection for stress tolerance (Yancy *et al.*, 1982; Jaleel *et al.*, 2007).

Mukesh *et al.* (2007), evaluated 50 tomato genotypes were screened for drought tolerance based on the per cent reduction in 0.4 over 1.2 IW/CPE. Results of pooled analysis indicated that, under the severe moisture stress of 0.4 IW/CPE ratio, was noticed among the biochemical traits, chlorophyll 'a' and proline content was maximum in the genotype L 10 (P) whereas, chlorophyll b total chlorophyll and ascorbic acid content were higher in the genotype L-30. TSS content was more in the genotype GK-3 while lycopene was higher in IIHR 2274. Number of pubescence on adaxial and abaxial surface was significantly higher in the L-30.

It also contributes to stabilizing sub-cellular structures, scavenging free radicals, and buffering cellular redox potential under stress conditions (Ashraf and Foolad, 2007). In wheat, it has been found that proline concentration was higher in stress-tolerant cultivars than sensitive cultivars (Nayyar and Walia, 2003). That the sugar and free amino acid content were increased up to 16.3 per cent and 38 per cent respectively under drought condition leads to drought tolerance in coconut. The results indicated that osmotic adjustment plays an important role in the drought tolerance.

Chaum *et al.* (2013) reported that, enhanced proline accumulation due to water deficit in rice cultivars. It was reported that proline accumulation in water deficit plants play a key role in osmoregulation defense mechanism under drought stress. Similar kind of increase in accumulation of proline was reported in tobacco (Ma *et al.*, 2007), papaya (Mahouachi *et al.*, 2012) and in sunflower (Iqbal *et al.*, 2011).

Leaf proline content increase significantly under mild and severe drought stress in comparison with control in a trail conducted on tomato genotypes. However stem proline content was not significantly affected by the stress imposed (Ghorbanli *et al.*, 2012). Higher accumulation of proline under stress protects cell membrane and total proteins.

Vyas *et al.* (2001) noticed significant increase in proline content when the cluster bean genotypes were induced to water stress at different phenological stages. Shubhra *et al.* (2003) recorded a threefold increase in proline content when the cluster bean genotypes were subjected to water stress at flowering stage when compared to vegetative and pod filling stages.

Naidu *et al.* (2001) reported that higher proline accumulation in green gram genotypes, K 851 and LGG 401 (5.05 and 4.76 $\mu\text{mol/g}$ of FW, respectively) under receding soil moisture contributed towards osmotic adjustment which played a major role in maintaining the turgor over fluctuating soil water potential. In papaya seedlings, maximum proline content was observed at 20 days after drought induction (35.01 $\mu\text{mol/g}$ of DW) compared to 10 days after drought (12.65 $\mu\text{mol/g}$ of DW) as observed by Adivappar *et al.* (2003). Proline content and RWC are reliable indicators of the environmental stress imposed on plants, thus allowing to establish stress thresholds for fruit yield and product quality of tomato (Claussen, 2005). Aazami *et al.* (2010) showed that proline content in transgenic tomato plants was higher than wild type under both normal and water deficit in 28 days old matured plant (Tsai *et al.*, 2002).

Pawar *et al.* (2010) suggested that the levels of both osmolytes namely proline and glycine betaine increased simultaneously under water stress condition and can be used to select the drought tolerant segregating population involving breeding of cotton for drought tolerance. Abdellah *et al.* (2011) reported that the increased proline content was observed in tolerant wheat cultivar by water stress (30 per cent FC) over

control. Similar increase in free proline content due to water deficit was reported by Johari-Pireivatlou *et al.* (2010) in wheat.

Kumar *et al.* (2011) reported that PEG induced drought stress imposed to plants, significantly increased proline content at stress levels of -0.45 MPa and -1.22 MPa. Shah *et al.* (2010) showed that the moisture stress increased the proline content 2.75 and 3.60 times that of control by moderate and severe stress respectively in *Withania somnifera*. The highest average proline content found in the tomato cultivar Denar, displayed the most evident adaptation to stress conditions through osmotic adjustment (Jurekova *et al.*, 2011). Patel *et al.* (2012) showed that the proline content was increased significantly by drought stress in chickpea.

Osmotic adjustment helps maintain higher relative leaf water content at low leaf water potential, and it is evident that this helps sustain growth while the plant is meeting the transpiration demand by reducing its leaf water potential (Blum, 2005). Osmotic adjustment sustains turgor maintenance and hence the yield-forming processes during moderate to severe drought stress (Ali *et al.*, 1999).

2.4.2 Effect of drought on chlorophyll content

Chlorophyll is one of the major chloroplast components for photosynthesis, and relative chlorophyll content has a positive relationship with photosynthetic rate. The decrease in chlorophyll content under drought stress has been considered a typical symptom of oxidative stress and may be the result of pigment photo-oxidation and chlorophyll degradation. Photosynthetic pigments are important to plants mainly for harvesting light and production of reducing powers. Both the chlorophyll a and b are prone to soil dehydration (Farooq *et al.*, 2009).

Gladden *et al.* (2012) showed that water deficit earlier in the growth of tomato caused a significant reduction in leaf chlorophyll content. Kirnak *et al.* (2001) studied the influence of water deficit on chlorophyll pigmentation in egg plant and recorded a significant reduction in chlorophyll a, chlorophyll b and total chlorophyll content (49, 40 and 45 per cent respectively) when the plants were subjected to water stress at 40 per cent irrigation to the pot capacity. The total chlorophyll content of cluster bean leaf was significantly declined when plants were subjected to water stress at vegetative stage (Shubhra *et al.*, 2003).

Adivappar *et al.* (2003) while studying the drought tolerance of papaya reported that total chlorophyll content was reduced from 2.27 to 1.99 mg g⁻¹ under stress condition. Drought stress produced changes in the ratio of chlorophyll 'a' and 'b' and carotenoids (Anjum *et al.*, 2003; Farooq *et al.*, 2009). A reduction in chlorophyll content was reported in drought stressed cotton (Massacci *et al.*, 2008) and *Catharanthus roseus* (Jaleel *et al.*, 2008). The chlorophyll content decreased to a significant level at higher water deficits in sunflower plants (Kiani *et al.*, 2008) and in *Vaccinium myrtillus* (Tahkokorpi *et al.*, 2007).

Shah *et al.* (2010) showed that the moisture stress reduced the chlorophyll content up to 60 per cent in *Withania somnifera*. Sanadhya *et al.* (2012) reported that the water stress reduced the chlorophyll content and hill activity with increased levels of stress in mung bean. Almeselmani *et al.* (2012) showed that the chlorophyll content was reduced significantly under drought condition compared to control in durum wheat.

Salami and Saadat (2013) reported that drought stress damaged chloroplast and reduced chlorophyll content in maize cultivars. The resistant cultivars were potential yielders and had higher amount of chlorophyll. Decline in concentration of chlorophyll a, b and total chlorophyll was reported in rice also by Chaum *et al.* (2013).

2.4.3 Effect of water stress on total soluble solid (TSS)

Manojkumar *et al.* (1998) reported that water stressed tomato plants showed significant difference in the TSS level at different irrigation levels. As the irrigation frequency increased TSS level decreased. Maximum per cent TSS was observed under IW/CPE ratio of 0.60 (6.10 per cent) and minimum was recorded at the IW/CPE ratio of 1.20 (4.80 per cent). Similar results were obtained by Ali *et al.* (1980) in tomato. When plants were supplied with 356 mm of water, The results of Amor and Amor (2007) showed that when irrigation was reduced by 50 per cent increased the pH by 13.2 per cent and TSS by 18.9 per cent and reduced acidity by 30 per cent in tomato fruits compared to full irrigation. Water stress throughout the growing season significantly reduced yield and fruit size, but plants stressed only during flowering showed fewer but bigger fruit than completely non-stressed plants.

Non stressed and flowering stressed fruits showed lower soluble solids and a lighter colour of red ripe fruit than the other stress treatments.

2.4.4 Effect of water stress on ascorbic acid content

Tambussi *et al.* (2000) conducted an experiment to study the oxidative damage to thylakoid proteins in water-stressed wheat and noticed an increase in the ascorbic acid content under stress in leaves compared to control and also concluded that the increase in ascorbic acid might be an effective strategy to protect thylakoid membranes from oxidative damage in water stressed leaves.

Mary and Balakrishnan (1990) studied the effect of irrigation regimes on chilli. ascorbic content in green and red ripe pods recorded highest in IW/CPE ratio of 0.75 (109.72 and 120.45 mg.100g⁻¹, respectively) and lowest ascorbic acid in IW/CPE ratio of 0.9 (87.85 mg.100g⁻¹) in green fruits, where as, in red ripe fruit significantly lowest ascorbic acid content recorded in IW/CPE ratio of 0.60 (109.56 mg. 100g⁻¹). The fruit quality improvement was observed under water deficit condition in tomato as a result of the synthesis of ascorbic acid, citric acid and malic acid (Nahar *et al.*, 2011).

2.4.5 Effect of water stress on lycopene

Martino *et al.* (2006) studied tomato plants adaptation to environmental stress and reported that lycopene content in tomato fruits increased to 32 per cent under osmotic stress. Similarly Bang *et al.* (2004) studied the irrigation impact on lycopene on watermelon and reported that fruit lycopene content increased with maturity (7 and 22 days after ripening) at all the irrigation levels.

2.4.6 Effect of water stress on relative water content (RWC)

Rao and Bhatt (2000) observed significant difference in RWC at all growth stage of tomato plants. In the stressed tomato plants, RWC decreased form 82.5 to 71.0 per cent. In the irrigated plant RWC varied from 89 to 84 per cent at different growth stages. Kirnak *et al.* (2001) while studying the influence of water deficit on egg plant observed significantly lower RWC in 60 per cent irrigation. Upreti *et al.*

(2000) noticed a progressive decline in RWC in all the cultivars of pea and the influence of stress was more pronounced at flowering stage.

Relative water content, leaf water potential, stomatal resistance, rate of transpiration and leaf temperature are important characters that influence plant water relations. Relative water content is considered a measure of plant water status, reflecting the metabolic activity in tissues and used as a most meaningful index for dehydration tolerance. RWC of leaves is higher in the initial stages of leaf development and declines as the dry matter accumulates and leaf matures. RWC related to water uptake by the roots as well as water loss by transpiration.

RWC was affected by the interaction of severity, duration of the drought event and species (Yang and Miao, 2010). In fact, although components of plant water relations are affected by reduced availability of water, stomatal opening and closing is more strongly affected. Moreover, change in leaf temperature may be an important factor in controlling leaf water status under drought stress. Patel *et al.* (2012) showed that the relative water content was decreased significantly by drought stress in chickpea.

RWC decreased significantly in water stressed plants at both vegetative and flowering stages of moth bean. In general, early flowering genotypes maintained higher RWC than late flowering genotypes under water stress condition as reported by Garg *et al.* (2004). Same trend was observed by Vyas *et al.* (2001) in cluster bean.

Water stress treatments led to gradual decline in leaf RWC in french bean cultivars. The stressed plants of tolerant cultivar maintained relatively balanced RWC. As the stress duration increased, there was decline in RWC (Upreti and Murti, 2005). In brinjal, leaf relative water content was decreased at water stress condition compared to control as shown by Kirnak *et al.* (2001). Galmes *et al.* (2011) reported that the leaf relative water content significantly decreased in all accessions of tomato under water stress conditions. Kumar *et al.* (2011) also noticed a significant reduction in RWC under water stress condition in pigeon pea.

For the three tomato genotypes studied, the growth of the leaf was limited by reduction of relative water content of the leaves as reported by Jurekova *et al.* (2011). Almeselmani *et al.* (2012) showed that the relative water content was reduced

significantly under drought condition in susceptible varieties than tolerant varieties in durum wheat. Choudhury *et al.* (2010) stated that the relative water content significantly affected by the water stress in french bean.

Sivakumar (2014). Reported that drought condition was created at 15 days after transplanting based on field capacity of soil. Experiment was laid out with 18 genotypes by adopting CRD with three replications and two treatments viz., 100 and 50 % field capacity. as the stress increased from 100 % field capacity to 50 % field capacity, reductions in photosynthetic rate, leaf water potential, relative water content (RWC) were noticed at all the growth stages.

2.5 Effect of water stress on yield and yield attributes

Many yield-determining processes in plants respond to water stress. Yield integrates many of these processes in a complex way. Thus, it is difficult to interpret how plants accumulate, combine and display the ever-changing and indefinite processes over the entire life cycle of crops. The deficiency of water leads to severe decline in yield traits of crop plants probably by disrupting leaf gas exchange properties which not only limited the size of the source and sink tissues but the phloem loading, assimilate translocation and dry matter partitioning are also impaired (Farooq *et al.*, 2009).

Fetching greater harvestable yield is the ultimate purpose of growing crops. The crop species show great differences for final harvestable yield under drought stress. In early plantings of sunflower, the yield increase was associated with both an increase in grain number and in individual grain weight (Soriano *et al.*, 2002). The partitioning of dry matter to the head is critical in the process of yield determination in water stressed parsley (Petropoulos *et al.*, 2008).

Mukesh *et al.* (2007), evaluated 50 tomato genotypes were screened for drought tolerance based on the per cent reduction in 0.4 over 1.2 IW/CPE. Results of pooled analysis indicated that, under the severe moisture stress of 0.4 IW/CPE ratio, higher yield was noticed in the genotype S-22 (40.43 t ha⁻¹) as compared to susceptible genotype L-28 (17.88 t/ha). Least per cent reduction in yield per plant at 0.4 over 1.2 IW/CPE ratio was found in the genotype L-38-1 (11.45%) whereas maximum yield reduction was observed in the genotype L-28 (67.18%).

Manjunatha *et al.* (2004) reported a significant difference in number of fruits per plant due to differential irrigation level in brinjal. Minimum number of fruits per plant was observed at 1.0 IW/CPE ratio compared to other treatments and maximum number of fruits per plant was recorded at 1.2 IW/CPE ratio. Pervez *et al.* (2009) reported that drought stress had non-significant effect on vigour, quality and yield of tomato seed. Panda and Srivastava (1996) reported that among the irrigation levels tested on tomato var. Rupali, the irrigation at 0.6 IW/CPE ratio recorded higher yield (24.88 t ha⁻¹) as compared to that at 0.3 IW/CPE ratio (16.32 t/ha).

The experiment on the study of influence of different irrigation regimes on dry yield of chilli conducted by Subramanian *et al.* (1998) revealed that significantly higher dry chilli yield was recorded at the IW/CPE ratio of 0.75 (2400 kg ha⁻¹) compared to other IW/CPE ratio and minimum yield was observed in the irrigation regime of 0.45 IW/CPE ratio (2280 kg ha⁻¹). Similarly maximum chilli yield was observed at IW/CPE ratio of 1.0 and significant reduction was observed in the irrigation at IW/CPE ratio of 0.4 (Gulati *et al.*, 1995). Kirnak *et al.* (2001) reported that the plants grown under high water stress had less fruit yield and quality than those in the control treatment. The decrease in fruit yield, quality and plant growth induced by water deficit was a consequence of a reduction in transpiration.

The experiment conducted by Thakur *et al.* (2000) to study the effect of water stress on chilli revealed that maximum yield was observed under control (88.20 q/ha) compared to the water deficit condition and maximum reduction in the yield was observed under 75 per cent of water deficit condition (36.90 q/ha).

Naidu *et al.* (2001) screened the green gram genotypes for drought tolerance under receding soil moisture and reported about 60 per cent reduction in seed yield under drought stress and this attributed to corresponding reduction in yield parameters. Results on the influence of irrigation level on mustard revealed that there was significantly higher seed yield at the higher IW/CPE ratio of 0.7 (226 kg/ha) and minimum yield was recorded at low IW/CPE ratio of 0.3 (102 kg/ha) (Garg *et al.*, 2001). The crop irrigated once at flowering and twice at flowering and pod development stages produced seed yield of 17.59 and 15.53 q/ha which were 67.1 and 41.0 per cent higher than un irrigated (10.82 q/ha) as reported by Panda *et al.* (2004).

Yadav *et al.* (2001) reported that the yield and yield components and harvest index were decreased significantly under soil water stress condition, compare to normally irrigated control in wheat. Renquist and Reid (2001) studied the effect of deficit moisture in tomatoes in the period of anthesis and formation of fruits as affected the yield and quality. They reported that 38 per cent reduction of fruit yield due to the fall of the fruit size by 35 per cent appeared at the water deficit in the period of fruit formation. Water stress decreased yield, flower number, fruit set percentage and dry matter production in all cultivars, but the reduction was greater in drought - sensitive cultivars than in tolerant ones in tomato (Rahman *et al.*, 1999). Almeselmani *et al.* (2012) showed that the yield and yield parameters were reduced significantly under drought condition in susceptible varieties than tolerant varieties in durum wheat.

2.6 Correlation and path analysis

Association of economically important quantitative characters which is statistically determined by correlation coefficient has been quite useful as a basis of selection. Correlation studies provide information that the selection for one character will result in progress for all correlated characters. The study of simple correlation does not provide an exact picture of relative importance of direct and indirect influence of each of the component character towards the desired character. So, this can be overcome by following path coefficient analysis technique by further partitioning the correlation coefficient into direct and indirect effects.

Yield per plant was positively and significantly associated with plant height, fruit number per plant, fruit shape index and pericarp thickness. Path coefficient analysis indicated that fruit number per plant had the highest positive direct effect on yield per plant followed by average fruit weight (Kumar *et al.* 2003).

Manivannan *et al.* (2005) revealed that fruit yield exhibited highly significant and positive correlation with number of leaves, weight of fruit and juice per cent at both genotypic and phenotypic level.

Makesh *et al.* (2007) reported that yield per plant was positively and significantly correlated with number of fruits per plant, plant height, number of

laterals per plant and number of fruits per cluster and was negatively correlated with number of locules per fruit and flesh thickness. Path analysis indicated that the number of fruits per plant, total soluble solids and acidity had positive and direct influence on yield, while the number of laterals per plant, number of fruits per cluster and flesh thickness had negative direct effect on yield.

Haydar *et al.* (2007) observed that fruit yield had high positive phenotypic and genotypic correlation with total number of fruits at harvesting period and number of fruits in three clusters per plant. Plant height at flowering, number of flowers in three clusters per plant, days to flowering and total number of fruits at harvesting period also contributed to yield directly.

Satoshi *et al.* (1989) studied the varietal differences in chilling tolerance of cucumber (*Cucumis sativus* L.) chilled at 4°C or 7°C for 2 days and changes in the photosynthetic rate and increase of leaf area were investigated. There was a positive and significant correlation between the chilling-induced depression of photosynthesis and of the increase in the apparent leaf area. Both parameters were also positively correlated among various varieties.

Tazuke and Sakiyam (1986) studied the effect of fruit temperature on the growth of cucumber fruit, relative growth rate (RGR) increased as the fruit temperature was raised to 30°C and was estimated to be 0 at about 5°C. The multiple regressions of RGR on fruit temperature and fruit volume gave high multiple correlation coefficients for different seasons and cultivars. Partial correlation was positive between RGR and fruit temperature and negative between RGR and fruit volume.

Haque *et al.* (2009) studied that, at 50 per cent photosynthetic active radiation (PAR) number of leaves per plant did not decrease significantly in bottle gourd. Leaf weight ratio (LWR) remained more or less similar up to 50 per cent reduction of PAR. SPAD value increased with the reduction of PAR level *i.e.*, partial shading stimulated chlorophyll synthesis in leaves. Bottle gourd produced the highest yield (41.53 t/ha) at 75 per cent PAR level and it did not show significant fruit yield reduction at 25 per cent PAR level compared to full sunlight. Higher AGR, CGR, RGR and NAR indicate better growth and development which in turn depends on the leaf area of cotton (Ningnur, 2012).

In male and female plants of cucumber, the bottom most leaf had higher leaf area as it was the first formed leaf. The leaf weight per unit area (SLW) was more in female as compare to the male plants. Though male plant had higher leaf area the leaves had lesser SLW indicating thin leaves with lesser number of cells per unit area reported by Singadhupe *et al.* (2012).

2.7 Association of SSR Markers linked with drought tolerance traits in tomato

Microsatellites or simple sequence repeats (SSRs) are simple sequence of tandemly repeats which can presently be a short motif of di-nucleotides, or tri-nucleotides, or tetra-nucleotides repeated and contain in 1-6 base pairs (bp) in length (Li *et al.*, 2004). On the chromosome, SSRs occur once in every 18.8 kb, on the average, with one SSR per 23.8 kb and 16 kb on short and long arms respectively. SSRs have become a popular type of co-dominant molecular marker in genetic analysis and plant breeding application (Yang *et al.*, 1994; Olufowte *et al.*, 2002; Cho *et al.*, 2000). Therefore, they represent new sources of informative genetic markers (Weber and May, 1989). Recent genetic studies and efforts to improve stress tolerance of crop plants using traditional protocols have largely determined that plant stress tolerance is a polygenic trait (Howarth, 2005). Thus, the use of correlation and co-segregation analysis, and molecular marker techniques in genetic stocks with different degrees of stress tolerance are promising approaches to dissect the genetic basis of tolerance (Maestri *et al.*, 2002). The simple sequence repeat (SSR) or microsatellite marker is currently the preferred molecular marker due to its highly desirable properties. Another advantage of the DNA markers is their use in interspecific crosses, for example to transfer potato gene into tomato (Stevens and Robbins, 2007). By 2008, more than 2500 markers, including RFLP, SSR, EST (Expressed Sequence Tag polymorphism) and COS (Conserved Orthologue Set) were mapped on 12 tomato chromosomes (Frary *et al.*, 2005; Barone *et al.*, 2009). Using 29 selected SSR primer pairs, 42 varieties of tomato from different provinces of China and other countries were evaluated. The average genetic similarity coefficient and PIC indicated a fairly close genetic relationship between these varieties. Similar groups were obtained using UPGMA clustering and PCA methods with the first 3 components in the PCA scatter diagram accounting for a large part of the total variation (Korir *et al.* 2014).

Table 1. Review of literature on mean, range, components of variance, heritability and genetic advance in tomato

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
1. Plant height										
	99.86	48.33-153.63	-	-	25.00	23.17	0.86	44.17	44.23	Shankar <i>et al.</i> (2013)
	46.17	33.43-56.51	67.28	66.96	17.85	17.72	98.57	16.74	36.24	Kumar <i>et al.</i> (2013a)
	95.89	-	-	-	17.41	19.84	77.00	30.36	31.48	Reddy <i>et al.</i> (2013)
	77.29	54.92-152.64	555.95	555.39	30.50	30.49	100	48.52	62.78	Meena and Bahadur (2014)
	87.40	70.37-120.00	132.81	112.64	13.19	12.14	84.81	20.13	23.03	Meitei <i>et al.</i> (2014)
	13.14	-	40.75	21.89	48.58	35.60	54.00	53.75	-	Nwosu <i>et al.</i> (2014)
	56.13	-	158.02	108.54	22.40	18.56	68.99	-	-	Osekita and Ademiluyi (2014)
	3.39	-	-	-	44.86	44.84	1.00	-	92.33	Ramzan <i>et al.</i> (2014)
3. Stem girth (mm)										
	1.39	1.17-1.80	0.045	0.031	-	12.61	68.00	0.30	21.58	Paranjothi and muthukrishnan (1979)
	1.18	0.87-1.55	0.016	0.0084	10.70	7.75	52.50	0.14	11.81	Prashanth (2003)
4. Days to first flowering										
	42.38	33.00-52.00	15.24	10.99	9.21	7.82	72.14	13.69	32.29	Ghosh <i>et al.</i> (2010)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	39.61	36.00-43.61	4.18	1.95	5.16	3.55	46.60	1.96	4.95	Shashikanth <i>et al.</i> (2010)
	31.27	27.47-35.29	-	-	9.52	9.05	90.40	5.54	17.72	Patil <i>et al.</i> (2013)
	42.39	-	41.75	33.23	15.24	13.59	80	24.98	-	Nwosu <i>et al.</i> (2014)
5. Days to 50% flowering										
	38.81	28.00-55.00	43.62	36.33	17.02	15.53	83.33	11.33	29.20	Chernet <i>et al.</i> (2013)
	40.79	-	-	-	5.50	5.88	87.40	4.43	10.58	Reddy <i>et al.</i> (2013)
	32.62	28.00-37.00	-	-	6.49	6.02	0.86	3.75	11.51	Shankar <i>et al.</i> (2013)
	38.33	33.33-44.66	10.37	10.14	8.52	8.31	93.74	6.35	16.57	Kumar <i>et al.</i> (2013b)
	61.51	45.20-74.60	67.33	67.13	13.34	13.32	100	16.85	27.40	Meena and Bahadur (2014)
	61.05	52.17-68.83	15.19	12.46	6.38	5.78	82.08	6.59	10.79	Meitei <i>et al.</i> (2014)
	-		105.79	86.43	20.82	18.82	82	35.04	-	Nwosu <i>et al.</i> (2014)
	58.00	-	47.47	47.43	11.88	11.86	99.68	-	-	Osekita and Ademiluyi (2014)
7. Polar diameter of the fruit										
	45.61	34.0-65.3	70.72	64.90	18.44	17.66	91.77	15.90	34.86	Chernet <i>et al.</i> (2013)
	4.31	3.88-4.67	-	-	4.85	4.62	91.00	0.39	9.08	Patil <i>et al.</i> (2013)
	4.71	-	-	-	11.48	12.99	78.10	1.02	20.91	Reddy <i>et al.</i> (2013)
	4.80	-	0.38	0.35	12.81	12.25	91.00	-	23.94	Saleem <i>et al.</i> (2013)
	4.33	3.00-6.10	-	-	15.47	13.97	0.82	1.13	25.98	Shankar <i>et al.</i> (2013)
	45.97	36.95-60.97	41.12	40.84	13.95	13.90	99.00	13.12	28.53	Meena and Bahadur (2014)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	4.58	-	-	-	34.96	34.35	0.97	-	69.53	Ramzan <i>et al.</i> (2014)
	-	-	149.06	144.05	33.93	33.36	97.00	67.55	-	Nwosu <i>et al.</i> (2014)
8. Equatorial diameter of the fruit										
	40.77	27.5-64.4	48.25	40.10	17.06	15.55	83.10	11.90	29.20	Chernet <i>et al.</i> (2013)
	4.35	3.81-5.23	-	-	8.88	7.93	79.50	0.63	14.57	Patil <i>et al.</i> (2013)
	3.47	-	-	-	9.96	15.18	43.10	0.47	13.47	Reddy <i>et al.</i> (2013)
	4.40	-	0.55	0.50	16.64	16.03	93.00	-	32.13	Saleem <i>et al.</i> (2013)
	5.28	3.43-6.97	-	-	13.95	13.56	0.95	1.43	27.18	Shankar <i>et al.</i> (2013)
	49.19	42.63-64.47	24.64	24.38	10.09	10.04	99.00	10.12	20.57	Meena and Bahadur (2014)
	5.23	2.78-6.47	0.63	0.54	15.18	14.14	86.78	1.42	27.15	Meitei <i>et al.</i> (2014)
	-	-	160.49	144.09	33.33	31.58	90.00	61.64	-	Nwosu <i>et al.</i> (2014)
	4.11	-	-	-	30.17	29.81	0.98	-	60.67	Ramzan <i>et al.</i> (2014)
9. Pericarp thickness										
	3.63	-	-	-	16.84	15.84	93.00	1.20	28.30	Khan and Samadia (2012)
	0.51	0.37-0.70	-	-	21.06	19.06	-	81.90	35.29	Manna and Paul (2012)
	4.06	2.58-5.27	-	-	16.78	15.96	90.00	2.54	62.56	Dar <i>et al.</i> (2012)
	4.70	2.55-7.48	1.658	1.341	27.41	24.65	80.88	2.15	45.66	Chernet <i>et al.</i> (2013)
	5.21	-	0.91	0.87	18.30	17.92	96.00	1.88	36.15	Kumar <i>et al.</i> (2013)
	4.33	3.42-5.10	-	-	11.55	9.16	63.00	0.64	14.97	Patil <i>et al.</i> (2013)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	5.29	3.83-6.70	-	-	14.99	14.19	0.90	1.46	27.67	Shankar <i>et al.</i> (2013)
	0.43	-	0.031	0.021	41.60	35.27	71.88	-	-	Osekita and Ademiluyi (2014)
10. Number of locules										
	3.18	2.00-6.00	-	-	43.19	42.13	-	95.10	84.86	Manna and Paul (2012)
	3.15	2.00-9.30	1.97	1.91	44.67	43.88	96.50	-	88.79	Narolia <i>et al.</i> (2012)
	3.36	2.00-5.00	1.047	0.990	30.52	29.69	94.62	2.00	59.49	Chernet <i>et al.</i> (2013)
	2.91	2.56-4.13	-	-	13.90	12.84	85.30	0.71	24.43	Patil <i>et al.</i> (2013)
	4.40	2.33-6.50	-	-	19.65	17.13	0.76	1.35	30.77	Shankar <i>et al.</i> (2013)
	3.56	2.00-4.66	0.66	0.61	24.78	21.92	78.19	1.42	39.92	Kumar <i>et al.</i> (2013b)
	3.44	-	0.88	0.11	27.27	9.64	12.5	-	-	Osekita and Ademiluyi (2014)
12. Number of fruits per plant										
	27.86	4.00-97.00	483.07	475.04	79.13	78.47	98.34	44.66	160.30	Chernet <i>et al.</i> (2013)
	41.37	-	37.22	35.38	14.75	14.38	95.00	11.95	28.18	Kumar <i>et al.</i> (2013)
	58.78	19.02-171.00	-	-	16.42	11.52	49.22	9.79	16.65	Reddy <i>et al.</i> (2013)
	44.92	-	-	-	27.51	31.93	74.20	20.72	48.82	Reddy <i>et al.</i> (2013)
	86.00	-	744.05	518.51	31.85	26.60	70.00	-	49.2	Saleem <i>et al.</i> (2013)
	17.33	6.33-31.00	61.28	60.58	45.67	44.91	96.67	15.77	90.96	Kumar <i>et al.</i> (2013)
	34.80	26.33-54.46	31.11	30.66	16.03	15.91	99.00	11.32	32.54	Meena and Bahadur (2014)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	34.70	20.01-112.41	511.33	503.93	65.16	64.69	98.55	45.91	132.30	Meitei <i>et al.</i> (2014)
	-	-	4826.12	4349.08	124.84	118.51	90.00	231.74	-	Nwosu <i>et al.</i> (2014)
	39.25	-	422.95	56.33	52.40	19.11	13.32	-	-	Osekita and Ademiluyi (2014)
	30.87	-	-	-	43.26	43.23	1.00	-	89.00	Ramzan <i>et al.</i> (2014)
13. Average fruit weight										
	57.46	15.17-119.20	-	-	23.32	21.45	84.65	23.36	40.66	Reddy <i>et al.</i> (2013)
	62.26	-	-	-	25.66	26.91	90.90	32.60	50.40	Reddy <i>et al.</i> (2013)
	53.00	-	224.49	190.44	28.38	26.14	85.00	-	49.25	Saleem <i>et al.</i> (2013)
	73.04	40.20-105.53	-	-	22.88	22.76	0.99	34.08	46.66	Shankar <i>et al.</i> (2013)
	32.75	15.13-58.18	163.91	163.76	39.12	39.06	99.72	26.32	80.36	Kumar <i>et al.</i> (2013b)
	50.51	32.70-66.30	85.45	85.14	18.30	18.27	100.0	18.97	37.56	Meena and Bahadur (2014)
	53.78	21.35-71.33	148.84	134.38	22.68	21.55	90.28	22.69	42.19	Meitei <i>et al.</i> (2014)
	-	-	772.6	672.56	75.63	75.58	100.0	135.6	-	Nwosu <i>et al.</i> (2014)
	0.66	-	0.48	0.36	104.97	90.91	75.00	-	-	Osekita and Ademiluyi (2014)
15. Lycopene										
	10.209	4.43-17.78	12.34	12.02	34.42	33.97	97.40	7.05	69.056	Prashanth (2003)
	1.99	0.58-4.24	0.691	0.657	41.63	40.599	95.1	-	1.62	Hedau <i>et al.</i> (2008)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	5.86	-	1.73	1.67	22.46	22.07	97.00	2.62	44.68	Kumar <i>et al.</i> (2013)
	5.65	2.07-11.73	-	-	41.73	41.11	0.97	4.71	83.41	Shankar <i>et al.</i> (2013)
16. Vit-C										
	22.43	9.56-36.02	48.81	48.12	31.15	30.93	98.60	-	63.26	Narolia <i>et al.</i> (2012)
	25.78	-	4.40	3.53	8.14	7.29	80.00	3.47	13.47	Kumar <i>et al.</i> (2013)
	22.75	8.67-38.53	-	-	12.90	8.45	42.99	2.60	11.42	Reddy <i>et al.</i> (2013)
	24.38	-	-	-	18.96	21.04	81.20	8.54	35.19	Reddy <i>et al.</i> (2013)
	24.42	14.67-40.67	-	-	27.50	27.49	1.00	13.82	56.61	Shankar <i>et al.</i> (2013)
	29.67	17.67-43.04	58.32	58.19	25.74	25.71	100.00	15.70	52.90	Meena and Bahadur (2014)
17. Total soluble solid (⁰ brix)										
	4.91	2.09-8.85	2.21	2.20	30.33	30.25	99.50	-	62.14	Narolia <i>et al.</i> (2012)
	5.18	3.58-6.71	0.433	0.420	12.71	12.52	97.07	1.32	25.41	Chernet <i>et al.</i> (2013)
	6.01	-	1.33	1.29	19.16	18.85	97.00	2.30	38.20	Kumar <i>et al.</i> (2013)
	5.92	-	-	-	18.19	21.06	74.60	1.94	32.36	Reddy <i>et al.</i> (2013)
	4.12	3.17-5.00	-	-	10.63	9.20	0.75	0.68	16.41	Shankar <i>et al.</i> (2013)
	4.19	2.46-6.16	1.14	1.12	25.43	25.24	98.00	2.16	51.59	Meena and Bahadur (2014)
20. Fruit yield per plant										
	2.43	0.79-5.17	-	-	47.74	45.48	91.00	2.26	93.20	Khan and Samadia (2012)
	825.30	437.10-1285.00	-	-	27.13	26.71	-	97.00	54.19	Manna and Paul (2012)

Contd.....

Character	Mean	Range	PV	GV	PCV (%)	GCV (%)	h ² (%)	GA	GAM (%)	References
	1.59	-	0.39	0.17	39.24	25.91	43.00	0.54	33.9	Mohamed <i>et al.</i> (2012)
	1.34	0.35-3.75	0.78	0.65	65.97	60.43	83.90	-	114.04	Narolia <i>et al.</i> (2012)
	3.20	-	0.25	0.23	15.60	15.10	94.00	0.96	30.10	Kumar <i>et al.</i> (2013)
	0.80	0.46-1.03	-	-	21.56	20.00	86.00	0.30	38.22	Patil <i>et al.</i> (2013)
	1.21	-	-	-	40.04	46.13	75.40	0.82	71.61	Reddy <i>et al.</i> (2013)
	1.30	0.18-5.63	-	-	30.57	21.05	47.41	0.39	29.85	Reddy <i>et al.</i> (2013)
20. Fruit yield per plant										
	3.6	-	1.05	0.79	28.73	24.92	75.00	-	43.76	Saleem <i>et al.</i> (2013)
	2.44	1.00-3.90	-	-	31.65	31.29	0.98	1.55	63.70	Shankar <i>et al.</i> (2013)
	587.70	221.55-1803.85	222738.34	221089.73	80.89	80.01	97.81	95.79	162.99	Kumar <i>et al.</i> (2013b)
	1734.58	1124.48-2600.29	98150.70	97062.21	18.06	17.96	99.00	638.22	36.79	Meena and Bahadur (2014)
	827.88	540.50-1309.50	38002.41	32809.96	23.55	21.88	86.33	346.71	41.87	Meitei <i>et al.</i> (2014)
	-	-	1049841.90	775796.12	80.70	63.37	74.00	122.85	-	Nwosu <i>et al.</i> (2014)
25. Fruit yield per ha										
	30.99	15.90-42.90	33227571.00	6121602.00	18.60	7.98	18.42	1869	6.03	Al-Aysh <i>et al.</i> (2012b)
	17.88	3.33-52.67	144.39	137.00	67.22	65.48	94.88	23.49	131.39	Chernet <i>et al.</i> (2013)
	27.19	13.51-40.16	4022.84	3571.66	23.32	21.98	88.78	116.00	42.65	Meitei <i>et al.</i> (2014)
	20.27	-	-	-	56.78	56.71	1.00	-	116.68	Ramzan <i>et al.</i> (2014)

3. MATERIAL AND METHODS

Drought is an inevitable and recurring feature of our semi-arid tropics and despite our improved ability to predict onset, duration and impact, crop scientists are still concerned about it as it remains the single most important factor affecting the yield potential of crop species.

Although tomato is generally grown under irrigated conditions, its cultivation as a rainfed crop has gained importance particularly in semi-arid region. It is therefore imperative to obtain information on the drought resistance mechanisms of such types to enable us to incorporate these traits in breeding programme for crop improvement.

Hence, the present investigation on “Physiological and genetical investigation for drought tolerance in tomato (*Solanum lycopersicum* L.) genotypes” was conducted in the Department of Biotechnology and Crop Improvement, Kittur Rani Channamma College of Horticulture, Arabhavi, during the period between 2014 to 2016. The details of the materials used and techniques adopted during the course of investigation are described in this chapter.

3.1 Experimental site

The experiment was conducted at the Biotechnology and Crop Improvement unit of Kittur Rani Channamma College of Horticulture, Arabhavi, is situated in northern dry zone of Karnataka at 16°15' north latitude, 75°45' east longitude and at an altitude of 612.03 meters above mean sea level. Arabhavi comes under zone-3 of region-2 of agro-climatic zones of Karnataka. The meteorological data during the period of experiments, as recorded at the meteorological observatory of Agricultural Research Station, Arabhavi are presented in Appendix-A. The mean temperature during first experiential period varied from 20.2⁰C (January, 2015) to 33.25⁰C (April 2015). The mean temperature during the second trial varied from 17.97⁰C (August, 2015) to 32⁰C (November, 2015).

3.2 Soil characteristics

The experimental site comprised of medium red sandy loam soil. The chemical properties of the soil are presented in the Appendix B.

3.3 Details of experiment

3.3.1 Design and layout

The experiments were laid out in a factorial randomised block design with fifty genotypes and two replications. The experimental field was brought to fine tilth by repeated ploughing. Farmyard manure was incorporated into soil at the rate of 20 tonnes per hectare. Ridges were prepared at a spacing of 60 cm. Healthy and uniform seedlings were transplanted on one side of the ridges with a spacing of 60 cm between the plants. Regular irrigation and hand weeding operations were carried out. Three weeks after transplanting, plants were supported to galvanised wire which was tied to bamboo poles. Other cultivation operations including plant protection measures were carried out as per recommended package of practices of University of Agricultural Sciences, Dharwad (Anon., 2014).

3.3.2 Fertilizer application

Fertilizers at the rate 60 kg N, 50 kg P_2O_5 and 30 kg K_2O /ha were applied uniformly to all the genotypes. Half the dose of nitrogen and entire dose of phosphorous and potassium were applied before transplanting of seedlings and remaining 50 per cent of nitrogen was applied four weeks after transplanting.

3.3.3 Experimental plot size

Fifty genotypes and 10 plants of each genotypes were accommodated in a plot size of 360 m². The total area of the experimental site was 1440 m².

3.3.4 Treatment imposition

Drought was imposed two weeks of transplanting to all the genotypes in both the IW/CPE ratio of 0.40, 1.20 and farmers practice (Irrigation given as farmers it should be weekly twice) treatments. Furrow irrigation was given when the pan evaporation reading reached 41.66 mm (1.20 IW/CPE ratio) and 125 mm (0.40 IW/CPE ratio) using V notch.

3.3.4.1 Scheduling of irrigation and method

The quantity of water to be irrigated through furrow was measured with the help of V notch installed at plot head. Accordingly the measured quantity of water was applied to the plots as per the irrigation schedules. It was applied based on IW/CPE ratio, where in depth of irrigation (IW) was maintained constantly at 50 mm. Soon after reaching the particular ratio based on the cumulative pan evaporation (CPE), irrigation was given to particular treatment. In 0.40 IW/CPE ratio treatment crop was irrigated for every 125 mm of CPE where as in 1.20 IW/CPE ratio irrigation was given for every 41.66 mm of CPE.

3.3.4.2 Treatment details

Experiment I.

There were 150 treatment combinations with 50 genotypes and three irrigation treatments in each replication during 2014.

Table 2. Genotypes used for the study

Sl. No.	Genotypes	Source	Sl. No.	Genotypes	Source
1	EC 608271	NBPGR, New Delhi.	26	EC 686548	NBPGR, New Delhi.
2	Arka Meghali	IIHR Bangalore	27	Hissar Arun	IIVR, Varanasi.
3	EC 608362	NBPGR, New Delhi.	28	EC 686542	NBPGR, New Delhi.
4	EC 608368	NBPGR, New Delhi.	29	EC 686543	NBPGR, New Delhi.
5	EC 608389	NBPGR, New Delhi.	30	EC 677044	NBPGR, New Delhi.
6	EC 610652	NBPGR, New Delhi.	31	EC 608269	NBPGR, New Delhi.
7	EC 634394	NBPGR, New Delhi.	32	Swarna Lalima	IIVR, Varanasi.
8	EC 638519	NBPGR, New Delhi.	33	EC 686553	NBPGR, New Delhi.
9	EC 610661	NBPGR, New Delhi.	34	Pusa 120	IIVR, Varanasi.
10	EC 632944	NBPGR, New Delhi.	35	Pusa Gaurav	IIVR, Varanasi.
11	EC 630512	NBPGR, New Delhi.	36	HUB-18	K.R.C. C. H. Arabhavi
12	EC 631962	NBPGR, New Delhi.	37	Megha	UAS Dharwad

13	EC 654725	NBPGR, New Delhi.	38	ArkaAbha	IIHR Bangalore
14	EC 654724	NBPGR, New Delhi.	39	T-26	K.R.C. C. H. Arabhavi
15	EC 654719	NBPGR, New Delhi.	40	DMT-2	UAS Dharwad
16	EC 638577	NBPGR, New Delhi.	41	HUB T-10	K.R.C. C. H. Arabhavi
17	EC 608288	NBPGR, New Delhi.	42	HUB T-06	K.R.C. C. H. Arabhavi
18	KashiHemanth	IIVR, Varanasi.	43	HUB T-11	K.R.C. C. H. Arabhavi
19	EC 686554	NBPGR, New Delhi.	44	HUB T-05	K.R.C. C. H. Arabhavi
20	EC 686550	NBPGR, New Delhi.	45	HUB T-07	K.R.C. C. H. Arabhavi
21	KashiAnupam	IIVR, Varanasi.	46	HUB T-04	K.R.C. C. H. Arabhavi
22	EC 677111	NBPGR, New Delhi.	47	HUB T-09	K.R.C. C. H. Arabhavi
23	SEL 12	K.R.C. C. H. Arabhavi	48	HUB T-12	K.R.C. C. H. Arabhavi
24	EC 608348	NBPGR, New Delhi.	49	HUB T-08	K.R.C. C. H. Arabhavi
25	EC 608320	NBPGR, New Delhi.	50	HUB T-13	K.R.C. C. H. Arabhavi

Irrigation levels:

T₁= 0.40 pan co-efficient (IW/CPE)

T₂= 1.20 pan co-efficient (IW/CPE)

T₃= farmers practice (Irrigation given like farmers at command area: weekly twice).

Number of replications : Two

Experiment II

Based on the first year experimental results, 13 genotypes were selected and tested at three irrigation levels during 2015. Among 13 genotypes, eight were drought tolerant, four were drought susceptible and one was local check. There were two irrigation treatments in each replication.

Genotypes

Drought tolerant genotypes

1. EC 608362

2. EC 610652

3. EC 634394

4. EC 638519

5. EC 610661

6. EC 631962

7. Kashi Anupam

8. Pusa 120



Plate 1. General view of the experimental plot

Drought Susceptible genotypes

- | | |
|--------------|--------------|
| 1. EC 608269 | 2. EC 686543 |
| 3. EC 686550 | 4. EC 686553 |

Check:

1. Arka Meghali

Irrigation levels:

$T_1 = 0.40$ pan co-efficient (IW/CPE)

$T_2 = 1.20$ pan co-efficient (IW/CPE)

$T_3 =$ Farmers practice (Irrigation given as a farmers it should be weekly twice).

Number of replications: Three

3.4 Experiment-I: Screening the genotypes for drought tolerance

Experiment design : Factorial randomized complete block design.

Total number of genotypes : 50

Season : Summer, 2015

Replication : 2

Spacing : 0.6 m x 0.45 m

Plot size : 2.7 Sq. meters.

Experimental site size : 810 sq. meters.

3.5 Collection of experimental data

Five randomly chosen plants in each genotype and in each replication were labeled and used for recording different morphological, biochemical and yield parameters at 45 and 90 days after transplanting (DAT). The mean of five plants was taken for analysis. The characters studied and techniques adopted to record the observation are given below.

Tolerance genotypes

EC 608362

EC 610652

EC 634394

EC 631962

EC 638519

EC 610661

1.2 IW/CPE



0.4 IW/CPE



Plate 2. Performance of tomato genotypes at 1.2 and 0.4 IW/CPE water regime

Contd.....

Plate 2 contd.....

Tolerance genotypes

Kashi Anupam



PUSA 120



Local Check

Arka Meghali



Susceptible genotypes

EC 686550



EC 686543



1.2 IW/CPE



EC 608269



EC 686553



0.4 IW/CPE

3.5.1 Morphological characters

3.5.1.1 Plant height (cm)

The height of the plant was measured from ground level to the tip of the shoot at 45, 90 days after transplanting (DAT) and at harvest and average height was calculated and expressed in cm.

3.5.1.2 Number of branches per plant

Number of primary branches on main stem were counted at 45 and 90 DAT

3.5.1.3 Stem girth (mm)

The girth of the main stem at ground level was measured using vernier callipers at 45 and 90 DAT and average girth was calculated and expressed in cm.

3.5.2 Dry matter production and its partitioning

Two plants of each genotype in each replication were uprooted and partitioned into their component parts viz., leaves and stem with root. These were air dried and then transferred to hot air oven at 80°C for 72 hours (until constant weight obtained) and their dry weight was recorded. The sum of the mean dry weight of all the plant parts was taken separately at 45 and 90 DAS and the mean was expressed as g/plant.

3.5.3 Growth parameters

Various growth parameters were calculated on the dry weight basis of different plant parts and leaf area as described below.

3.5.3.1 Leaf area

Leaf area was determined by using leaf area meter by Biovis Pvt. Ltd.

3.5.3.2 Absolute Growth Rate (AGR)

It is the dry matter production per unit time (g/day) and was calculated by using the following formula.

$$AGR = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where,

W_1 = Dry weight of the plant at time t_1 ,

W_2 = Dry weight of the plant at time t_2

3.5.3.3 Relative Growth Rate (RGR)

It is the rate of increase in the dry weight per unit dry weight ($\text{mg/m}^2/\text{day}$) already present and was calculated by using the formula given by Blackman (1919).

$$RGR = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$$

Where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

3.5.3.4 Crop Growth Rate (CGR)

It is the rate of dry matter production per unit ground area per unit time. It was calculated by using the formula given by Watson (1952) and expressed as $\text{g/m}^2/\text{day}$.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{1}{A}$$

Where,

W_1 = Dry weight of the plant at time t_1

W_2 = Dry weight of the plant at time t_2

A = Land area

3.5.3.5 Net Assimilation Rate (NAR)

It is the rate of dry weight increase per unit leaf area per unit time ($\text{g/cm}^2/\text{day}$) and was calculated as suggested by Gregory (1926).

$$NAR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times \frac{(\log_e W_2 - \log_e W_1)}{(L_2 - L_1)}$$

Where,

L_1 and W_1 = Leaf area (cm^2) and dry weight of the plant (g) respectively at time t_1 .

L_2 and W_2 = Leaf area (cm^2) and dry weight of the plant (g) respectively at time t_2 .

3.5.3.6 Specific Leaf Weight (SLW)

The specific leaf weight (g/cm^2) indicates the leaf thickness and was determined by the following formula given by Radford (1967).

$$SLW = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (cm}^2\text{)}}$$

3.5.3.7 Specific Leaf Area (SLA)

The specific leaf area was determined by the following formula and expressed as cm^2/g .

$$SLA = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Leaf dry weight (g)}}$$

3.5.3.8 Leaf Area Index (LAI)

The leaf area index was determined by the following formula and unit less.

$$LAI = \frac{\text{Leaf area of the entire plant (cm}^2\text{)}}{\text{Spacing provided (cm}^2\text{)}}$$

3.5.3.9 Leaf area ratio (LAR) (cm^2/g)

The leaf area ratio was worked out by the formula of Radford (1967) and expressed as cm^2 per gram.

$$\text{LAR} = \frac{\text{Leaf area (cm}^2 \text{ /plant)}}{\text{Total dry matter (g/plant)}}$$

3.5.3.8 Biomass duration (BMD)

Biomass duration (g/day) was calculated using the formula given by Sestak *et al.* (1971).

$$\text{BMD} = \frac{\text{TDM}_i + \text{TDM}_{(i+1)}}{2} \times (t_2 - t_1)$$

Where

TDM_i = Total dry matter at ith stage

TDM_(i+1) = Total dry matter at (i+1)th stage

t₂-t₁ = Time interval between ith and (i+1)th stage (day).

3.5.4 Biophysical parameters

Biophysical parameters viz., stomatal conductance, Transpiration (mmol H₂O/m²/s), PAR (Lux), leaf temperature and photosynthesis were measured on the adaxial surface of the fully expanded top leaf at 75 DAT using the steady state porometer (LICOR model LI 1600). These measurements were taken between 10 am to 12 noon on the sampling date. Stomatal conductance was expressed as cm/sec, leaf temperature was expressed as °C and photosynthesis was expressed as m.mole.CO₂/m/s.

The leaf temperature was measured directly from the same leaf used for stomatal conductance and photosynthesis. The leaf temperature was recorded using the inbuilt thermocouple of the steady state porometer pressed against the adaxial surface of the leaf.

3.5.5 Yield parameters

3.5.5.1 Number of fruits per plant

Number of fruits harvested from five tagged plants at each picking (harvest) were counted and total number of fruits per plant was calculated.

3.5.5.2 Yield (kg/plant & t/ha)

The total weight of fruits harvested from five tagged plants of all six picking was added and average yield per plant was worked out and expressed in kilogram per plant. Later the yield per hectare was calculated and expressed as tons per hectare.

3.5.6 Fruit parameters

Five randomly selected fruits from each of five tagged plants were used for recording observations on fruit quality parameters.

3.5.6.1 Polar diameter of the fruit (mm)

Polar diameter was measured from stalk end to blossom end of fruit by using vernier callipers and average of 5 fruits was worked out and expressed in centimetres.

3.5.6.2 Equatorial diameter of the fruit (mm)

The fruit breadth at maximum bulged portion was measured by using vernier callipers and average of 5 fruits was worked out and expressed in centimetres.

3.5.6.3 Pericarp thickness (mm)

Fruits were cut in middle at horizontal axis and thickness of pericarp was measured by using vernier callipers and expressed in centimetres.

3.5.6.4 Number of locules per fruit

Fruits were cut in horizontal axis and number of locules were counted.

3.5.6.5 Total soluble solids (°Brix)

Drops of juice extracted from cut fruit was used to determine total soluble solids (TSS) with the help of (0 to 32°Brix) hand refractometer at room temperature and the value was noted in °Brix.

3.5.6.6 Average fruit weight (g)

Average fruit weight was calculated by adding the weight of five fruits from each of five tagged plants at second harvest and divided it by total number of fruits and expressed in grams per fruit.

3.5.6.8 Number of pubescence

Pubescence count was done as given by Maiti *et al.* (1979). Healthy leaf was taken and chlorophyll was bleached out using DMSO. Intact leaf sample was kept in 7 ml of DMSO for 3 hr. at 65°C. Then leaf was removed from the dimethyl sulphoxide (DMSO) and leaf was made into pieces of 0.5 x 0.5 cm then observed under microscope of area 0.284 cm² and pubescence was counted both on adaxial and abaxial leaf surface and expressed as number of pubescence per cm².

3.5.7 Biochemical parameters

Biochemical parameters were estimated at 45 and 90 DAS in all the genotypes.

3.5.7.1 Chlorophyll (mg/g fresh weight)

Chlorophyll content of leaf tissue was estimated as suggested by Hiscox and Israelstom (1979). Thousand mg of freshly harvested and cleaned leaf was taken and cut in to small pieces. Cut pieces were transferred in to test tube containing 7 ml of dimethyl sulphoxide (DMSO) and heated at 65°C for three hour in oven. Extract was collected by discarding the leaf sample. Then volume was made up to 10 ml with DMSO. Optical density of the extract was measured at 645nm and 663nm using DMSO as blank.

Total chlorophyll was calculated by using the following formulae.

$$\text{Total chlorophyll} = 20.2 (A_{645}) + 8.02 (A_{663}) \frac{V}{1000 \times w \times a}$$

Where,

v = Final volume of the chlorophyll extract (ml)

w = Fresh weight of the sample (g)

a = Path length of light

3.5.7.2 Proline (µg/g of fresh weight)

Two hundred and fifty mg of leaf sample was taken in pestle and mortar and 10 ml of 3 per cent sulphosalicylic acid was added and crushed and filtered through

Whatman No. 2 filter paper. Extraction procedure was repeated once again. From the extractant 2 ml was pipetted into a test tube, to which 2 ml of glacial acetic acid and 2 ml of acid ninhydrin was added. Then test tube was boiled on hot water bath at 100°C for one hour. Then the test tubes were transferred to ice bath to terminate the reaction. Then 4 ml of toluene was added and shake the test tube gently and transferred the content to the separating funnel and collected pink colored layer. Optical density of the extract was read at 520 nm. A blank was maintained with the reactants except the leaf extract. Proline content of the sample was calculated by using the formula given by Bates *et al.* (1973) and was expressed in (µg/g of fresh weight).

$$\text{Proline content} = \frac{36.23 \times \text{Optical Density} \times \text{volume of aliquot taken}}{\text{Fresh weight of the sample}}$$

3.5.7.3 Ascorbic acid (mg/100 g)

Samples of the red ripe fruits were analysed for the ascorbic acid content, using 2,6- Dichlorophenol Indophenol dye titrimetrically as per Sadasivam and Manickam (1996). Two grams of sample was blended with 10 ml of 4 per cent oxalic acid and filtered through muslin cloth. An aliquat of extract (2ml) of the sample was titrated against 2,6-Dichlorophenol indophenol dye till the pink end point which persisted for at least 15 seconds (TV₂). Similar procedure was followed against acid mixture to get blank titre value and against standard solution made in 4 per cent oxalic acid to get standard titre value (TV₁)

$$\text{Ascorbic acid (mg/100g}^{-1}) = \frac{\text{Ascorbic acid (mg)}}{\text{content in standard}} \times \frac{\text{TV}_2}{\text{ml of aliquat}} \times \frac{\text{TV}_1}{\text{Total sample volume}} \times \frac{\text{Weight of sample}}{100} \times 100$$

3.5.5.11 Lycopene (mg/100 g)

Five grams of fruit sample was crushed and extracted repeatedly with acetone until residue becomes colourless. This acetone extract was transferred to separating funnel containing 15 ml of petroleum ether and mixed gently. To this, 5 ml of 5 per cent sodium sulphate solution in water was added and mixed thoroughly by shaking. This aided in separating out any water present in the separating funnel and helped to form a clear extract. The lower phase (petroleum ether extract containing carotenoid)

was transferred to another separating funnel to remove any residual acetone and finally the extract was transferred to amber coloured bottle. The extraction procedure with petroleum ether was repeated till the acetone phase becomes colourless. Acetone phase was discarded and small quantity of anhydrous sodium sulphate was added to the petroleum ether extract. Then petroleum ether extract was transferred to 25 ml volumetric flask and diluted to 25 ml with petroleum ether and from this, 5 ml was again diluted to 25 ml with petroleum ether for colour measurement.

Optical density (OD) of the extract was measured at 503 nm in UV-VIS-spectrophotometer using petroleum ether as a blank (Ranganna, 1986).

Lycopene content of the sample was calculated by using the following formula.

$$\text{Lycopene (mg/100 g)} = \frac{3.1206 \times \text{OD of sample} \times \text{volume made up} \times \text{dilution}}{\text{Weight of sample} \times 1000} \times 100$$

3.5.8 Estimation of genetic parameters

3.7.2.1 Genotypic and phenotypic variances

Genotypic and phenotypic variances were computed based on the expected mean sum of squares from the ANOVA.

$$\text{Genotypic variance, } \sigma_g^2 = \sigma_p^2 - \sigma_e^2$$

Where,

$$\sigma_p^2 = \text{Phenotypic variance}$$

$$\sigma_e^2 = \text{Environmental variance}$$

$$\text{Phenotypic variance, } \sigma_p^2 = \sigma_g^2 + \sigma_e^2$$

Where,

$$\sigma_g^2 = \text{Genotypic variance}$$

$$\sigma_p^2 = \text{Phenotypic variance}$$

$$\sigma_e^2 = \text{Environmental variance}$$

3.7.2.2 Phenotypic (PCV) and genotypic (GCV) coefficients of variations

Phenotypic and genotypic coefficients of variations were worked out as suggested by Burton and Devane (1953).

$$PCV(\%) = \frac{\sqrt{\text{Phenotypic variance}}}{\text{Grand mean}} \times 100$$

$$GCV(\%) = \frac{\sqrt{\text{Genotypic variance}}}{\text{Grand mean}} \times 100$$

PCV and GCV were classified and suggested as follows,

<10%	Low
10-20%	Moderate
>20%	High

3.7.2.3 Heritability

The broad sense heritability (h^2_{bs}) was estimated by following the procedure suggested by Weber and Moorthy (1952) as indicated here below.

$$\text{Heritability} = \frac{V_g}{V_p} \times 100$$

Where,

V_p is the phenotypic variance and V_g is the genotypic variance of respective germplasm.

Heritability percentage was categorized as follows (Robinson *et al.* (1949)

<30%	Low
30-60%	Moderate
>60%	High

3.7.2.4 Genetic advance (GA)

It was predicted by using the formula provided by Johnson *et al.* (1955).

$$GA = h^2_{bs} \times \sigma_p \times k$$

Where,

h^2_{bs} = Heritability in broad sense

σ_p = Phenotypic standard deviation of the trait

k = Standard selection differential which is 2.06 at 5 per cent selection intensity

3.7.2.5. Genetic advance as per cent over mean (GAM)

It is calculated the formula

$$GAM (\%) = \frac{\text{Genetic Advance}}{\text{General mean of the character}} \times 100$$

The genetic advance as per cent over mean was categorized as follows (Johnson *et al.* 1955).

<10%	- Low
10-20%	Moderate
>20%	High

3.7.2.6. Correlation analysis

In all the generation, the simple correlation coefficient was calculated to determine the degree of association of different characters with seed yield and its components in each of the population separately. Simple correlation was calculated by employing formula (Al-Jibouri *et al.*, 1958).

$$\text{Correlation, } r_{xy(P)} = \frac{Cov_{(xy)}(P)}{\sqrt{\sigma_{(x)P}^2 \times \sigma_{(y)P}^2}}$$

Where,

$Cov_{(xy)}(P)$ is phenotypic covariance between x and y characters, while $\sigma_{(x)P}^2$ represent variance of x character and $\sigma_{(y)P}^2$ denote variance of y character at phenotypic level.

The test of significance for association between characters was done by comparing table 'r' values at n-2 error degrees of freedom with estimated values (Fisher and Yates, 1963).

3.7.2.7 Path coefficient analysis

Path coefficient analysis was carried out using the simple correlation coefficient to know the direct and indirect effects of the yield components on seed yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959). Standard path coefficients which are the standardized partial regression coefficient were obtained by solving the following set of 'P' simultaneous equation through the use of "DO LITTLE TECHNIQUE" as described by Goulden (1959).

$$Po_1 + Po_2 r_{12} + \dots + Po_p r_{1p} = ro_1$$

$$Po_1 + r_{12} + Po_2 + \dots + Po_p r_{2p} = ro_2$$

$$Po_1 + r_{1p} + Po_2 r_{2p} + \dots + Po_p = ro_p$$

Where,

$Po_1, Po_2, \dots, Po_p$ = Direct path coefficients of variable 1, 2, ..., P on the dependent variables.

$r_{12}, r_{13}, \dots, r_{1p}, \dots, r_p(p-1)$ = Possible correlation coefficients between various independent variables.

$ro_1, ro_2, \dots, ro_p$ = the correlations between dependent variable and independent variables.

The direct effect of i^{th} variable via j^{th} variable was worked out as $(Po_j \times r^{ij})$. From the simultaneous equation, it is clear that the correlation coefficient is the sum of direct and indirect effect on dependent character. Residual effect of P^2_{ox} was calculated as under:

$$P^2_{ox} = 1 - (P^2_{01} + 2 Po_2 r_{12} + 2 Po_1 Po_3 r_{13} + \dots - 2 Po_2 Po_3 r_{23} + \dots - P^2_{op}).$$

1.2. Analysis of genetic polymorphisms in tomato genotypes

The molecular analysis done in the present study is described below.

3.5.1 Sample preparation

Two hundred mg of young leaves was collected. The leaves were first washed with distilled water and these leaf samples were used immediately for extraction or stored at -20°C for short term or stored at -80°C for long term, for future use.

3.5.2 Buffers and solutions prepared for extraction of DNA

Stock solutions used

Extraction buffer	
C-TAB (N Cetyl- N, N, N, Trimethyl Ammonium Bromide)	: 2 per cent
NaCl (Sodium Chloride)	: 2M
Tris- HCl	: 100 mM (pH-8.0)
EDTA (Ethylene Diamine Tetra Acetic Acid)	: 25 mM (pH-8.0)

Other chemicals	
Chloroform/ Isoamylalcohol	: 24: 1 (v/v)
Poly vinyl pyrolidone (PVP)	: 2 per cent
β-Mercaptoethanol	: 0.2 per cent
Isopropanol	: 100 per cent
Ethanol	: 70 per cent
Tris- EDTA (TE) buffer	: 10 mM Tris-base and 1 mM
EDTA,	pH 8.0

Isolation of total genomic DNA of turmeric mutants and mother plant was carried out according to Porebski *et al.*, 1997 using CTAB with some modifications, the protocol standardized is as follows.

3.5.3 Genomic DNA isolation

1. Genomic DNA was extracted from fresh young leaves using a modified CTAB method.
2. Two hundred mg of young leaves were taken and they were placed into mortar. The leaves were ground into fine powder in liquid nitrogen with the help of pestle and they were crushed using extraction buffer (consisting of 100 mM Tris HCl of 8 pH, 2M NaCl, 25 mM EDTA, 2% C-TAB, 2% PVP and 0.2% β -Mercaptoethanol) using pestle and mortar. Homogenate was transferred to 2 ml Eppendorf tube.
1. The tubes were incubated at 60°C for 1 hour with occasional shaking. After incubation, the tubes were cooled to the room temperature.
2. Equal volume of chloroform: Iso-amyl alcohol (24:1) was added and the tubes were inverted gently for minimum twenty times for mixing two phases and centrifuged at 11000 rpm for 10 minutes at 10°C for separation of DNA from rest of the materials (proteins). The upper aqueous phase (supernatant) was taken without disturbing the lower solid portion to another tube then this step is repeated once again.
3. The supernatant was transferred without disturbing the lower solid portion to fresh labeled 1.5 ml tubes then 750 μ l isopropanol (IPA) was added and the tubes were inverted gently for mixing two phases and then kept in deepfreezer for 30 min. and later centrifuged at 10000 rpm for 10 min at 4°C.
4. The pellet formed after centrifugation was washed with 70% (v/v) ethanol for 30 min. Then alcohol was decanted and pellets were dried at least for 30 min till there was no alcohol smell. After drying the pellet was later dissolved in (150 μ l) T₁₀E₁ buffer and stored at -20°C until use.

5. RNase treatment: Required quantity (3 μ l) of RNase was mixed to the DNA sample and tubes were incubated on water bath at 37° C for one hour and 50°C for five minutes to remove the RNA present in the DNA.

3.5.4 Purification of extracted genomic DNA

1. Equal volume (100 μ l) of chloroform: isoamyl alcohol (24:1) mixture was added to each tube and the contents were mixed by inverting
2. The contents were centrifuged at 11000 rpm for 10 min at 10°C and supernatant was transferred to fresh tubes.
3. Steps 1 and 2 were repeated
4. Treated the supernatant with sodium acetate about 1/10th volume and absolute ethanol about 2 volume of supernatant. Mixture contents gently and incubated at -20°C for 15-20 min
5. The DNA was spooled in 1.5 ml Eppendorf tubes using a glass hook, washed with 70% alcohol and dried in vacuum
6. DNA was dissolved in T₁₀E₁ and kept at -20°C till its further use.

3.5.5 DNA quantification using nano drop

1. Nano drop was used to measure the absorbance of isolated genomic DNA at A₂₆₀ and A₂₈₀ nm.
2. While the purity of extracted DNA was determined based on the ratio of A₂₆₀/A₂₈₀, the yield was measured automatically using nano drop software.
3. A sample run on 0.8 per cent agarose gel was utilized to have a visible test of quantity and quality of extracted DNA.
4. The gel was run in 1 x TAE (Tris-base, glacial acetic acid, 0.5 M EDTA) buffer and stained in 3 μ l ethidium bromide solution. Pure DNA preparations showed a ratio between 1.80 -2.00
5. DNA dilution for PCR: The re-suspended DNA was then diluted in sterile distilled water to 100 ng/ μ l concentration for use in amplification reactions.

3.5.6 Testing of Polymorphism using Molecular markers

The SSR markers were chosen based on previous reports and used to assess polymorphism between the genotypes. The details of primers used were presented in Appendix- III.

3.3.3.10.3 SSR-PCR analysis

Table 3. PCR cocktail

S. No.	Contains	Volume for one reaction (μL)	Stock concentration	Final PCR concentration
1.	dNTPs	2.0	2.5 mM	0.25 mM
2.	PCR buffer	2.0	10x	1x
3.	Taq-polymerase	0.3	5-10 Units /μL	1 unit
4.	Sterile water	10.7	-	-
5.	Template DNA	2.0	25 ng /μL	50 ng /μL
6.	Primer (F/R)	1 each	3.0 μM each	0.45 μM
7.	Grand Total	20	-	-

3.3.3.10.3.2. PCR amplifications protocol

DNA from 10 genotypes was amplified using a set of 6 SSR primer pairs. The SSR primers which are located near to the agronomical important QTLs in the previous linkage maps were selected in the present study. Those SSR primers which are amplified in the present set of germplasm were used for genetic diversity analysis after optimizing the PCR conditions. Finally we selected primers that amplified properly. Amplification reactions were done in 20 μL volume containing 50ng of genomic DNA, 0.45 μM forward and reverse primers, 0.2 mM MgCl₂, 0.25 mM dNTP's and 1 unit of Taq polymerase. Amplifications was performed in BIORAD Thermocycler (Bio-Rad Laboratories Inc.) programmed for an initial denaturation of 94°C for 5 min., followed by 35 cycles of 30 sec. denaturation at 94°C, 30 sec.

annealing at 52⁰C and extension of 45 second at 72⁰C. Final extension was done to a period of 5 min. at 72⁰C and then product was stored at 4⁰C. For the determination of bands on the gel the agarose percentage was increased to 3 per cent. The length of the alleles was determined by comparison with marker loaded on adjacent gel tracks.

All the genotypes were scored for the presence or absence of the SSR bands and the data were entered into a binary matrix as discrete variables, band size of the character and this data matrix was subjected to further analysis. The genetic associations between varieties were evaluated by calculating the Jaccard's similarity coefficient for pair wise comparisons based on the proportions of shared bands produced by the SSR primers. The Similarity Index (SI) values were obtained for each pair wise comparisons of SSR following the UPGMA method. Option SAHN was performed which resulted in the dendrogram.

4. EXPERIMENTAL RESULTS

The results of the experiment conducted for the studies on screening of genotype for high physiological efficiency, earliness, growth, biophysical, biochemical, fruit quality parameters are presented separately in this chapter under the following heads.

Experiment-I: To screen the tomato germplasm for drought tolerance under field condition

4.1 Morphological characters of tomato genotypes

4.1.1 Plant height (cm)

Significant differences were observed for plant height between the genotypes and different irrigation schedules at all the morphological stages during 45 and 90 DAT (Table 4).

During 45 DAT, irrespective of the irrigation levels, genotype EC 638519 recorded significantly maximum plant height of 58.00 cm. Compared to all other genotypes, however, it was on par with EC 686548 (57.83 cm), Pusa 120 (55.50 cm), Arka Abha (55.33 cm). EC 686550 exhibited minimum plant height (41.33 cm). Among the different types of irrigation level, significantly maximum plant height of 60.89 cm and minimum of was noticed water stress level of 0.4 IW/CPE. The interaction effect between the genotype and irrigation levels was found significant. Maximum plant height was recorded in HUB T-8 (65.50 cm), it was on par with Swarna Lalima (65.00), HUT- 10 and EC 686548 (64.50, each) and minimum plant height was recorded in the genotype EC 686550 (29.00 cm) at high water stress level of 0.4 IW/CPE ratio.

During 90 DAT irrespective of the irrigation levels, genotype EC 638519 recorded significantly maximum plant height 77.33 cm, compared to all other genotypes, however, it was on par with EC 686554 (75.50 cm), EC 610661 (74.00 cm), EC 610652 (71.50 cm), Whereas EC 686550 exhibited minimum plant height 53.00 cm.

Table 4. Plant height (cm) as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Plant height at 45 DAT				Plant height at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	61.00	52.00	43.00	52.00	73.50	63.00	52.00	62.83
2	Arka Meghali	61.50	40.00	42.50	48.00	81.50	68.50	59.50	69.83
3	EC 608362	57.00	43.50	34.50	45.00	81.50	55.00	65.00	67.17
4	EC 608368	63.00	47.00	53.50	54.50	91.00	66.50	57.00	71.50
5	EC 608389	60.50	49.50	40.50	50.17	81.50	63.50	52.00	65.67
6	EC 610652	58.50	53.00	48.00	53.17	94.00	55.00	65.50	71.50
7	EC 634394	61.50	42.00	47.50	50.33	81.50	56.00	60.50	66.00
8	EC 638519	61.50	53.50	59.00	58.00	93.50	73.50	65.00	77.33
9	EC 610661	60.50	43.00	58.00	53.83	88.50	72.50	61.00	74.00
10	EC 632944	60.00	55.50	33.00	49.50	79.00	70.00	37.50	62.17
11	EC 630512	58.50	41.00	45.50	48.33	78.00	54.00	66.50	66.17
12	EC 631962	58.50	56.50	45.50	53.50	77.50	63.50	52.00	64.33
13	EC 654725	62.50	49.00	36.50	49.33	74.00	63.50	54.00	63.83
14	EC 654724	62.00	50.00	49.50	53.83	74.50	70.50	42.50	62.50
15	EC 654719	57.50	51.00	38.00	48.83	85.50	56.50	61.00	67.67
16	EC 638577	59.00	45.00	42.50	48.83	79.50	61.00	65.50	68.67
17	EC 608288	59.50	46.00	37.00	47.50	76.50	55.00	56.50	62.67
18	Kashi Hemanth	61.50	44.50	36.50	47.50	81.00	53.00	50.50	61.50
19	EC 686554	59.50	42.50	56.00	52.67	93.00	75.50	58.00	75.50
20	EC 686550	60.50	34.50	29.00	41.33	73.50	52.50	33.00	53.00
21	Kashi Anupam	63.50	48.50	43.00	51.67	89.50	54.00	52.50	65.33
22	EC 677111	59.00	51.50	45.00	51.83	72.00	60.50	59.00	63.83
23	SEL 12	61.00	49.50	37.50	49.33	75.50	60.00	52.50	62.67
24	EC 608348	60.00	47.50	37.50	48.33	77.50	59.00	47.00	61.17
25	EC 608320	59.00	53.00	38.50	50.17	65.50	69.50	48.50	61.17
26	EC 686548	64.50	56.50	52.50	57.83	73.00	58.00	53.00	61.33
27	Hissar Arun	59.50	53.00	45.00	52.50	89.50	60.00	63.50	71.00
28	EC 686542	63.00	42.50	55.00	53.50	90.50	71.00	41.50	67.67
29	EC 686543	62.00	40.50	31.50	44.67	78.50	53.00	37.00	56.17
30	EC 677044	60.00	58.00	44.50	54.17	84.00	46.00	56.00	62.00
31	EC 608269	63.50	42.25	32.86	46.20	71.50	51.55	41.62	54.89
32	Swarna Lalima	65.00	50.50	33.00	49.50	86.00	64.00	46.00	65.33
33	EC 686553	58.50	39.50	31.85	43.28	88.50	53.00	34.00	58.50
34	Pusa 120	63.00	51.00	52.50	55.50	89.00	67.00	57.00	71.00
35	Pusa Gaurav	63.50	44.50	50.50	52.83	84.00	74.50	56.00	71.50
36	HUB-18	59.00	49.00	46.00	51.33	90.50	71.00	35.50	65.67
37	Megha	64.00	57.50	42.00	54.50	70.50	64.00	66.50	67.00
38	Arka Abha	62.00	54.00	50.00	55.33	75.50	61.00	38.50	58.33
39	T-26	56.00	57.50	42.00	51.83	88.00	57.50	54.50	66.67
40	DMT-2	59.50	50.50	39.50	49.83	87.50	52.50	58.50	66.17
41	HUB T-10	64.50	53.50	43.50	53.83	72.50	52.50	48.50	57.83
42	HUB T-06	59.00	46.50	43.00	49.50	84.50	48.50	45.50	59.50
43	HUB T-11	58.00	52.00	45.00	51.67	74.00	73.50	39.50	62.33
44	HUB T-05	62.50	43.50	34.50	46.83	76.00	57.50	35.50	56.33
45	HUB T-07	61.50	50.00	34.50	48.67	75.50	62.50	49.00	62.33
46	HUB T-04	58.00	47.00	47.00	50.67	73.50	52.50	41.00	55.67
47	HUB T-09	64.00	51.00	48.00	54.33	80.50	64.50	60.00	68.33
48	HUB T-12	61.00	53.50	36.00	50.17	82.00	70.00	55.50	69.17
49	HUB T-08	65.50	48.00	40.50	51.33	87.50	60.50	42.50	63.50
50	HUB T-13	61.00	50.50	47.00	52.83	89.00	68.00	53.50	70.17
Mean		60.89	48.63	42.89	50.80	81.20	61.31	51.67	64.73
Range		56.00	34.50	29.00	41.33	65.50	46.00	33.00	53.00
		65.50	58.00	59.00	58.00	94.00	75.50	66.50	77.33
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		2.18		6.08		3.67		10.27	
Irrigation		0.53		1.49		0.90		2.51	
G X I		3.77		10.54		6.36		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

Among the different types of irrigation level, significantly maximum plant height of 81.20 cm and minimum of 51.67 cm was noticed to water stress level of 0.4 IW/CPE. The interaction effect between the genotype and irrigation levels was found non significant. However, maximum plant height was recorded in EC 610652 (94.00 cm) and minimum plant height was recorded in the genotype EC 686550 (33.00cm) at 0.4 IW/CPE ratio.

PCV was observed to be of 29.51 per cent and 37.27 per cent at 45 and 90 DAS respectively. GCV of 24.96 per cent and 30.89 per cent, the broad sense heritability (71.54% and 68.69%), genetic advance (14.73 and 22.76) and GAM (42.50, and 52.74) were noticed at 45 and 90 DAS respectively.

4.1.2 Plant spread (cm)

4.1.2.1 North – south

During 45 DAT plant spread (North-South) was found significant only for irrigation levels. Among the different irrigation levels control (54.29 cm) was found to be significantly higher compare to the 1.2 and 0.4 IW/CPE ratio. Among the genotypes, numerical the genotype Hissar Arun was found to be exhibiting higher plant spread of 49.50 cm and lower plant spread was observed in HUB-18 (39.83 cm). The interaction effect between the genotype and irrigation levels was found non-significant. However, maximum plant spread was recorded in EC 608348 (62.00 cm) at control and minimum plant spread was recorded in the genotype HUB-18 (26.50 cm) at 0.4 IW/CPE ratio (Table 5).

During 90 DAT irrespective of the irrigation levels, genotype EC 610652 recorded significantly maximum plant spread (65.65 cm), compared to all other genotypes, it was on par with EC 634394 (65.39), HUB T-10 (63.92 cm) and EC 638519 (63.28 cm).Whereas EC 608269 exhibited minimum plant spread (45.93 cm). Among the irrigation levels, was found significantly maximum plant spread was recorded (70.58 cm) at control and minimum was recorded at 0.4 IW/CPE ratio. The interaction effect between the genotype and irrigation levels was found non-significant. However, maximum plant spread was recorded in EC 608348 (80.60 cm) and minimum plant spread was recorded in the genotype EC 686543 (27.24 cm) at 0.4 IW/CPE ratio.

PCV of 32.23 per cent and 34.40 per cent was observed at 45 and 90 DAT respectively. GCV of 24.15 per cent and 27.56 per cent, the broad sense heritability (56.13% and 64.19.69%), genetic advance (11.25 and 17.68) and GAM (37.28, and 45.50) were noticed at 45 and 90 DAS respectively.

4.1.2.2 East – West

During 45 DAT irrespective of the irrigation levels, there was significant among different irrigation level, but their was found to be non significant among differences genotypes and their interactions between genotype and irrigation. For plant spread (East- West) was found significant only for irrigation levels (Table 6).

During 45 DAT irrespective of the irrigation levels, there was no significant differences among genotypes. However, maximum plant spread was recorded in the genotype EC 608348 (46.17) and minimum plant spread was in the EC 638519 (33.67). Among the irrigation levels significantly maximum spread was found in control (50.57) and minimum was at 0.4 IW/CPE ratio (32.79). The interaction effect between the genotype and irrigation levels was found non-significant. However, maximum plant spread was recorded in HUB T-12 (58.00 cm) at CONTROL and minimum plant spread was recorded in the genotype EC 638519 (23.00 cm) at 0.4 IW/CPE ratio.

At 90 DAT irrespective of the irrigation levels, genotype EC 608348 recorded significantly maximum plant spread (60.02) compared to all other genotypes, however, it was on par with EC 610652 (58.75), EC 686548 (58.72). Whereas HUB T-04 exhibited minimum plant spread (46.11).

Among the different types of irrigation level, significantly maximum plant spread of 66.16 cm and minimum was noticed in water stress level of 0.4 IW/CPE. The interaction effect between the genotype and irrigation levels was found significantly maximum plant spread was recorded in HUB T-12 (75.40) it was on par with EC 630512 (74.75) and EC 686543 (74.10) at control and minimum plant spread was recorded in the genotype Arka Abha (31.07) at 0.4 IW/CPE ratio.

Table 5. Plant spread – North to South (cm) as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Plant spread at 45 DAT				Plant spread at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	55.50	45.50	33.00	44.67	72.15	59.15	42.90	58.07
2	Arka Meghali	55.50	42.50	34.50	44.17	72.15	55.25	44.85	57.42
3	EC 608362	53.50	45.50	41.00	46.67	69.55	59.15	58.87	62.52
4	EC 608368	45.50	42.50	39.00	42.33	59.15	55.25	50.70	55.03
5	EC 608389	60.50	42.00	33.50	45.33	78.65	54.60	43.55	58.93
6	EC 610652	57.50	49.50	37.50	48.17	74.75	64.35	57.85	65.65
7	EC 634394	56.00	49.50	41.50	49.00	72.80	64.35	59.02	65.39
8	EC 638519	57.00	39.50	29.00	41.83	74.10	59.00	56.73	63.28
9	EC 610661	54.50	53.50	34.50	47.50	70.85	60.50	54.23	61.86
10	EC 632944	54.50	48.00	35.00	45.83	70.85	62.40	45.50	59.58
11	EC 630512	50.50	45.50	34.00	43.33	65.65	59.15	44.20	56.33
12	EC 631962	57.50	42.50	43.50	47.83	74.75	55.25	56.55	62.18
13	EC 654725	60.00	46.50	34.50	47.00	78.00	60.45	44.85	61.10
14	EC 654724	51.00	37.50	39.00	42.50	66.30	48.75	50.70	55.25
15	EC 654719	52.00	48.50	35.00	45.17	67.60	63.05	45.50	58.72
16	EC 638577	57.00	44.00	28.00	43.00	74.10	57.20	36.40	55.90
17	EC 608288	55.50	53.50	30.00	46.33	72.15	69.55	39.00	60.23
18	Kashi Hemanth	57.00	50.50	37.00	48.17	74.10	65.65	48.10	62.62
19	EC 686554	50.50	49.00	30.00	43.17	65.65	63.70	39.00	56.12
20	EC 686550	58.00	42.00	37.00	45.67	75.40	39.66	31.82	48.96
21	Kashi Anupam	47.50	53.00	43.00	47.83	61.75	68.90	55.90	62.18
22	EC 677111	57.00	49.50	34.50	47.00	74.10	64.35	44.85	61.10
23	SEL 12	59.50	42.50	29.50	43.83	77.35	55.25	38.35	56.98
24	EC 608348	62.00	37.00	43.50	47.50	80.60	48.10	56.55	61.75
25	EC 608320	53.50	47.00	36.50	45.67	69.55	61.10	47.45	59.37
26	EC 686548	55.00	35.00	33.50	41.17	71.50	45.50	43.55	53.52
27	Hissar Arun	59.50	46.50	42.50	49.50	77.35	60.45	55.25	64.35
28	EC 686542	54.00	42.00	36.00	44.00	70.20	54.60	46.80	57.20
29	EC 686543	60.50	45.50	36.00	47.33	78.65	34.50	27.24	46.80
30	EC 677044	54.50	47.00	38.00	46.50	70.85	61.10	49.40	60.45
31	EC 608269	54.00	44.00	32.50	43.50	70.20	38.82	28.79	45.94
32	Swarna Lalima	55.00	40.00	32.50	42.50	71.50	52.00	42.25	55.25
33	EC 686553	53.50	45.00	35.50	44.67	69.55	39.17	35.24	47.99
34	Pusa 120	49.00	43.50	36.50	43.00	63.70	56.55	47.45	55.90
35	Pusa Gaurav	54.50	36.50	36.50	42.50	70.85	47.45	47.45	55.25
36	HUB-18	50.00	43.00	26.50	39.83	65.00	55.90	34.45	51.78
37	Megha	52.50	54.50	37.00	48.00	68.25	70.85	48.10	62.40
38	Arka Abha	53.50	44.50	35.00	44.33	69.55	57.85	45.50	57.63
39	T-26	52.00	52.50	40.00	48.17	67.60	68.25	52.00	62.62
40	DMT-2	50.00	46.50	37.00	44.50	65.00	60.45	48.10	57.85
41	HUB T-10	60.00	47.00	40.50	49.17	78.00	61.10	52.65	63.92
42	HUB T-06	55.50	44.50	32.00	44.00	72.15	57.85	41.60	57.20
43	HUB T-11	50.50	48.00	35.50	44.67	65.65	62.40	46.15	58.07
44	HUB T-05	50.00	47.50	36.50	44.67	65.00	61.75	47.45	58.07
45	HUB T-07	48.50	51.50	30.50	43.50	63.05	66.95	39.65	56.55
46	HUB T-04	55.50	46.00	41.00	47.50	72.15	59.80	53.30	61.75
47	HUB T-09	46.00	50.50	37.50	44.67	59.80	65.65	48.75	58.07
48	HUB T-12	57.00	45.50	32.00	44.83	74.10	59.15	41.60	58.28
49	HUB T-08	53.50	45.50	45.00	48.00	69.55	59.15	58.50	62.40
50	HUB T-13	52.00	45.50	37.00	44.83	67.60	59.15	48.10	58.28
Mean		54.29	45.68	35.92	45.30	70.58	57.81	46.45	58.28
Range		45.50	35.00	26.50	39.83	59.15	34.50	27.24	45.94
		62.00	54.50	45.00	49.50	80.60	70.85	59.02	65.65
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		2.63		NS		3.27		9.13	
Irrigation		0.64		1.80		0.80		2.24	
G X I		4.56		NS		5.66		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

Table 6. Plant spread – East to west (cm) as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Plant spread (EW) at 45 DAT				Plant spread (EW) at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	54.00	39.50	32.50	42.00	70.20	51.35	42.25	54.60
2	Arka Meghali	45.00	41.50	37.50	41.33	58.50	56.72	49.05	54.76
3	EC 608362	49.00	38.50	26.00	37.83	63.70	52.90	45.79	54.13
4	EC 608368	49.00	35.50	25.00	36.50	63.70	46.15	32.50	47.45
5	EC 608389	55.00	44.50	31.00	43.50	71.50	57.85	40.30	56.55
6	EC 610652	52.50	35.50	38.00	42.00	68.25	57.67	50.32	58.75
7	EC 634394	54.00	41.50	36.50	44.00	70.20	51.10	44.82	55.37
8	EC 638519	45.00	33.00	23.00	33.67	58.50	60.32	51.81	56.88
9	EC 610661	45.00	38.50	37.50	40.33	61.67	57.42	49.45	56.18
10	EC 632944	47.50	43.00	34.50	41.67	61.75	55.90	44.85	54.17
11	EC 630512	57.50	34.00	30.50	40.67	74.75	44.20	39.65	52.87
12	EC 631962	42.00	44.00	36.00	40.67	54.60	57.20	46.80	52.87
13	EC 654725	56.50	39.00	30.00	41.83	73.45	50.70	39.00	54.38
14	EC 654724	50.50	46.50	32.50	43.17	65.65	60.45	42.25	56.12
15	EC 654719	48.00	35.50	33.50	39.00	62.40	46.15	43.55	50.70
16	EC 638577	46.00	35.00	30.00	37.00	59.80	45.50	39.00	48.10
17	EC 608288	52.00	39.00	25.50	38.83	67.60	50.70	33.15	50.48
18	Kashi Hemanth	46.50	46.50	29.50	40.83	60.45	60.45	38.35	53.08
19	EC 686554	49.00	45.50	26.50	40.33	63.70	59.15	34.45	52.43
20	EC 686550	53.50	45.00	25.00	41.17	69.55	43.80	34.30	49.22
21	Kashi Anupam	53.50	41.00	33.00	42.50	69.55	53.30	42.90	55.25
22	EC 677111	50.50	46.00	34.50	43.67	65.65	59.80	44.85	56.77
23	SEL 12	55.00	31.50	36.50	41.00	71.50	40.95	47.45	53.30
24	EC 608348	49.50	49.50	39.50	46.17	64.35	64.35	51.35	60.02
25	EC 608320	54.00	46.50	32.50	44.33	70.20	60.45	42.25	57.63
26	EC 686548	55.50	44.50	35.50	45.17	72.15	57.85	46.15	58.72
27	Hissar Arun	49.00	43.00	32.50	41.50	63.70	55.90	42.25	53.95
28	EC 686542	46.50	40.00	34.50	40.33	60.45	52.00	44.85	52.43
29	EC 686543	57.00	43.00	33.00	44.33	74.10	41.78	33.15	49.67
30	EC 677044	53.00	33.50	39.50	42.00	68.90	43.55	51.35	54.60
31	EC 608269	56.00	33.50	37.50	42.33	72.80	41.50	34.78	49.69
32	Swarna Lalima	47.50	45.50	40.50	44.50	61.75	59.15	52.65	57.85
33	EC 686553	56.50	36.50	34.00	42.33	73.45	40.77	32.50	48.91
34	Pusa 120	54.00	45.00	31.00	43.33	70.20	58.50	40.30	56.33
35	Pusa Gaurav	49.50	39.50	33.50	40.83	64.35	51.75	43.55	53.22
36	HUB-18	53.50	40.50	24.00	39.33	69.55	40.82	32.67	47.68
37	Megha	49.00	40.00	39.50	42.83	63.70	52.00	51.35	55.68
38	Arka Abha	48.00	39.50	30.50	39.33	71.40	51.35	31.07	51.27
39	T-26	46.00	47.00	34.00	42.33	59.80	61.10	44.20	55.03
40	DMT-2	54.00	42.50	29.00	41.83	70.20	55.25	37.70	54.38
41	HUB T-10	49.50	39.00	33.00	40.50	65.82	50.05	40.61	52.16
42	HUB T-06	50.00	39.50	31.00	40.17	69.20	51.35	40.30	53.62
43	HUB T-11	43.50	41.50	30.00	38.33	56.55	53.95	39.00	49.83
44	HUB T-05	51.50	43.00	35.00	43.17	66.95	55.90	45.50	56.12
45	HUB T-07	48.00	40.00	37.00	41.67	62.40	52.00	48.10	54.17
46	HUB T-04	47.50	48.00	41.00	45.50	64.78	39.62	33.92	46.11
47	HUB T-09	51.00	45.00	35.00	43.67	66.30	58.50	45.50	56.77
48	HUB T-12	58.00	38.50	28.50	41.67	75.40	50.05	37.05	54.17
49	HUB T-08	51.50	36.00	25.00	37.50	66.95	46.80	32.50	48.75
50	HUB T-13	43.00	36.50	39.00	39.50	55.90	47.45	50.70	51.35
Mean		50.57	40.72	32.79	41.36	66.16	52.27	42.04	53.49
Range		42.00	31.50	23.00	33.67	54.60	39.62	31.07	46.11
		58.00	49.50	41.00	46.17	75.40	64.35	52.65	60.02
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		2.19		NS		2.49		6.95	
Irrigation		0.54		1.50		0.61		1.70	
G X I		3.79		NS		4.31		12.04	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

PCV observed was 33.76 per cent and 34.66 per cent at 45 and 90 DAT respectively. GCV of 27.60 per cent and 30.15 per cent, the broad sense heritability (66.85 and 75.69), genetic advance (12.82 and 19.27) and GAM (46.50 and 54.05) were noticed at 45 and 90 DAS respectively.

4.1.3 Stem girth (mm)

Significant differences were observed for stem girth between the genotypes and different irrigation schedules at all the morphological stages, except for genotypes during 45 DAT. Irrespective of the irrigation levels, among the genotypes HUB T-07 numerically recorded higher stem girth of 5.42 mm compared to all other genotypes, EC 608288 exhibited lower stem girth (3.77mm) (Table 7).

Among the different types of irrigation level, significantly maximum stem girth of 5.06 mm and minimum stem girth was noticed at control. The interaction effect between the genotype and irrigation levels significantly maximum stem girth was recorded in HUB T-07 (6.44), it was on par with Arka Meghali (6.34 mm), EC 608362 (6.32 mm) and minimum stem girth was recorded in the genotype HUB T-06 (2.97 mm) at high water stress level of 0.4 IW/CPE ratio.

During 90 DAT irrespective of the irrigation levels, among the genotypes were shows the non significant. However, numerically EC 630512 recorded higher stem girth of 8.88 mm. compared to all other genotypes, HUB T-04 exhibited lower stem girth (7.56 mm).

Among the different types of irrigation level, significantly maximum stem girth of 10.27 mm and minimum of 7.01mm was noticed in control. The interaction effects were non significant. However maximum stem girth were observed in the genotype SEL 12 (12.22 mm) at water stress level of 0.4 IW/CPE ratio and minimum was exhibited by EC 686548 (6.30 mm) at control.

PCV was observed of 17.97 per cent and 20.42 per cent at 45 and 90 DAS respectively. GCV of 10.88 per cent and 17.58 per cent, the broad sense heritability (36.67% and 74.12%), genetic advance (0.63 and 2.57) and GAM (13.57, and 31.18) were noticed at 45 and 90 DAS respectively.

Table 7. Stem girth (cm) as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Stem girth at 45 DAT				Stem girth at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	3.86	4.87	4.33	4.35	6.68	8.11	8.73	7.84
2	Arka Meghali	4.09	4.46	6.34	4.96	7.64	7.46	8.95	8.01
3	EC 608362	4.24	4.74	6.32	5.10	7.31	7.67	10.03	8.34
4	EC 608368	4.72	5.35	4.15	4.74	6.74	7.38	10.92	8.35
5	EC 608389	4.52	4.93	4.02	4.49	6.73	7.73	8.74	7.73
6	EC 610652	3.99	5.58	5.30	4.95	6.75	7.54	9.90	8.06
7	EC 634394	4.40	4.80	6.21	5.13	7.46	7.49	9.78	8.24
8	EC 638519	4.18	4.37	4.48	4.34	7.40	7.73	10.86	8.66
9	EC 610661	4.04	5.64	4.68	4.78	6.74	7.91	9.01	7.88
10	EC 632944	4.41	5.15	4.20	4.59	7.27	7.79	10.51	8.52
11	EC 630512	4.45	5.19	3.82	4.48	7.75	7.49	11.39	8.88
12	EC 631962	3.87	5.07	5.14	4.69	7.02	7.34	10.40	8.25
13	EC 654725	4.35	5.34	5.93	5.21	7.43	7.39	11.32	8.71
14	EC 654724	4.62	5.30	4.56	4.82	6.65	7.30	10.32	8.09
15	EC 654719	4.27	4.97	5.12	4.79	6.96	8.06	10.10	8.37
16	EC 638577	4.13	5.56	4.94	4.88	7.38	7.77	10.05	8.40
17	EC 608288	3.92	4.22	3.18	3.77	6.67	7.57	10.11	8.11
18	Kashi Hemanth	4.69	5.15	4.63	4.82	7.28	7.04	11.21	8.51
19	EC 686554	3.81	5.23	5.55	4.86	7.28	7.60	11.18	8.69
20	EC 686550	3.94	4.71	4.35	4.33	6.57	7.17	10.07	7.93
21	Kashi Anupam	4.22	5.56	5.68	5.15	6.79	7.31	10.70	8.26
22	EC 677111	4.13	5.02	4.75	4.63	7.28	7.71	9.41	8.13
23	SEL 12	4.31	5.09	3.87	4.42	6.71	7.51	12.22	8.81
24	EC 608348	4.20	5.38	3.53	4.37	6.60	7.98	10.98	8.52
25	EC 608320	4.50	4.97	5.15	4.87	7.06	7.75	7.94	7.58
26	EC 686548	3.80	5.75	4.53	4.69	6.30	7.93	9.34	7.86
27	Hissar Arun	4.07	5.52	4.84	4.81	7.33	7.59	9.46	8.12
28	EC 686542	4.07	5.60	3.37	4.35	7.48	7.31	11.57	8.79
29	EC 686543	4.57	5.22	6.05	5.28	7.28	7.49	9.40	8.05
30	EC 677044	4.13	5.27	3.95	4.45	7.02	7.48	11.18	8.56
31	EC 608269	4.08	4.34	5.20	4.54	6.78	7.03	9.51	7.77
32	Swarna Lalima	3.75	5.07	6.28	5.03	6.75	7.29	8.77	7.60
33	EC 686553	4.37	5.33	3.69	4.46	6.54	7.71	10.78	8.34
34	Pusa 120	4.10	5.36	4.42	4.63	6.82	6.85	10.75	8.14
35	Pusa Gaurav	4.52	5.70	5.30	5.17	6.68	7.52	11.80	8.67
36	HUB-18	4.28	4.80	5.81	4.96	6.42	6.97	10.06	7.81
37	Megha	4.18	4.95	4.62	4.58	6.80	7.39	9.99	8.06
38	Arka Abha	4.50	5.05	4.60	4.71	7.02	6.92	11.92	8.62
39	T-26	4.48	5.11	3.78	4.45	6.78	7.16	9.15	7.69
40	DMT-2	4.05	4.08	5.39	4.51	7.25	7.24	11.05	8.51
41	HUB T-10	4.12	4.45	5.68	4.75	7.40	7.42	10.31	8.37
42	HUB T-06	4.36	4.72	2.97	4.01	6.81	7.57	11.06	8.48
43	HUB T-11	4.04	4.96	5.19	4.73	7.34	7.15	10.63	8.37
44	HUB T-05	4.17	4.45	5.30	4.64	7.68	7.66	10.85	8.73
45	HUB T-07	4.46	5.36	6.44	5.42	6.51	8.07	9.52	8.03
46	HUB T-04	3.68	5.30	3.85	4.28	6.97	7.64	8.07	7.56
47	HUB T-09	4.47	4.67	3.98	4.37	7.22	7.23	11.57	8.67
48	HUB T-12	4.10	5.47	6.21	5.26	6.68	7.46	9.87	8.00
49	HUB T-08	4.24	5.08	6.28	5.20	6.97	7.63	11.25	8.61
50	HUB T-13	3.94	4.81	5.30	4.68	7.42	7.33	10.74	8.49
Mean		4.21	5.06	4.86	4.71	7.01	7.49	10.27	8.26
Range		3.68	4.08	2.97	3.77	6.30	6.85	7.94	7.56
		4.72	5.75	6.44	5.42	7.75	8.11	12.22	8.88
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.27		NS		0.35		NS	
Irrigation		0.07		0.19		0.09		0.24	
G X I		0.48		1.33		0.61		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

4.2 Growth parameters

4.2.1 Leaf area (cm²/plant) at different crop growth period

The photosynthetic surface area (leaf area) varied progressively from 45 DAT upto 90 DAT. Significant difference in leaf area were observed among the genotypes and different irrigation schedules as well as for their interaction during 45 and 90 DAT (Table 8).

Leaf area were ranged from 387.12 to 1554.74, 243 to 2969.5 at control and 339.84 to 1162.81 and 642.7 to 2249.5 at 1.2 IW/CPE ratio. Whereas at 0.4 IW/CPE ratio it varied from 219.97 to 1070.76 and 337.0 to 2023.1 at 45, 90 DAT respectively.

During 45 DAT, irrespective of the irrigation levels, genotype Kashi Aupam had significantly maximum leaf area (1165.76) and was on par with EC 634394 (1116.64), EC 638577 (1096.92) and minimum was in the genotype HUB T- 13 (320.39). Among the different types of irrigation level, significantly maximum leaf area of 994.07cm² at control and minimum was noticed 605.79 at 0.4 IW/CPE ratio. There was significant interaction between genotypes and irrigation levels, maximum leaf area was noticed in the genotype EC 654725 (1554.74 cm²) at control. and least was in the genotype EC 686553 (219.97 cm²) at 0.4 IW/CPE ratio.

During 90 DAT, among the different genotypes, significantly maximum leaf area was found in the genotype EC 638519 (2190.20 cm²) it was on par with EC 638577 (2136.3cm²), EC 610652 (2096.5 cm²) and least was recorded in the genotype EC 686550 (733.50 cm²) irrespective of the irrigation levels. Among the different types of irrigation level, significantly maximum leaf area of 1877.8 cm² at control and minimum was noticed 1235.00 cm² at 0.4 IW/CPE ratio. There was significant interaction between genotypes and irrigation levels. Significantly maximum leaf area was noticed in the genotype Megha (2969.5 cm²) it was on par with (2817.5 cm²) at control and least was in the genotype EC 686543 (337.00 cm²) at 0.4 IW/CPE ratio.

PCV was observed to be 51.21 per cent and 49.83 per cent at 45 and 90 DAS respectively. GCV of 48.89 per cent and 48.32 per cent, the broad sense heritability (91.14% and 94.03%), genetic advance (506.22 and 998.04) and GAM (96.15 and 96.51) were noticed at 45 and 90 DAS respectively.

Table 8. Leaf area (cm²/plant) of tomato genotypes as influenced by irrigation levels at various growth stages

Sl. No.	Genotypes	Leaf area at 45 DAT				Leaf area at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	993.63	790.18	692.81	825.54	1977.1	1887.3	1603.6	1822.7
2	Arka Meghali	1144.79	1011.22	954.94	1036.98	2137.7	1863.3	1721.8	1907.6
3	EC 608362	991.31	838.68	793.23	874.41	2156.5	1906.5	1674.1	1912.4
4	EC 608368	1025.12	794.78	513.68	777.86	1680.2	1672.8	1567.1	1640.0
5	EC 608389	1298.11	832.04	695.44	941.86	2567.3	1820.7	1403.9	1930.6
6	EC 610652	1158.87	940.64	879.03	992.84	2248.1	2162.9	1878.6	2096.5
7	EC 634394	1266.21	1087.60	996.12	1116.64	1926.4	1771.3	1623.4	1773.7
8	EC 638519	1203.82	1001.83	944.54	1050.06	2297.9	2249.5	2023.1	2190.2
9	EC 610661	915.61	869.08	795.45	860.05	1972.1	1789.9	1677.5	1813.2
10	EC 632944	889.04	673.54	477.96	680.18	2157.6	1624.4	1524.7	1768.9
11	EC 630512	1004.54	906.52	478.65	796.57	1736.8	1428.1	1293.9	1486.2
12	EC 631962	1272.59	903.18	736.24	970.67	2199.0	1986.9	1727.5	1971.1
13	EC 654725	1554.74	903.41	502.69	986.95	2616.7	1641.9	1456.2	1905.0
14	EC 654724	977.04	739.64	469.57	728.75	2310.7	1923.2	1670.2	1968.0
15	EC 654719	809.91	604.94	549.99	654.95	1548.4	1432.6	1159.9	1380.3
16	EC 638577	1321.62	1045.45	923.69	1096.92	2624.7	1949.2	1835.0	2136.3
17	EC 608288	1201.14	993.55	816.60	1003.76	1932.5	1470.5	1350.6	1584.5
18	Kashi Hemanth	1033.22	725.79	474.44	744.48	1868.2	1407.7	616.4	1297.5
19	EC 686554	913.67	491.61	437.09	614.12	1984.6	1534.9	1295.8	1605.1
20	EC 686550	633.55	470.96	236.95	447.15	1154.5	642.7	403.4	733.5
21	Kashi Anupam	1264.21	1162.81	1070.26	1165.76	2102.0	1877.4	1726.6	1902.0
22	EC 677111	725.09	600.11	490.79	605.33	1436.3	1340.3	1156.4	1311.0
23	SEL 12	821.87	595.91	480.87	632.88	1882.5	1558.6	1439.5	1626.9
24	EC 608348	1037.36	680.18	479.63	732.39	2311.2	1986.4	1616.2	1971.2
25	EC 608320	1107.82	906.70	832.71	949.08	2348.1	2075.0	1679.2	2034.1
26	EC 686548	920.83	494.30	325.79	580.31	1866.8	1746.9	1507.6	1707.1
27	Hissar Arun	1131.81	937.96	836.80	968.86	2183.7	1795.2	1382.3	1787.1
28	EC 686542	674.37	474.38	406.52	518.42	2280.6	1982.4	1471.3	1911.4
29	EC 686543	828.55	453.92	257.65	513.37	1223.7	748.4	337.0	769.7
30	EC 677044	983.90	812.95	812.40	869.75	1243.2	1586.9	1311.1	1380
31	EC 608269	970.39	473.24	340.54	594.72	1349.0	926.1	547.2	940.8
32	Swarna Lalima	801.76	689.92	355.28	615.65	1540.6	1291.1	986.9	1272.9
33	EC 686553	837.55	489.87	219.97	515.79	1457.2	940.3	365.7	921.1
34	Pusa 120	1077.25	971.22	884.00	977.49	1832.1	1702.3	1573.1	1702.5
35	Pusa Gaurav	894.65	716.89	523.13	711.56	1830.4	1664.2	1347.4	1614.0
36	HUB-18	978.72	675.63	492.64	715.66	1564.1	1286.7	1057.7	1302.8
37	Megha	1191.12	1017.34	903.63	1037.36	2969.5	1736.8	1362.7	2023.0
38	Arka Abha	880.14	805.63	516.43	734.07	1821.2	1577.3	859.8	1419.4
39	T-26	1040.50	880.14	620.15	846.93	1670.7	997.8	986.4	1218.3
40	DMT-2	972.16	727.87	426.49	708.84	1550.2	990.8	653.8	1064.9
41	HUB T-10	1101.23	991.17	718.38	936.93	1965.8	1279.0	398.6	1214.4
42	HUB T-06	1078.45	968.94	699.75	915.71	1585.5	1272.5	765.1	1207.7
43	HUB T-11	1019.16	880.38	569.57	823.04	1789.5	1685.8	963.0	1479.4
44	HUB T-05	1063.81	862.27	803.39	909.82	2817.5	1522.3	1266.8	1868.9
45	HUB T-07	905.62	725.90	528.89	720.13	1462.0	1043.4	880.9	1128.8
46	HUB T-04	806.68	436.65	357.70	533.68	1400.7	1234.1	1086.5	1240.4
47	HUB T-09	1186.06	866.59	751.24	934.63	1943.9	1590.5	1022.6	1519.0
48	HUB T-12	852.49	599.88	494.37	648.91	1614.5	1295.9	902.8	1271.1
49	HUB T-08	554.46	600.21	487.16	547.27	1619.6	1404.3	1085.1	1369.7
50	HUB T-13	387.12	339.84	234.23	320.39	1129.8	711.7	505.8	782.4
Mean		994.07	769.27	605.79	789.71	1877.8	1540.3	1235.0	1551.0
Range		387.12	339.84	219.97	320.39	1129.8	642.7	337.0	733.5
		1554.74	1162.81	1070.26	1165.76	2969.5	2249.5	2023.1	2190.2
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		32.76		91.54		51.39		143.62	
Irrigation		8.02		22.42		12.59		35.18	
G X I		56.74		158.55		89.02		248.76	

DAT= Days after transplanting Control = Farmers practice

4.2.2 Leaf area ratio (LAR) at different crop growth period

For LAR, significant difference were observed among the genotypes and different irrigation schedules as well as for their interaction during 45 and 90 DAT (Table 9).

During 45 DAT, irrespective of the irrigation levels, genotype EC 608288 had significantly maximum leaf area ratio (41.11) and was on par with T-26 (40.47), HUB T- 10 (40.76) and Hisar Arun (40.13), and minimum was in the genotype EC 608269 (16.21).

Among the different types of irrigation level, significantly maximum leaf area ratio of 30.04 at 0.4 IW/CPE ratio and minimum was noticed 27.93 at 1.2 IW/CPE ratio. There was significant interaction between genotypes and irrigation levels, significantly maximum leaf area ratio was noticed in the genotype HUB T- 10 (53.16) it was on par with Hisar Arun (51.30), EC 677044 (40.57) and Kashi Aupam (40.34) at 0.4 IW/CPE ratio and least was in the genotype EC 608269 (13.04) at 0.4 IW/CPE ratio.

During 90 DAT, there was significant difference among the genotypes and pan evaporation ratios. Significantly maximum leaf area ratio was found in the genotype SEL -12 (48.36) it was on par with EC 686548 (47.32), EC 686542 (43.22) and least was recorded in the genotype EC 686543 (15.34) irrespective of the irrigation levels. Among the different types of irrigation level, maximum leaf area ratio of 34.83 at 0.4 IW/CPE ratio and minimum was noticed 28.22 at control. There was significant interaction between genotypes and irrigation levels, significantly maximum leaf area ratio was noticed in the genotype EC 686548 (71.32) and minimum was noticed in EC 677044 (4.34) at control.

PCV was observed to be 29.47 per cent and 30.81 per cent at 45 and 90 DAS respectively. GCV of 24.90 per cent and 27.67 per cent, the broad sense heritability (71.38% and 80.71%), genetic advance (12.83 and 16.46) and GAM (12.13 and 51.22) were noticed at 45 and 90 DAS respectively.

Table 9. Influence of irrigation levels on leaf area ratio (LAR) of tomato genotypes at various growth stages

Sl. No.	Genotypes	Leaf area ratio 45 DAT				Leaf area ratio 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	25.50	21.43	20.99	22.64	22.48	39.49	40.12	34.03
2	Arka Meghali	32.78	35.46	36.73	34.99	35.27	37.36	40.35	37.66
3	EC 608362	26.81	24.87	25.61	25.76	40.31	37.87	34.96	37.71
4	EC 608368	29.28	26.95	25.00	27.08	26.66	30.82	32.47	29.98
5	EC 608389	36.59	27.79	23.32	29.23	31.16	41.46	37.48	36.70
6	EC 610652	32.20	28.30	28.22	29.57	29.13	29.31	26.18	28.21
7	EC 634394	27.25	25.03	24.35	25.54	20.68	19.57	18.47	19.57
8	EC 638519	29.75	27.73	28.34	28.61	29.98	30.67	28.44	29.70
9	EC 610661	16.60	16.53	15.60	16.24	24.51	22.83	21.89	23.07
10	EC 632944	28.32	22.11	21.79	24.07	30.44	33.82	37.14	33.80
11	EC 630512	23.38	25.93	15.44	21.58	31.00	30.31	31.85	31.05
12	EC 631962	32.62	26.96	24.97	28.18	23.80	50.14	53.15	42.36
13	EC 654725	43.12	27.78	16.97	29.29	31.25	31.91	34.27	32.48
14	EC 654724	22.21	22.74	17.08	20.68	42.87	40.90	37.97	40.58
15	EC 654719	26.59	21.26	22.91	23.58	24.79	28.26	27.47	26.84
16	EC 638577	28.11	26.77	25.65	26.84	30.16	26.69	30.05	28.97
17	EC 608288	42.90	41.54	38.89	41.11	32.11	27.51	41.16	33.59
18	Kashi Hemanth	31.29	27.55	21.20	26.68	35.56	33.38	22.88	30.60
19	EC 686554	30.96	21.03	24.28	25.42	30.63	37.41	46.21	38.08
20	EC 686550	22.10	24.10	23.33	23.18	18.12	16.44	17.81	17.45
21	Kashi Anupam	39.48	39.40	40.34	39.74	31.83	30.18	28.97	30.33
22	EC 677111	28.44	31.64	29.08	29.72	29.10	41.63	46.57	39.10
23	SEL 12	30.99	30.63	40.26	33.96	35.78	47.29	62.01	48.36
24	EC 608348	24.37	21.62	21.02	22.34	24.46	31.03	31.42	28.97
25	EC 608320	31.17	32.96	38.04	34.06	28.49	41.68	53.52	41.23
26	EC 686548	30.66	18.66	15.90	21.74	28.22	42.41	71.32	47.32
27	Hissar Arun	35.61	33.48	51.30	40.13	38.28	36.66	36.35	37.10
28	EC 686542	24.07	19.72	20.89	21.56	35.73	45.85	48.08	43.22
29	EC 686543	23.06	16.79	14.06	17.97	16.60	16.09	13.32	15.34
30	EC 677044	31.82	36.07	40.57	36.15	4.34	49.15	51.09	34.86
31	EC 608269	20.74	13.04	14.84	16.21	17.04	16.30	17.69	17.01
32	Swarna Lalima	33.23	33.34	13.93	26.83	20.72	32.85	31.80	28.46
33	EC 686553	32.82	25.76	14.65	24.41	25.61	29.23	20.71	25.18
34	Pusa 120	33.72	33.51	32.77	33.33	32.77	31.47	30.30	31.51
35	Pusa Gaurav	23.25	31.65	29.66	28.19	20.21	31.87	40.44	30.84
36	HUB-18	42.19	35.56	25.05	34.27	22.69	30.52	40.27	31.16
37	Megha	28.73	34.50	27.76	30.33	31.20	37.16	37.44	35.27
38	Arka Abha	38.27	41.33	28.59	36.06	34.54	43.82	36.04	38.13
39	T-26	38.61	42.92	39.89	40.47	36.66	29.68	40.54	35.63
40	DMT-2	41.48	36.39	23.06	33.65	27.26	32.93	28.31	29.50
41	HUB T-10	32.35	36.76	53.16	40.76	27.72	36.03	14.98	26.24
42	HUB T-06	29.96	29.38	29.27	29.54	28.46	31.49	26.18	28.71
43	HUB T-11	26.17	31.43	21.14	26.25	25.41	38.56	34.91	32.96
44	HUB T-05	21.53	21.59	27.80	23.64	32.01	31.29	35.25	32.85
45	HUB T-07	31.21	27.56	23.51	27.43	28.39	23.41	31.43	27.74
46	HUB T-04	36.09	23.10	24.61	27.93	27.09	34.66	43.67	35.14
47	HUB T-09	25.52	24.06	25.92	25.17	27.14	33.60	28.62	29.79
48	HUB T-12	28.94	24.45	23.51	25.63	25.92	40.49	37.77	34.73
49	HUB T-08	20.85	26.16	23.15	23.39	34.15	35.36	38.74	36.08
50	HUB T-13	17.31	21.24	17.12	18.56	22.40	21.21	23.43	22.35
Mean		29.82	27.93	26.23	27.99	28.22	33.40	34.83	32.15
Range		16.60	13.04	13.93	16.21	4.34	16.09	13.32	15.34
		43.12	42.92	53.16	41.11	42.87	50.14	71.32	48.36
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		1.80		5.04		1.78		4.96	
Irrigation		0.44		1.23		0.435		1.22	
G X I		3.12		8.72		3.08		8.60	

DAT= Days after transplanting Control = Farmers practice

4.2.3 Leaf area index (LAI) at different crop growth period

Leaf area index was significant for irrigation schedules, control genotypes and their interaction at all the irrigation level during 45 and 90 DAT (Table 10).

During 45 DAT, irrespective of the irrigation levels, among the different genotype Kashi Aupam had significantly maximum LAI (0.43) it was on par with EC 634394 (0.41), EC 638577 (0.41) and lower LAI was recorded in the genotype HUB T-13 (0.12). Significantly maximum LAI found in control irrigation compare to the other stress level. Among the interaction between the genotypes and irrigation schedules, genotypes EC 654725 exhibited maximum LAI (0.58) at control and significantly lower LAI was recorded in the genotype EC 686553 (0.08) at 0.4 IW/CPE ratio.

During 90 DAT, irrespective of the irrigation levels, among genotypes EC 638519 had significantly maximum LAI (0.81) it was on par with EC 638577 (0.79), EC 610652 (0.78) and minimum LAI was recorded in the genotype EC 686550 (0.27).

Among the different types of irrigation levels, significantly maximum LAI of 0.70 at control and minimum was noticed 0.46 at 0.4 IW/CPE ratio. Among the interaction between the genotypes and irrigation schedules, the genotypes Megha exhibited maximum LAI (1.10) at control, where as LAI ranged between 0.09 to 1.10 and significantly lower LAI was recorded in the genotype EC 686543 (0.09) at control.

PCV was observed of 34.14 per cent and 33.22 per cent at 45 and 90 DAS respectively. GCV of 32.59 per cent and 35.21 per cent, the broad sense heritability (91.14% and 94.03%), genetic advance (0.18 and 0.36) and GAM (64.10 and 64.34) were noticed at 45 and 90 DAS respectively.

4.2.4 Specific leaf weight (gm.cm^{-2}) at different crop growth stages

The specific leaf weight (SLW) was found to be significantly different among genotypes but not among pan evaporation ratios and their interactions at all the growth stages (Table 11).

Table 10. Influence of irrigation levels on leaf area index (LAI) of tomato genotypes at various growth stages

Sl. No.	Genotypes	Leaf area index at 45 DAT				Leaf area index at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	0.37	0.29	0.26	0.31	0.73	0.70	0.59	0.68
2	Arka Meghali	0.42	0.37	0.35	0.38	0.79	0.69	0.64	0.71
3	EC 608362	0.37	0.31	0.29	0.32	0.80	0.71	0.62	0.71
4	EC 608368	0.38	0.29	0.19	0.29	0.62	0.62	0.58	0.61
5	EC 608389	0.48	0.31	0.26	0.35	0.95	0.67	0.52	0.72
6	EC 610652	0.43	0.35	0.33	0.37	0.83	0.80	0.70	0.78
7	EC 634394	0.47	0.40	0.37	0.41	0.71	0.66	0.60	0.66
8	EC 638519	0.45	0.37	0.35	0.39	0.85	0.83	0.75	0.81
9	EC 610661	0.34	0.32	0.29	0.32	0.73	0.66	0.62	0.67
10	EC 632944	0.33	0.25	0.18	0.25	0.80	0.60	0.56	0.66
11	EC 630512	0.37	0.34	0.18	0.30	0.64	0.53	0.48	0.55
12	EC 631962	0.47	0.33	0.27	0.36	0.81	0.74	0.64	0.73
13	EC 654725	0.58	0.33	0.19	0.37	0.97	0.61	0.54	0.71
14	EC 654724	0.36	0.27	0.17	0.27	0.86	0.71	0.62	0.73
15	EC 654719	0.30	0.22	0.20	0.24	0.57	0.53	0.43	0.51
16	EC 638577	0.49	0.39	0.34	0.41	0.97	0.72	0.68	0.79
17	EC 608288	0.44	0.37	0.30	0.37	0.72	0.54	0.50	0.59
18	Kashi Hemanth	0.38	0.27	0.18	0.28	0.69	0.52	0.23	0.48
19	EC 686554	0.34	0.18	0.16	0.23	0.74	0.57	0.48	0.59
20	EC 686550	0.23	0.17	0.09	0.17	0.43	0.24	0.15	0.27
21	Kashi Anupam	0.47	0.43	0.40	0.43	0.78	0.70	0.64	0.70
22	EC 677111	0.27	0.22	0.18	0.22	0.53	0.50	0.43	0.49
23	SEL 12	0.30	0.22	0.18	0.23	0.70	0.58	0.53	0.60
24	EC 608348	0.38	0.25	0.18	0.27	0.86	0.74	0.60	0.73
25	EC 608320	0.41	0.34	0.31	0.35	0.87	0.77	0.62	0.75
26	EC 686548	0.34	0.18	0.12	0.21	0.69	0.65	0.56	0.63
27	Hissar Arun	0.42	0.35	0.31	0.36	0.81	0.66	0.51	0.66
28	EC 686542	0.25	0.18	0.15	0.19	0.84	0.73	0.54	0.71
29	EC 686543	0.31	0.17	0.10	0.19	0.45	0.28	0.12	0.29
30	EC 677044	0.36	0.30	0.30	0.32	0.09	0.59	0.49	0.39
31	EC 608269	0.36	0.18	0.13	0.22	0.50	0.34	0.20	0.35
32	Swarna Lalima	0.30	0.26	0.13	0.23	0.57	0.48	0.37	0.47
33	EC 686553	0.31	0.18	0.08	0.19	0.54	0.35	0.14	0.34
34	Pusa 120	0.40	0.36	0.33	0.36	0.68	0.63	0.58	0.63
35	Pusa Gaurav	0.33	0.27	0.19	0.26	0.68	0.62	0.50	0.60
36	HUB-18	0.36	0.25	0.18	0.27	0.58	0.48	0.39	0.48
37	Megha	0.44	0.38	0.33	0.38	1.10	0.64	0.50	0.75
38	Arka Abha	0.33	0.30	0.19	0.27	0.67	0.58	0.32	0.53
39	T-26	0.39	0.33	0.23	0.31	0.62	0.37	0.37	0.45
40	DMT-2	0.36	0.27	0.16	0.26	0.57	0.37	0.24	0.39
41	HUB T-10	0.41	0.37	0.27	0.35	0.73	0.47	0.15	0.45
42	HUB T-06	0.40	0.36	0.26	0.34	0.59	0.47	0.28	0.45
43	HUB T-11	0.38	0.33	0.21	0.30	0.66	0.62	0.36	0.55
44	HUB T-05	0.39	0.32	0.30	0.34	1.04	0.56	0.47	0.69
45	HUB T-07	0.34	0.27	0.20	0.27	0.54	0.39	0.33	0.42
46	HUB T-04	0.30	0.16	0.13	0.20	0.52	0.46	0.40	0.46
47	HUB T-09	0.44	0.32	0.28	0.35	0.72	0.59	0.38	0.56
48	HUB T-12	0.32	0.22	0.18	0.24	0.60	0.48	0.33	0.47
49	HUB T-08	0.21	0.22	0.18	0.20	0.60	0.52	0.40	0.51
50	HUB T-13	0.14	0.13	0.09	0.12	0.42	0.26	0.19	0.29
Mean		0.37	0.28	0.22	0.29	0.70	0.57	0.46	0.57
Range		0.14	0.13	0.08	0.12	0.09	0.24	0.12	0.27
		0.58	0.43	0.40	0.43	1.10	0.83	0.75	0.81
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.01		0.03		0.02		0.05	
Irrigation		0.003		0.01		0.005		0.01	
G X I		0.02		0.06		0.03		0.09	

DAT= Days after transplanting Control = Farmers practice (FP)

At 45 DAT, irrespective of irrigation levels, genotypes HUB T-13 recorded higher SLW (2.89) it was on par with HUB T-08 (2.62) and least was in Kashi Anupam (0.97). SLW varied from 0.94 to 4.25 and 0.81 to 2.40 and 0.86 to 3.34 at control, 1.2 and 0.4 IW/CPE ratio respectively. There was no significant difference in the interactions. However, HUB T- 8 had higher SLW (4.25) at control and lesser SLW was observed in the genotype Kashi Anupam (0.81) at 1.2 IW/CPE ratio.

During 90 DAT, among the irrigation levels higher SLW was noticed at 0.4 IW/CPE ratio and it varied from 0.55 to 3.17.

Irrespective of the irrigation levels, genotype EC 686543 exhibited higher SLW (2.07) it was on par with HUB T-10 (2.03), HUB T-13 (1.98) and EC 608269 (1.97) and the least was noticed in the genotype EC 638577 (0.70). Among the interaction effect found non significant. However, genotype EC 677044 recorded significantly higher SLW (3.19) at control and least was noticed in the genotype EC 608320 (0.55) at 0.4 IW/CPE ratio.

PCV was observed of 38.73 per cent and 44.76 per cent at 45 and 90 DAS respectively. GCV of 23.3 per cent and 28.56 per cent, the broad sense heritability (36.30% and 40.69%), genetic advance (0.42 and 0.46) and GAM (28.95 and 37.53) were noticed at 45 and 90 DAS respectively.

4.2.5 Specific leaf area (cm²/g) (SLA) at different crop growth period

Specific leaf area was found significant for genotype and irrigation level but not for their interaction during 45 DAT (Table 12).

At 45 DAT, significantly SLA was increased as the stress level decrease from control to 0.4 IW/CPE ratio, Irrespective of the irrigation levels, genotype Kashi Anupam (106.96) recorded higher SLA it was on par with EC 608320 (103.10), HUB T-10 (102.85), EC 677044 (100.03) while, least was noticed in the genotype HUB T-13 (37.26). Among the irrigation levels significantly maximum SLA was recorded in control and least was at 0.4 IW/CPE ratio. Among the interaction effect found non-significant. However, genotype Kashi Anupam recorded significantly higher SLA (127.29) at 1.2 IW/CPE ratio and least was noticed in the genotype HUB T-13 (32.24) at 0.4 IW/CPE ratio.

Table 11. Influence of irrigation levels on specific leaf weight (g/cm²) in tomato genotypes at various growth stages

Sl. No.	Genotypes	Specific leaf weight 45 DAT				Specific leaf weight 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1.51	1.14	1.09	1.25	1.48	0.94	0.89	1.10
2	Arka Meghali	1.13	1.04	0.94	1.04	1.03	0.81	0.77	0.87
3	EC 608362	1.31	1.31	1.10	1.24	0.88	0.86	0.93	0.89
4	EC 608368	1.22	1.20	1.66	1.36	1.26	0.77	0.66	0.90
5	EC 608389	0.96	1.21	1.23	1.13	0.97	1.03	0.92	0.97
6	EC 610652	1.11	1.22	1.12	1.15	0.92	0.89	0.88	0.90
7	EC 634394	1.30	1.27	1.26	1.28	1.71	1.74	1.74	1.73
8	EC 638519	1.12	1.23	1.17	1.17	1.09	1.03	0.98	1.03
9	EC 610661	1.45	1.34	1.22	1.34	1.41	1.46	1.44	1.44
10	EC 632944	1.41	1.49	1.78	1.56	1.01	0.98	0.81	0.93
11	EC 630512	1.19	1.16	1.89	1.41	1.04	1.00	0.92	0.99
12	EC 631962	0.98	1.27	1.36	1.21	0.95	0.83	0.79	0.85
13	EC 654725	0.94	1.10	1.79	1.28	0.96	1.31	1.21	1.16
14	EC 654724	1.33	1.48	1.92	1.58	0.87	0.86	0.82	0.85
15	EC 654719	1.36	1.49	1.47	1.44	1.23	1.09	1.03	1.12
16	EC 638577	1.20	1.27	1.29	1.25	0.72	0.75	0.62	0.70
17	EC 608288	1.33	1.37	1.34	1.35	1.19	1.45	1.23	1.29
18	Kashi Hemanth	1.11	1.32	1.79	1.41	1.02	0.98	1.52	1.17
19	EC 686554	1.21	1.63	1.48	1.44	1.13	0.95	0.64	0.90
20	EC 686550	1.76	1.70	1.93	1.80	1.56	1.88	1.81	1.75
21	Kashi Anupam	1.06	0.81	1.02	0.97	1.19	1.21	1.20	1.20
22	EC 677111	1.45	1.50	1.54	1.50	1.18	0.98	0.81	0.99
23	SEL 12	1.34	1.51	1.56	1.47	1.08	0.87	0.64	0.86
24	EC 608348	1.63	1.94	2.29	1.96	1.32	0.99	0.74	1.02
25	EC 608320	0.99	1.04	0.90	0.98	0.89	0.69	0.55	0.71
26	EC 686548	1.30	1.92	2.46	1.89	1.17	0.92	0.78	0.96
27	Hissar Arun	1.11	1.07	1.08	1.09	0.98	0.80	0.90	0.89
28	EC 686542	1.78	2.01	1.84	1.88	1.05	0.92	0.94	0.97
29	EC 686543	1.75	2.23	2.09	2.02	1.91	2.05	2.26	2.07
30	EC 677044	1.07	1.11	0.86	1.01	3.19	0.88	0.94	1.67
31	EC 608269	1.50	2.32	1.63	1.82	1.99	2.00	1.93	1.97
32	Swarna Lalima	1.62	1.52	1.97	1.71	1.51	1.54	1.70	1.58
33	EC 686553	1.56	1.86	2.34	1.92	1.42	1.50	2.55	1.82
34	Pusa 120	1.13	1.00	1.04	1.06	1.09	1.09	1.09	1.09
35	Pusa Gaurav	1.96	2.03	2.31	2.10	1.41	1.46	1.57	1.48
36	HUB-18	1.43	1.56	1.72	1.57	1.49	1.61	1.62	1.57
37	Megha	1.43	1.23	1.27	1.31	1.15	1.14	1.16	1.15
38	Arka Abha	1.08	1.06	1.48	1.21	1.05	0.84	1.22	1.04
39	T-26	0.96	1.02	1.12	1.03	0.95	1.23	0.85	1.01
40	DMT-2	1.03	1.17	1.53	1.24	1.18	1.33	1.73	1.41
41	HUB T-10	1.10	0.96	0.90	0.99	1.00	1.38	3.71	2.03
42	HUB T-06	1.30	1.24	1.21	1.25	1.15	1.35	1.69	1.40
43	HUB T-11	1.23	1.19	1.48	1.30	1.32	1.06	1.45	1.28
44	HUB T-05	1.60	1.45	1.12	1.39	0.76	1.06	1.05	0.95
45	HUB T-07	1.44	1.46	1.61	1.51	1.60	1.90	1.72	1.74
46	HUB T-04	1.24	2.07	1.95	1.75	1.37	1.14	1.05	1.19
47	HUB T-09	1.49	1.55	1.39	1.48	1.52	1.51	2.00	1.68
48	HUB T-12	1.34	1.53	1.53	1.47	1.36	1.07	1.17	1.20
49	HUB T-08	4.25	1.78	1.83	2.62	1.02	1.03	0.96	1.00
50	HUB T-13	2.95	2.40	3.34	2.89	1.68	2.06	2.19	1.98
Mean		1.40	1.44	1.55	1.46	1.25	1.18	1.26	1.23
Range		0.94	0.81	0.86	0.97	0.72	0.69	0.55	0.70
		4.25	2.40	3.34	2.89	3.19	2.06	3.71	2.07
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.18		0.52		0.18		0.48	
Irrigation		0.045		NS		0.045		NS	
G X I		0.32		NS		0.32		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

Table 12. Influence of irrigation levels on specific leaf area (cm²/g) in tomato genotypes at various growth stages

Sl. No.	Genotypes	Specific leaf area at 45 DAP				Specific leaf area 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	66.57	99.18	104.80	90.18	68.03	106.28	122.38	98.90
2	Arka Meghali	88.44	96.32	107.00	97.25	97.35	124.60	135.02	118.99
3	EC 608362	76.25	76.24	90.70	81.07	116.14	119.52	110.39	115.35
4	EC 608368	82.28	83.92	60.26	75.49	85.16	129.21	152.53	122.30
5	EC 608389	103.85	87.05	84.77	91.89	102.64	97.35	108.48	102.82
6	EC 610652	90.25	82.40	90.05	87.57	112.75	118.97	123.39	118.37
7	EC 634394	76.70	78.77	79.42	78.30	58.46	57.64	57.51	57.87
8	EC 638519	89.80	81.82	86.28	85.97	91.70	97.55	101.76	97.01
9	EC 610661	69.19	74.58	82.44	75.40	71.43	69.10	70.35	70.29
10	EC 632944	71.31	67.35	56.49	65.05	99.64	109.09	124.30	111.01
11	EC 630512	84.18	86.47	54.10	74.91	97.69	101.30	108.45	102.48
12	EC 631962	101.80	78.59	74.46	84.95	112.30	122.98	127.22	120.83
13	EC 654725	107.03	90.76	55.74	84.51	106.61	76.71	82.70	88.67
14	EC 654724	75.53	67.38	52.80	65.24	115.51	116.45	122.88	118.28
15	EC 654719	73.63	68.25	70.26	70.71	83.58	98.66	98.80	93.68
16	EC 638577	87.11	81.41	81.35	83.29	140.50	140.84	165.46	148.93
17	EC 608288	75.19	74.86	74.60	74.88	85.12	69.45	84.78	79.79
18	Kashi Hemanth	89.83	76.81	56.06	74.23	98.68	102.04	66.03	88.92
19	EC 686554	83.06	61.45	67.48	70.66	90.21	118.82	157.36	122.13
20	EC 686550	57.19	59.02	53.85	56.69	68.45	53.84	55.51	59.26
21	Kashi Anupam	94.05	127.29	99.54	106.96	84.11	82.96	83.39	83.49
22	EC 677111	69.19	66.68	66.02	67.30	84.72	103.27	123.92	103.97
23	SEL 12	74.72	66.68	64.29	68.56	95.96	118.08	156.66	123.57
24	EC 608348	61.27	54.21	43.98	53.16	84.20	137.05	152.12	124.45
25	EC 608320	100.92	97.33	111.04	103.10	112.63	156.19	189.74	152.85
26	EC 686548	76.84	52.03	40.72	56.53	86.91	113.36	128.57	109.61
27	Hissar Arun	90.85	93.80	92.98	92.54	112.23	124.67	111.71	116.20
28	EC 686542	56.20	49.81	54.26	53.42	95.03	110.36	107.56	104.31
29	EC 686543	57.48	46.19	48.89	50.85	63.62	55.17	46.25	55.01
30	EC 677044	93.72	90.33	116.06	100.03	16.41	119.29	116.02	83.91
31	EC 608269	69.10	43.24	62.77	58.37	54.52	51.71	53.51	53.24
32	Swarna Lalima	61.66	65.64	50.75	59.35	78.49	76.25	66.64	73.79
33	EC 686553	64.43	55.53	46.18	55.38	70.79	66.89	39.53	59.07
34	Pusa 120	92.07	107.49	97.27	98.94	91.60	91.97	91.39	91.65
35	Pusa Gaurav	51.21	49.35	43.59	48.05	81.41	81.22	72.62	78.42
36	HUB-18	70.01	64.66	58.02	64.23	85.65	89.63	74.49	83.26
37	Megha	70.07	81.37	79.07	76.84	87.34	88.16	87.97	87.82
38	Arka Abha	92.74	95.16	69.70	85.86	95.61	122.62	86.20	101.48
39	T-26	104.57	98.64	89.95	97.72	110.08	86.55	122.96	106.53
40	DMT-2	97.99	85.55	66.06	83.20	86.12	75.06	57.98	73.05
41	HUB T-10	92.92	104.92	110.72	102.85	104.90	76.40	30.10	70.46
42	HUB T-06	77.03	80.74	84.41	80.73	88.08	75.75	59.64	74.49
43	HUB T-11	85.43	85.02	68.05	79.50	77.44	96.79	73.34	82.52
44	HUB T-05	63.32	69.79	93.54	75.55	133.46	96.21	97.04	108.90
45	HUB T-07	70.34	69.58	62.16	67.36	67.52	58.26	63.79	63.19
46	HUB T-04	80.67	48.52	51.36	60.18	73.43	87.79	95.85	85.69
47	HUB T-09	71.32	65.68	72.57	69.86	65.79	66.19	50.15	60.71
48	HUB T-12	74.65	68.13	66.55	69.77	73.82	95.21	85.97	85.00
49	HUB T-08	47.35	62.17	63.39	57.64	101.22	97.52	103.84	100.86
50	HUB T-13	37.55	42.00	32.24	37.26	59.66	51.38	46.02	52.35
Mean		77.98	75.20	71.78	74.99	88.49	95.65	97.00	93.72
Range		37.55	42.00	32.24	37.26	16.41	51.38	30.10	52.35
		107.03	127.29	116.06	106.96	140.50	156.19	189.74	152.85
		S.E.m ±		CD at 5%		S.E.m ±		CD at 5%	
Genotypes		5.47		15.30		10.55		29.47	
Irrigation		1.341		3.75		2.583		NS	
G X I		9.48		NS		18.26		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

Specific leaf area was found significant for genotype but not in the irrigation level for their interaction during 90 DAT.

During 90 DAT, among the irrigation levels higher SLA was noticed at 0.4 IW/CPE ratio and it varied from 30.10 to 189.74 while, at 1.2 IW/CPE ratio (51.38 to 156.19). Irrespective of the irrigation levels, genotype EC 608320 exhibited higher SLA (152.85) it was on par with EC 638577 (148.93), EC 608348 (124.45), SEL-12 (123.57) and the least was noticed in the genotype HUB T-13 (52.35). Among the interaction effect were found non-significant. However, numerically the genotype EC 608320 (189.74) had higher SLA and least was recorded in the HUB T-10 (30.10).

PCV was observed of 27.49 per cent and 36.11 per cent at 45 and 90 DAS respectively. GCV of 20.87 per cent and 23.32 per cent, the broad sense heritability (57.68% and 41.73%), genetic advance (24.49 and 29.08) and GAM (32.66 and 31.03) were noticed at 45 and 90 DAS respectively.

4.2.6 Total biomass (g/plant)

Total biomass increased progressively from 45 DAT upto 90 DAT. Significant difference in total biomass were observed among the genotypes, different irrigation schedules and their interactions at 45 and 90 DAT (Table 13).

During 45 DAT, irrespective of the irrigation levels, among the genotype EC 610661 had significantly maximum total biomass (52.90) and minimum was in the genotype HUB T-13 (17.17). Among the different types of irrigation level, significantly maximum total biomass of 34.31 was noticed under control irrigation system and minimum was recorded at 0.4 IW/CPE ratio (23.46). There was significant interaction between genotypes and irrigation levels, maximum total biomass was noticed in the genotype EC 610661 (55.16) it was on par with EC 610661 (50.98) at 0.4 IW/CPE ratio and least was in the genotype EC 686550 (10.50) at 0.4 IW/CPE ratio.

During 90 DAT, there was significant difference among the genotypes and pan evaporation ratios, maximum total biomass was found in the genotype EC 634394 (90.62) and least was recorded in the genotype T-26 (34.73) irrespective of the irrigation levels. Among the different types of irrigation level, significantly maximum

Table 13. Biomass (g/plant) of tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Biomass at 45 DAT				Biomass at 90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	39.00	37.00	33.00	36.33	87.75	48.40	39.97	58.71
2	Arka Meghali	35.00	28.50	26.00	29.83	60.75	50.00	42.90	51.22
3	EC 608362	37.00	33.75	31.00	33.92	53.50	50.40	47.90	50.60
4	EC 608368	35.00	29.50	20.50	28.33	63.50	54.30	48.85	55.55
5	EC 608389	35.50	30.00	30.00	31.83	82.50	44.30	37.55	54.78
6	EC 610652	36.00	33.25	31.16	33.47	77.25	73.80	71.79	74.28
7	EC 634394	46.50	43.50	41.00	43.67	93.25	90.65	87.95	90.62
8	EC 638519	40.50	36.13	33.33	36.65	76.50	73.40	71.15	73.68
9	EC 610661	55.16	52.57	50.98	52.90	80.50	78.46	76.70	78.55
10	EC 632944	31.50	30.50	22.00	28.00	70.75	48.30	41.80	53.62
11	EC 630512	43.00	35.00	31.00	36.33	56.05	47.10	40.75	47.97
12	EC 631962	39.00	33.50	29.50	34.00	92.41	39.90	32.80	55.04
13	EC 654725	36.00	32.50	29.50	32.67	83.75	51.50	42.60	59.28
14	EC 654724	44.00	32.50	27.50	34.67	53.90	46.97	43.85	48.24
15	EC 654719	30.50	28.50	24.00	27.67	62.75	50.70	42.45	51.97
16	EC 638577	47.00	39.00	36.00	40.67	86.98	73.00	61.19	73.72
17	EC 608288	28.00	24.00	21.00	24.33	60.50	54.10	32.80	49.13
18	Kashi Hemanth	33.00	26.50	22.50	27.33	54.00	42.00	28.20	41.40
19	EC 686554	29.50	23.50	18.00	23.67	64.50	41.20	28.40	44.70
20	EC 686550	28.50	19.50	10.50	19.50	64.75	40.30	23.15	42.73
21	Kashi Anupam	32.00	29.50	26.50	29.33	66.25	62.30	59.75	62.77
22	EC 677111	25.50	19.00	17.00	20.50	49.25	32.20	24.90	35.45
23	SEL 12	26.50	19.50	12.00	19.33	53.75	33.00	25.60	37.45
24	EC 608348	42.50	31.50	23.00	32.33	95.09	65.07	52.05	70.73
25	EC 608320	35.50	27.50	22.00	28.33	82.25	49.70	31.30	54.42
26	EC 686548	30.00	26.50	20.50	25.67	66.24	41.54	21.15	42.98
27	Hissar Arun	32.00	28.00	17.00	25.67	57.98	49.50	38.10	48.53
28	EC 686542	28.00	24.00	19.50	23.83	64.00	43.30	30.60	45.97
29	EC 686543	36.00	27.00	18.68	27.23	74.25	46.50	25.40	48.72
30	EC 677044	33.00	23.00	11.00	22.33	56.00	33.20	25.70	38.30
31	EC 608269	47.00	36.28	22.95	35.41	80.25	57.00	31.25	56.17
32	Swarna Lalima	26.00	21.50	25.50	24.33	74.90	39.20	31.05	48.38
33	EC 686553	25.50	19.00	15.55	20.02	57.00	32.40	18.71	36.04
34	Pusa 120	32.00	29.00	27.00	29.33	56.25	54.45	52.36	54.35
35	Pusa Gaurav	38.50	23.00	18.00	26.50	90.75	55.60	33.40	59.92
36	HUB-18	27.50	19.00	20.00	22.17	69.20	42.05	26.30	45.85
37	Megha	41.50	29.50	32.50	34.50	95.25	46.60	36.50	59.45
38	Arka Abha	23.00	19.50	18.00	20.17	52.75	35.90	24.10	37.58
39	T-26	27.00	20.50	16.00	21.17	46.00	33.80	24.40	34.73
40	DMT-2	23.50	20.00	18.50	20.67	56.75	30.10	23.20	36.68
41	HUB T-10	34.00	27.00	14.00	25.00	70.80	35.50	27.00	44.43
42	HUB T-06	36.00	33.00	24.00	31.00	55.49	41.00	29.30	41.93
43	HUB T-11	39.00	28.00	26.90	31.30	70.25	43.70	27.70	47.22
44	HUB T-05	49.50	40.00	29.00	39.50	87.97	48.72	35.95	57.55
45	HUB T-07	29.00	26.50	22.58	26.03	51.47	44.57	28.15	41.39
46	HUB T-04	22.50	19.00	14.50	18.67	51.50	35.72	24.84	37.35
47	HUB T-09	46.50	36.00	17.50	33.33	71.75	47.40	35.95	51.70
48	HUB T-12	29.50	24.50	21.00	25.00	62.00	32.01	23.95	39.32
49	HUB T-08	25.50	22.50	20.50	22.83	47.25	39.80	28.00	38.35
50	HUB T-13	22.00	16.00	13.50	17.17	50.25	33.60	21.60	35.15
Mean		34.31	28.29	23.46	28.69	67.77	47.68	37.22	50.89
Range		22.00	16.00	10.50	17.17	46.00	30.10	18.71	34.73
		55.16	52.57	50.98	52.90	95.25	90.65	87.95	90.62
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		1.39		3.87		1.96		5.49	
Irrigation		0.34		0.95		0.48		1.34	
G X I		2.40		6.70		3.40		9.51	

DAT= Days after transplanting Control = Farmers practice

total biomass of 67.77 at control and minimum was noticed 37.22 at 0.4 IW/CPE ratio. There was significant interaction between genotypes and irrigation levels, maximum total biomass was noticed in the genotype Megha (95.25) it was on par with EC 634394 (93.25) (90.65) (87.95) at control, 1.2 and 0.4 IW/CPE ratio respectively and least was in the genotype EC 686553 (18.71) at 0.4 IW/CPE ratio.

PCV was observed to be 47.78 per cent and 57.14 per cent at 45 and 90 DAS respectively. GCV of 44.36 per cent and 55.34 per cent, the broad sense heritability (86.22% and 93.84%), genetic advance (16.22 and 37.47) and GAM (84.85 and 110.45) were noticed at 45 and 90 DAS respectively.

4.2.7 Biomass duration (Kg/day) at different crop growth period

Biomass duration (BMD) was significantly differed within the genotypes, irrigation levels and their interaction effect at 45-90 DAT (Table 14).

During 45-90 DAT, genotype EC 634394 had significantly higher BMD (3.02), and was on par with EC 610661 (2.96) while, the least BMD was noticed in the genotype HUB T-13 (1.18) irrespective of irrigation levels. Interaction between genotype and irrigation schedule was found significant. Significantly higher BMD was observed in the genotype EC 634394 (3.14) which was on par with EC 610661 (2.087) at 0.4 IW/CPE ratio, wherein the BMD ranged between 1.63 to 3.14, 1.12 to 3.02 and 0.76 to 2.90 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Significantly lesser BMD was exhibited by the genotype EC 686550 (0.76) at 0.4 IW/CPE ratio.

As the stress level increased from control to 0.4 IW/CPE ratio, BMD decreased significantly to the extent of 40.43 per cent at 45-90 DAT.

4.2.8 Absolute growth rate (g/day) at different crop growth period

There was significant difference for absolute growth rate (AGR) among the genotypes and irrigation levels during the growth period and the interaction effect was significant during 45 to 90 DAT (Table 15).

Between 45 to 90 DAT, irrespective of the irrigation levels, genotype EC 634394 had significantly maximum AGR (1.04) and minimum was exhibited by the genotype HUB T-06 (0.24). Significantly higher AGR was recorded in the control and

Table 14. Biomass duration (g/day) of tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Biomass duration			
		Control	1.2	0.4	Mean
1	EC 608271	2.85	1.92	1.64	2.14
2	Arka Meghali	2.15	1.77	1.55	1.82
3	EC 608362	2.04	1.89	1.78	1.90
4	EC 608368	2.22	1.89	1.56	1.89
5	EC 608389	2.66	1.67	1.52	1.95
6	EC 610652	2.55	2.41	2.32	2.42
7	EC 634394	3.14	3.02	2.90	3.02
8	EC 638519	2.63	2.46	2.35	2.48
9	EC 610661	3.05	2.95	2.87	2.96
10	EC 632944	2.30	1.77	1.44	1.84
11	EC 630512	2.23	1.85	1.61	1.90
12	EC 631962	2.96	1.65	1.40	2.00
13	EC 654725	2.69	1.89	1.62	2.07
14	EC 654724	2.20	1.79	1.61	1.87
15	EC 654719	2.10	1.78	1.50	1.79
16	EC 638577	3.01	2.52	2.19	2.57
17	EC 608288	1.99	1.76	1.21	1.65
18	Kashi Hemanth	1.96	1.54	1.14	1.55
19	EC 686554	2.12	1.46	1.04	1.54
20	EC 686550	2.10	1.35	0.76	1.40
21	Kashi Anupam	2.21	2.07	1.94	2.07
22	EC 677111	1.68	1.15	0.94	1.26
23	SEL 12	1.81	1.18	0.85	1.28
24	EC 608348	3.10	2.17	1.69	2.32
25	EC 608320	2.65	1.74	1.20	1.86
26	EC 686548	2.17	1.53	0.94	1.54
27	Hissar Arun	2.02	1.74	1.24	1.67
28	EC 686542	2.07	1.51	1.13	1.57
29	EC 686543	2.48	1.65	0.99	1.71
30	EC 677044	2.00	1.26	0.83	1.36
31	EC 608269	2.86	2.10	1.22	2.06
32	Swarna Lalima	2.27	1.37	1.27	1.64
33	EC 686553	1.86	1.16	0.77	1.26
34	Pusa 120	1.99	1.88	1.79	1.88
35	Pusa Gaurav	2.91	1.77	1.16	1.94
36	HUB-18	2.18	1.37	1.04	1.53
37	Megha	3.08	1.71	1.55	2.11
38	Arka Abha	1.70	1.25	0.95	1.30
39	T-26	1.64	1.22	0.91	1.26
40	DMT-2	1.81	1.13	0.94	1.29
41	HUB T-10	2.36	1.41	0.92	1.56
42	HUB T-06	2.06	1.67	1.20	1.64
43	HUB T-11	2.46	1.61	1.23	1.77
44	HUB T-05	3.09	2.00	1.46	2.18
45	HUB T-07	1.81	1.60	1.14	1.52
46	HUB T-04	1.67	1.23	0.89	1.26
47	HUB T-09	2.66	1.88	1.48	2.00
48	HUB T-12	2.06	1.27	1.01	1.45
49	HUB T-08	1.64	1.40	1.09	1.38
50	HUB T-13	1.63	1.12	0.79	1.18
Mean		2.30	1.71	1.37	1.79
Range		1.63	1.12	0.76	1.18
		3.14	3.02	2.90	3.02
		S.Em $\pm$		CD at 5%	
Genotypes		0.06		0.16	
Irrigation		0.01		0.04	
G X I		0.10		0.28	

DAT= Days after transplanting

Control = Farmers practice

it ranged from 0.22 to 1.19 while at 1.2 IW/CPE ratio it ranged from 0.14 to 1.05, it was least in 0.4 IW/CPE ratio and it varied from 0.01 to 1.04. Among the interaction effects, the maximum AGR was noticed in the genotype EC 631962 (1.19) which was on par with EC 634394 (1.04), 1.05, 1.04 at control, 1.2 and 0.4 IW/CPE ratio respectively. The genotype EC 686548 recorded significantly the least AGR (0.01) at 0.4 IW/CPE ratio.

PCV was observed of 61.36 per cent at 45-90 DAT growth stage. GCV of 57.22 per cent, the broad sense heritability (86.95%), genetic advance (0.54) and GAM (109.91) were noticed at 45-90 DAT growth stage.

4.2.9 Crop growth rate ($\text{g.m}^{-2}/\text{day}$) (CGR) at different crop growth stages

There was significant difference for crop growth rate among the genotypes, different pan evaporation ratios and their interaction during 45-90 DAT (Table 15).

During 45-90 DAT, the genotype EC 634394 had significantly higher CGR (1.39) whereas, HUB T-06 showed significantly lesser CGR (0.32) irrespective of the irrigation levels. There was significant interaction effect where in the genotype Megha had significantly maximum CGR (1.59) and it was on par with EC 634394 1.40, 1.39 at 1.2 and 0.4 IW/CPE ratio, while the minimum CGR (0.02) was exhibited by the genotype HUB T-13 at 0.4 IW/CPE ratio.

PCV was observed of 61.36 per cent at 45-90 DAT growth stage. GCV of 57.22 per cent, the broad sense heritability (86.95%), genetic advance (0.72) and GAM (109.91) were noticed at 45-90 DAT growth stage.

4.2.10 Net assimilation rate ($\text{g.dm}^{-2} \text{ day}^{-1} \times 10^2$) at different crop growth period

Net assimilation rate (NAR) was decreased in all the growth stages irrespective of the irrigation schedules. Significant difference among the genotypes, irrigation levels and the interaction effect at all the growth stages of the crop was noticed (Table 16).

Table 15. Influence of irrigation levels on absolute growth rate (g/day) and crop growth rate (g/m²/day) in tomato genotypes at various growth stages

Sl. No.	Genotypes	Absolute growth rate (45-90 DAT)				Crop growth rate (45-90 DAT)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1.08	0.25	0.16	0.50	1.44	0.34	0.21	0.66
2	Arka Meghali	0.57	0.48	0.38	0.48	0.76	0.64	0.50	0.63
3	EC 608362	0.37	0.37	0.38	0.37	0.49	0.49	0.50	0.49
4	EC 608368	0.63	0.55	0.63	0.60	0.84	0.73	0.84	0.81
5	EC 608389	1.04	0.32	0.17	0.51	1.39	0.42	0.22	0.68
6	EC 610652	0.92	0.90	0.90	0.91	1.22	1.20	1.20	1.21
7	EC 634394	1.04	1.05	1.04	1.04	1.39	1.40	1.39	1.39
8	EC 638519	0.80	0.83	0.84	0.82	1.07	1.10	1.12	1.10
9	EC 610661	0.56	0.58	0.57	0.57	0.75	0.77	0.76	0.76
10	EC 632944	0.87	0.40	0.44	0.57	1.16	0.53	0.59	0.76
11	EC 630512	0.29	0.27	0.22	0.26	0.39	0.36	0.29	0.34
12	EC 631962	1.19	0.14	0.07	0.47	1.58	0.19	0.10	0.62
13	EC 654725	1.06	0.42	0.29	0.59	1.41	0.56	0.39	0.79
14	EC 654724	0.22	0.32	0.36	0.30	0.29	0.43	0.48	0.40
15	EC 654719	0.72	0.49	0.41	0.54	0.96	0.66	0.55	0.72
16	EC 638577	0.89	0.76	0.56	0.73	1.18	1.01	0.75	0.98
17	EC 608288	0.72	0.67	0.26	0.55	0.96	0.89	0.35	0.73
18	Kashi Hemanth	0.47	0.34	0.13	0.31	0.62	0.46	0.17	0.42
19	EC 686554	0.78	0.39	0.23	0.47	1.04	0.52	0.31	0.62
20	EC 686550	0.81	0.46	0.28	0.52	1.07	0.62	0.37	0.69
21	Kashi Anupam	0.76	0.73	0.74	0.74	1.01	0.97	0.99	0.99
22	EC 677111	0.53	0.29	0.18	0.33	0.70	0.39	0.23	0.44
23	SEL 12	0.61	0.30	0.30	0.40	0.81	0.40	0.40	0.54
24	EC 608348	1.17	0.75	0.65	0.85	1.56	0.99	0.86	1.14
25	EC 608320	1.04	0.49	0.21	0.58	1.39	0.66	0.28	0.77
26	EC 686548	0.81	0.33	0.01	0.38	1.07	0.45	0.02	0.51
27	Hissar Arun	0.58	0.48	0.47	0.51	0.77	0.64	0.63	0.68
28	EC 686542	0.80	0.43	0.25	0.49	1.07	0.57	0.33	0.66
29	EC 686543	0.85	0.43	0.15	0.48	1.13	0.58	0.20	0.64
30	EC 677044	0.51	0.23	0.33	0.35	0.68	0.30	0.44	0.47
31	EC 608269	0.74	0.46	0.18	0.46	0.99	0.61	0.25	0.62
32	Swarna Lalima	1.09	0.39	0.12	0.53	1.45	0.52	0.16	0.71
33	EC 686553	0.70	0.30	0.07	0.36	0.93	0.40	0.09	0.47
34	Pusa 120	0.54	0.57	0.56	0.56	0.72	0.75	0.75	0.74
35	Pusa Gaurav	1.16	0.72	0.34	0.74	1.55	0.97	0.46	0.99
36	HUB-18	0.93	0.51	0.14	0.53	1.24	0.68	0.19	0.70
37	Megha	1.19	0.38	0.09	0.55	1.59	0.51	0.12	0.74
38	Arka Abha	0.66	0.36	0.14	0.39	0.88	0.49	0.18	0.52
39	T-26	0.42	0.30	0.19	0.30	0.56	0.39	0.25	0.40
40	DMT-2	0.74	0.22	0.10	0.36	0.99	0.30	0.14	0.47
41	HUB T-10	0.82	0.19	0.29	0.43	1.09	0.25	0.39	0.58
42	HUB T-06	0.43	0.18	0.12	0.24	0.58	0.24	0.16	0.32
43	HUB T-11	0.69	0.35	0.02	0.35	0.93	0.47	0.02	0.47
44	HUB T-05	0.85	0.19	0.15	0.40	1.14	0.26	0.21	0.53
45	HUB T-07	0.50	0.40	0.12	0.34	0.67	0.54	0.17	0.46
46	HUB T-04	0.64	0.37	0.23	0.42	0.86	0.50	0.31	0.55
47	HUB T-09	0.56	0.25	0.14	0.32	0.75	0.34	0.19	0.42
48	HUB T-12	0.72	0.17	0.07	0.32	0.96	0.22	0.09	0.42
49	HUB T-08	0.48	0.38	0.17	0.34	0.64	0.51	0.22	0.46
50	HUB T-13	0.63	0.39	0.18	0.40	0.84	0.52	0.24	0.53
Mean		0.74	0.43	0.30	0.49	0.99	0.57	0.40	0.66
Range		0.22	0.14	0.01	0.24	0.29	0.19	0.02	0.32
		1.19	1.05	1.04	1.04	1.59	1.40	1.39	1.39
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.04		0.12		0.06		0.17	
Irrigation		0.011		0.03		0.015		0.04	
G X I		0.08		0.22		0.10		0.29	

DAT= Days after transplanting Control = Farmers practice

During 45-90 DAT, irrespective of the irrigation levels, genotype EC686550 had significantly higher NAR (0.39), this was on par with HUB T-13 (0.33) and the least NAR was noticed in the genotype HUB T-06 (0.10).

Among the three irrigation levels, control recorded significantly higher NAR compared to 1.2 and 0.4 IW/CPE ratio where in, NAR ranged from 0.06 to 0.43, 0.04 to 0.36 and 0.01 to 0.39 respectively. There was significant interaction effect where in the genotype EC 677044 had maximum NAR (0.43) and it was on par with EC686550 (0.36, 0.39) at 1.2 and 0.4 IW/CPE ratio respectively, while the minimum NAR (0.01) was exhibited by the genotype EC 686548 at 0.4 IW/CPE ratio.

PCV was observed of 52.33 per cent at 45-90 DAT growth stage. GCV of 44.70 per cent, the broad sense heritability (72.98%), genetic advance (1.48) and GAM (78.67) were noticed at 45-90 DAT growth stage.

4.2.11 Relative growth rate (RGR) ($\text{g.g}^{-1}\text{day}^{-1} \times 10^2$) at different crop growth period

Significant difference were observed for RGR among the genotypes, irrigation levels and their interaction during 45-90 DAT (Table 16).

Irrespective of the irrigation levels, genotype EC 610652 had significantly higher RGR (7.71) which was on par with Pusa Gurav (7.53), EC 608348 (7.51), EC 686550 (7.47) and EC 638519 (6.76) while, the least RGR was recorded in the genotype EC 630512 (2.70). Among the three irrigation levels, control recorded significantly higher RGR compared to 1.2 and 0.4 IW/CPE ratio where in, RGR ranged from 2.00 to 9.10, 1.70 to 8.30 and 0.321 to 8.04 respectively. There was significant difference in interaction effects, the genotypes Swarna Lalima showed the highest RGR (9.1) it was on par with EC 610652 (8.45), Hisar arun (8.04) and the least was noticed in the genotype EC 686548 (0.30) at 0.4 IW/CPE ratio.

PCV was observed to be 43.49 per cent at 45-90 DAT growth stage. GCV of 38.03 per cent, the broad sense heritability (76.43%), genetic advance (3.57) and GAM (68.48) were noticed at 45-90 DAT growth stage.

Table 16. Influence of irrigation levels on relative growth rate (RGR) (g/g/day x 10³) and Net assimilation rate (NAR) (g/dm²/day X 10³) in tomato genotypes at various growth stage

Sl. No.	Genotypes	Relative growth rate at 45-90 DAT				Net assimilation rate at 45—90 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	7.8	2.5	1.9	4.1	0.33	0.09	0.06	0.16
2	ArkaMeghali	5.3	5.4	4.8	5.2	0.16	0.15	0.13	0.14
3	EC 608362	3.6	3.9	4.2	3.9	0.11	0.12	0.14	0.12
4	EC 608368	5.7	5.9	8.4	6.7	0.21	0.20	0.30	0.24
5	EC 608389	8.1	3.7	2.2	4.7	0.24	0.11	0.07	0.14
6	EC 610652	7.4	7.7	8.1	7.7	0.24	0.27	0.30	0.27
7	EC 634394	6.7	7.1	7.4	7.0	0.29	0.33	0.35	0.32
8	EC 638519	6.1	6.8	7.3	6.8	0.21	0.23	0.26	0.23
9	EC 610661	3.6	3.9	3.9	3.8	0.18	0.20	0.21	0.19
10	EC 632944	7.8	4.4	6.1	6.1	0.26	0.16	0.21	0.21
11	EC 630512	2.6	2.9	2.6	2.7	0.09	0.10	0.12	0.10
12	EC 631962	8.3	1.7	1.0	3.7	0.30	0.04	0.03	0.13
13	EC 654725	8.1	4.4	3.5	5.4	0.23	0.15	0.14	0.17
14	EC 654724	2.0	3.6	4.5	3.3	0.06	0.11	0.17	0.11
15	EC 654719	7.0	5.6	5.5	6.0	0.27	0.22	0.22	0.24
16	EC 638577	5.9	6.1	5.1	5.7	0.20	0.23	0.18	0.20
17	EC 608288	7.4	7.8	4.3	6.5	0.20	0.24	0.11	0.18
18	KashiHemanth	4.6	4.4	1.9	3.7	0.14	0.15	0.10	0.13
19	EC 686554	7.5	5.4	4.4	5.8	0.24	0.19	0.13	0.19
20	EC 686550	7.9	6.9	7.6	7.5	0.41	0.36	0.39	0.39
21	KashiAnupam	7.0	7.2	7.9	7.4	0.20	0.21	0.24	0.22
22	EC 677111	6.4	5.1	3.6	5.0	0.22	0.14	0.10	0.15
23	SEL 12	6.8	5.0	6.7	6.2	0.21	0.13	0.15	0.16
24	EC 608348	7.8	6.9	7.8	7.5	0.32	0.27	0.30	0.30
25	EC 608320	8.1	5.7	3.4	5.7	0.27	0.15	0.07	0.17
26	EC 686548	7.6	4.3	0.3	4.1	0.26	0.15	0.01	0.14
27	HissarArun	5.7	5.5	8.0	6.4	0.16	0.16	0.19	0.17
28	EC 686542	8.0	5.7	4.4	6.0	0.26	0.18	0.13	0.19
29	EC 686543	7.0	5.2	3.0	5.1	0.36	0.32	0.22	0.30
30	EC 677044	5.5	3.6	3.5	4.2	0.43	0.09	0.13	0.21
31	EC 608269	5.1	4.3	2.9	4.1	0.28	0.30	0.18	0.25
32	SwarnaLalima	9.1	5.9	1.9	5.6	0.42	0.18	0.09	0.23
33	EC 686553	7.8	5.1	1.8	4.9	0.27	0.19	0.11	0.19
34	Pusa 120	5.4	6.1	6.4	5.9	0.16	0.19	0.21	0.19
35	Pusa Gaurav	8.3	8.3	6.0	7.5	0.39	0.29	0.17	0.28
36	HUB-18	8.5	7.6	2.7	6.3	0.32	0.23	0.08	0.21
37	Megha	8.0	4.4	1.1	4.5	0.27	0.12	0.04	0.14
38	ArkaAbha	8.0	5.9	2.8	5.6	0.22	0.14	0.09	0.15
39	T-26	5.1	4.8	4.2	4.7	0.14	0.14	0.10	0.13
40	DMT-2	8.5	3.9	2.2	4.9	0.26	0.11	0.09	0.15
41	HUB T-10	7.1	2.7	6.5	5.4	0.24	0.07	0.23	0.18
42	HUB T-06	4.2	2.1	1.9	2.7	0.14	0.07	0.07	0.10
43	HUB T-11	5.7	4.3	0.3	3.4	0.22	0.12	0.01	0.12
44	HUB T-05	5.6	1.9	2.1	3.2	0.21	0.07	0.07	0.12
45	HUB T-07	5.5	5.1	2.2	4.3	0.19	0.20	0.08	0.16
46	HUB T-04	8.0	6.1	5.2	6.4	0.26	0.21	0.15	0.21
47	HUB T-09	4.2	2.7	1.9	2.9	0.16	0.09	0.07	0.11
48	HUB T-12	7.1	2.6	1.3	3.7	0.26	0.08	0.04	0.13
49	HUB T-08	6.0	5.5	3.0	4.8	0.28	0.18	0.10	0.19
50	HUB T-13	8.0	7.2	4.5	6.6	0.42	0.34	0.23	0.33
Mean		6.6	5.0	4.1	5.2	0.24	0.18	0.15	0.19
Range		2.0	1.7	0.3	2.7	0.06	0.04	0.01	0.10
		9.1	8.3	8.4	7.7	0.43	0.36	0.39	0.39
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.45		1.26		0.02		0.06	
Irrigation		0.11		0.31		0.01		0.01	
G X I		0.78		2.18		0.04		0.10	

DAT= Days after transplanting Control = Farmers practice

4.3 Biophysical parameters

4.3.1 PAR (Lux)

There was a significant difference between the different pan evaporation rates and tomato genotypes for the PAR at 75 DAT (Table 17).

The PAR varied from 912.5 to 1755.00 at control, 515.5 to 1358 at 1.2 IW/CPE ratio and 259.5 to 1202.00 at 0.4 IW/CPE ratio.

Among the genotypes EC 632944 had significantly more mean PAR (1438.33) and this was on par with EC 677044 (1429.33), EC 610661 (1402.33). While, minimum PAR was recorded in the genotype EC 686550 (595.83) irrespective of the irrigation levels. Interaction between the different irrigation schedules of control, 1.2 and 0.4 IW/CPE ratio found non significant. However, higher PAR was observed in the genotype EC 632944 (1755.00) at control, and lower PAR was exhibited by the genotype EC 686550 (359.50) at 0.4 IW/CPE ratio.

PCV was observed to be 52.94 per cent at 75 DAT. GCV of 51.88 per cent, the broad sense heritability (96.04%), genetic advance (680.96) and GAM (104.75) were noticed at 75 DAT.

4.3.2 Leaf temperature ($^{\circ}\text{C}$)

There were significant difference in the leaf temperature between the genotypes, irrigation levels but the interaction between genotypes and irrigation levels shows non significance (Table 17).

Leaf temperature ranged from 26.94 to 36.20, 25.90 to 37.05 and 26.79 to 40.16 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, EC 610661 (36.35) had significantly higher leaf temperature and was on par with EC 608362 (36.31), HUB T-05 (35.72) and Pusa Gaurav (35.46). Minimum leaf temperature was noticed in the genotype EC 686553 (28.05). There was significant difference between the irrigation levels. Significantly higher leaf temperature was recorded in the 0.4 IW/CPE ratio (33.67) compared to 1.2 IW/CPE ratio (31.47). Interaction of genotypes and irrigation levels was not significant. However, maximum

Table 17. Photosynthetic active radiation (PAR) and Leaf temperature of tomato genotypes as influenced by irrigation levels at 75 DAT

Sl. No.	Genotypes	PAR (lux)				Leaf temperature (°C)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1396.00	999.00	843.00	1079.33	30.76	28.66	33.28	30.90
2	Arka Meghali	1505.00	1108.00	952.00	1188.33	30.50	32.62	39.66	34.26
3	EC 608362	1430.00	1033.00	877.00	1113.33	33.50	36.35	39.07	36.31
4	EC 608368	1072.00	675.00	519.00	755.33	32.81	27.52	35.86	32.06
5	EC 608389	932.50	535.50	379.50	615.83	36.20	35.16	31.32	34.22
6	EC 610652	1059.00	662.00	506.00	742.33	27.90	34.65	39.15	33.90
7	EC 634394	953.00	556.00	400.00	636.33	28.20	31.99	37.86	32.68
8	EC 638519	1206.00	809.00	653.00	889.33	27.14	35.89	40.00	34.34
9	EC 610661	1719.00	1322.00	1166.00	1402.33	35.10	34.75	39.21	36.35
10	EC 632944	1755.00	1358.00	1202.00	1438.33	32.95	36.56	29.62	33.04
11	EC 630512	1020.00	623.00	467.00	703.33	27.14	35.76	29.66	30.85
12	EC 631962	1113.00	716.00	560.00	796.33	28.36	27.68	35.83	30.62
13	EC 654725	1139.00	742.00	586.00	822.33	33.97	34.07	28.40	32.15
14	EC 654724	1190.00	793.00	637.00	873.33	28.94	33.36	30.86	31.05
15	EC 654719	1009.00	612.00	456.00	692.33	33.06	34.33	29.19	32.19
16	EC 638577	1059.00	662.00	506.00	742.33	34.78	34.64	31.63	33.68
17	EC 608288	950.00	553.00	397.00	633.33	32.05	31.34	37.94	33.77
18	Kashi Hemanth	1386.00	989.00	833.00	1069.33	33.27	37.05	34.91	35.08
19	EC 686554	1348.00	951.00	795.00	1031.33	33.04	30.64	34.54	32.74
20	EC 686550	912.50	515.50	359.50	595.83	31.04	28.33	31.87	30.41
21	Kashi Anupam	1399.00	1002.00	846.00	1082.33	35.04	33.20	37.19	35.14
22	EC 677111	1327.00	930.00	774.00	1010.33	31.15	33.61	30.26	31.67
23	SEL 12	1610.00	1213.00	1057.00	1293.33	30.50	35.86	29.73	32.03
24	EC 608348	1676.00	1279.00	1123.00	1359.33	35.38	33.28	28.80	32.48
25	EC 608320	1642.00	1245.00	1089.00	1325.33	31.96	32.14	31.00	31.70
26	EC 686548	1632.00	1235.00	1079.00	1315.33	28.19	32.82	35.83	32.28
27	Hissar Arun	1513.00	1116.00	960.00	1196.33	31.38	32.43	35.33	33.04
28	EC 686542	1524.00	1127.00	971.00	1207.33	26.94	30.76	33.19	30.30
29	EC 686543	1668.00	1271.00	1115.00	1351.33	33.09	26.94	26.79	28.94
30	EC 677044	1746.00	1349.00	1193.00	1429.33	31.06	27.79	29.62	29.49
31	EC 608269	1492.00	1095.00	939.00	1175.33	29.97	26.15	28.99	28.37
32	Swarna Lalima	1637.00	1240.00	1084.00	1320.33	31.66	28.26	31.16	30.36
33	EC 686553	1039.00	740.50	590.50	790.00	29.54	26.83	27.78	28.05
34	Pusa 120	1075.50	539.50	710.00	775.00	29.90	33.22	38.38	33.83
35	Pusa Gaurav	1114.00	717.00	561.00	797.33	35.75	34.53	36.11	35.46
36	HUB-18	1418.00	1021.00	865.00	1101.33	30.86	29.43	34.36	31.55
37	Megha	1583.00	1186.00	1030.00	1266.33	33.99	33.80	35.75	34.51
38	Arka Abha	1320.00	923.00	767.00	1003.33	33.22	28.29	33.53	31.68
39	T-26	1147.00	750.00	594.00	830.33	32.16	29.15	34.39	31.90
40	DMT-2	1235.00	761.00	605.00	867.00	32.46	31.49	38.16	34.03
41	HUB T-10	1235.00	799.00	643.00	892.33	29.60	34.57	33.21	32.46
42	HUB T-06	1064.50	667.50	511.50	747.83	31.40	27.95	30.11	29.82
43	HUB T-11	936.00	539.00	383.00	619.33	34.69	32.11	34.78	33.86
44	HUB T-05	978.50	581.50	425.50	661.83	31.65	35.37	40.16	35.72
45	HUB T-07	1119.00	882.50	726.50	909.33	30.34	30.25	33.84	31.48
46	HUB T-04	935.00	784.00	628.00	782.33	29.15	28.52	34.53	30.73
47	HUB T-09	1501.00	1104.00	948.00	1184.33	30.04	30.53	31.31	30.63
48	HUB T-12	1235.00	838.00	682.00	918.33	30.51	27.83	32.88	30.41
49	HUB T-08	1194.00	797.00	641.00	877.33	30.41	31.28	34.36	32.01
50	HUB T-13	1160.00	763.00	607.00	843.33	31.08	25.90	32.46	29.81
Mean		1286.19	894.19	744.84	975.07	31.47	31.71	33.67	32.29
Range		912.50	515.50	359.50	595.83	26.94	25.90	26.79	28.05
		1755.00	1358.00	1202.00	1438.33	36.20	37.05	40.16	36.35
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		27.94		78.08		1.47		4.11	
Irrigation		6.84		19.13		0.36		1.01	
G X I		48.40		NS		2.55		NS	

DAT= Days after transplanting NS= Non significant control = Farmers practice

leaf temperature was recorded in the genotype HUB T-05 (40.16) at 0.4 IW/CPE ratio and minimum leaf temperature was recorded in the genotype HUB T-13 (25.90) at 1.2 IW/CPE ratio.

PCV was observed of 19.07 per cent at 75 DAT. GCV of 9.15 per cent, the broad sense heritability (23.02%), genetic advance (1.94) and GAM (9.04) were noticed at 75 DAT.

4.3.3 Intercellular CO₂ content of the leaf (ppm)

In general, all the genotypes of tomato and pan evaporation ratios was significantly differed for intercellular CO₂ content of the leaf, but there was no significant interaction effect (Table 19).

The internal CO₂ concentration ranged from 214.50 to 275, 192.5 to 242.5 and 166.5 to 237 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Among all the genotypes, EC 638519 had significantly higher mean intercellular CO₂ level (248.83), it was on par with EC 610661 (246.17), Arka Meghali (239.17) and minimum was recorded in the genotype EC 686550 (198.5) irrespective of irrigation levels. Among the different pan evaporation ratios, significantly higher intercellular CO₂ was recorded in the control (248.28) over 0.4 IW/CPE ratio (198.16). Interaction of genotypes and different pan evaporation ratios were non significant. However, maximum intercellular CO₂ content was exhibited by the genotype Kashi Hemanth (275) at control and the minimum was found in the genotype EC 608320 (166.5) at 0.4 IW/CPE ratio.

PCV was observed of 19.07 per cent at 75 DAT. GCV of 15.46 per cent, the broad sense heritability (65.66%), genetic advance (37.89) and GAM (25.80) were noticed at 75 DAT.

4.3.4 Rate of transpiration (Table 19)

Rate of transpiration significantly differed among the tomato genotypes and between the irrigation schedules, but there was no significant difference in interaction between irrigation schedules and genotypes (Table 19).

Table 18. Stomatal conductance and Photosynthetic rate of tomato genotypes as influenced by irrigation levels at 75 DAT

Sl. No.	Genotypes	Stomatal conductance (mmol/m ² /s)				Photosynthesis (A) (mmolCO ₂ /m ² /s)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	0.86	0.57	0.34	0.59	24.83	19.07	10.41	18.10
2	Arka Meghali	0.76	0.78	0.70	0.74	22.45	16.82	14.07	17.78
3	EC 608362	1.04	0.78	0.71	0.84	19.34	17.72	7.28	14.78
4	EC 608368	0.91	0.47	0.43	0.60	19.74	18.28	13.74	17.25
5	EC 608389	0.92	0.64	0.66	0.74	22.26	15.91	12.93	17.03
6	EC 610652	0.74	0.71	0.62	0.69	22.44	14.88	14.08	17.13
7	EC 634394	0.91	0.75	0.67	0.78	23.41	15.19	11.94	16.84
8	EC 638519	1.02	0.54	0.64	0.73	22.11	16.88	13.12	17.37
9	EC 610661	0.82	0.74	0.65	0.74	21.42	17.75	15.48	18.21
10	EC 632944	0.74	0.55	0.39	0.56	20.76	16.95	8.77	15.49
11	EC 630512	0.75	0.70	0.51	0.65	20.83	17.87	10.94	16.55
12	EC 631962	0.93	0.64	0.36	0.64	22.04	16.54	11.83	16.80
13	EC 654725	0.92	0.58	0.46	0.65	18.97	16.56	13.11	16.21
14	EC 654724	0.87	0.73	0.37	0.66	24.44	18.05	10.64	17.71
15	EC 654719	0.90	0.54	0.52	0.65	19.65	16.27	9.77	15.23
16	EC 638577	1.15	0.54	0.57	0.75	19.70	19.44	11.40	16.84
17	EC 608288	0.84	0.62	0.48	0.65	22.24	17.32	10.76	16.77
18	Kashi Hemanth	1.00	0.64	0.52	0.72	20.87	18.38	13.84	17.69
19	EC 686554	0.94	0.61	0.43	0.66	20.75	16.99	10.97	16.24
20	EC 686550	0.91	0.49	0.34	0.58	21.09	10.55	6.00	12.54
21	Kashi Anupam	0.87	0.57	0.65	0.69	22.69	18.37	12.31	17.79
22	EC 677111	0.87	0.50	0.29	0.55	24.96	18.22	8.62	17.26
23	SEL 12	0.88	0.61	0.27	0.59	21.99	16.01	9.44	15.81
24	EC 608348	0.97	0.58	0.24	0.59	22.98	19.37	12.45	18.26
25	EC 608320	1.00	0.61	0.45	0.68	20.94	17.37	6.44	14.92
26	EC 686548	0.67	0.50	0.53	0.56	19.30	15.74	10.17	15.07
27	Hissar Arun	0.87	0.45	0.32	0.54	20.71	19.92	12.14	17.59
28	EC 686542	0.80	0.61	0.34	0.58	24.14	17.55	10.92	17.53
29	EC 686543	0.92	0.42	0.23	0.52	21.24	11.81	6.47	13.17
30	EC 677044	0.89	0.59	0.26	0.58	20.84	15.94	8.16	14.98
31	EC 608269	0.90	0.37	0.29	0.52	18.91	10.71	6.84	12.15
32	Swarna Lalima	0.98	0.54	0.27	0.59	23.62	15.94	9.79	16.45
33	EC 686553	0.85	0.32	0.23	0.46	21.01	12.73	6.91	13.55
34	Pusa 120	0.87	0.63	0.44	0.64	20.46	14.88	12.98	16.11
35	Pusa Gaurav	1.11	0.69	0.38	0.72	19.60	19.35	10.47	16.47
36	HUB-18	0.84	0.51	0.43	0.59	20.83	17.88	8.26	15.65
37	Megha	0.91	0.43	0.35	0.56	23.29	19.35	10.95	17.86
38	Arka Abha	0.92	0.62	0.48	0.67	18.29	17.70	12.74	16.24
39	T-26	1.05	0.52	0.25	0.61	21.37	16.24	9.26	15.62
40	DMT-2	0.84	0.52	0.33	0.56	22.76	18.91	11.52	17.73
41	HUB T-10	0.78	0.57	0.40	0.58	20.09	18.31	13.48	17.29
42	HUB T-06	0.82	0.39	0.28	0.50	20.82	17.76	14.01	17.53
43	HUB T-11	0.92	0.67	0.61	0.73	23.53	16.92	7.70	16.05
44	HUB T-05	0.72	0.59	0.26	0.52	21.61	17.71	11.70	17.01
45	HUB T-07	0.97	0.50	0.46	0.64	21.30	16.57	7.54	15.14
46	HUB T-04	0.75	0.63	0.44	0.60	23.74	17.61	9.71	17.02
47	HUB T-09	0.96	0.76	0.30	0.67	21.68	18.32	12.65	17.55
48	HUB T-12	0.87	0.47	0.57	0.63	21.25	18.09	9.25	16.19
49	HUB T-08	1.01	0.43	0.45	0.63	23.71	17.98	10.77	17.49
50	HUB T-13	0.85	0.47	0.61	0.64	20.72	18.09	10.36	16.39
Mean		0.89	0.57	0.43	0.63	21.55	16.97	10.70	16.41
Range		0.67	0.32	0.23	0.46	18.29	10.55	6.00	12.15
		1.15	0.78	0.71	0.84	24.96	19.92	15.48	18.26
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.06		0.17		0.90		2.51	
Irrigation		0.01		0.04		0.22		0.61	
G X I		0.10		NS		1.55		NS	

DAT= Days after transplanting NS= Non significant control = farmers practice

Table 19. Inter cellular CO₂ and Transpiration rate of tomato genotypes as influenced by irrigation levels at 75 DAT

Sl. No.	Genotypes	Inter cellular CO2 level (ppm)				Transpiration rate (T) (mmol H2O/m²/s⁻¹)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	255.00	218.00	176.00	216.33	10.97	7.35	5.48	7.93
2	Arka Meghali	260.00	220.50	237.00	239.17	11.27	7.80	7.28	8.78
3	EC 608362	257.00	203.00	222.50	227.50	11.26	8.04	7.23	8.84
4	EC 608368	231.50	220.00	206.00	219.17	10.99	9.29	6.88	9.05
5	EC 608389	242.00	220.00	196.00	219.33	11.04	7.66	5.25	7.98
6	EC 610652	239.50	227.50	215.00	227.33	10.42	8.68	7.55	8.88
7	EC 634394	238.50	219.50	219.50	225.83	10.65	8.50	6.94	8.70
8	EC 638519	274.50	242.50	229.50	248.83	9.70	8.82	7.80	8.77
9	EC 610661	273.50	233.50	231.50	246.17	11.42	8.26	7.75	9.14
10	EC 632944	262.00	217.00	192.00	223.67	9.68	10.01	7.38	9.02
11	EC 630512	259.50	204.50	176.00	213.33	11.73	8.72	5.37	8.60
12	EC 631962	264.00	204.00	203.00	223.67	9.93	9.01	6.68	8.54
13	EC 654725	246.50	207.00	217.00	223.50	11.22	9.37	6.58	9.06
14	EC 654724	242.00	224.50	218.00	228.17	10.97	7.56	6.75	8.43
15	EC 654719	252.00	209.00	198.00	219.67	9.80	9.28	7.53	8.87
16	EC 638577	264.50	205.00	216.50	228.67	10.82	9.21	6.93	8.99
17	EC 608288	262.00	215.00	195.50	224.17	10.62	8.24	5.90	8.25
18	Kashi Hemanth	275.00	203.00	198.00	225.33	9.50	8.02	6.87	8.13
19	EC 686554	257.50	226.00	178.00	220.50	12.04	7.44	6.02	8.50
20	EC 686550	214.50	211.00	170.00	198.50	9.62	5.88	4.13	6.54
21	Kashi Anupam	242.00	232.50	204.00	226.17	11.84	10.02	7.92	9.92
22	EC 677111	258.50	212.50	172.00	214.33	10.50	7.95	4.64	7.69
23	SEL 12	250.00	209.50	197.00	218.83	9.83	8.58	5.52	7.97
24	EC 608348	232.00	220.50	209.50	220.67	10.62	6.28	7.14	8.01
25	EC 608320	245.50	236.00	166.50	216.00	8.10	6.52	6.12	6.91
26	EC 686548	233.00	220.00	209.50	220.83	11.15	8.28	6.17	8.53
27	Hissar Arun	246.50	201.50	210.50	219.50	8.60	6.97	7.07	7.55
28	EC 686542	256.00	219.50	197.50	224.33	10.56	7.06	5.54	7.72
29	EC 686543	235.00	226.50	177.50	213.00	9.38	6.51	5.35	7.08
30	EC 677044	250.00	205.00	188.50	214.50	11.13	7.34	6.12	8.20
31	EC 608269	248.00	193.00	182.00	207.67	10.67	6.79	6.26	7.90
32	Swarna Lalima	245.00	192.50	206.00	214.50	9.46	9.48	4.73	7.89
33	EC 686553	234.50	198.00	169.50	200.67	12.08	6.27	4.77	7.70
34	Pusa 120	236.00	218.50	185.00	213.17	11.41	7.85	7.51	8.92
35	Pusa Gaurav	252.00	226.50	221.50	233.33	10.57	8.61	6.92	8.70
36	HUB-18	216.00	226.00	192.50	211.50	12.72	10.45	5.26	9.48
37	Megha	259.50	211.50	209.50	226.83	10.40	9.16	7.32	8.96
38	Arka Abha	257.50	227.50	182.50	222.50	10.06	7.93	6.24	8.08
39	T-26	240.00	195.00	207.00	214.00	12.69	7.36	6.31	8.79
40	DMT-2	244.50	223.50	197.00	221.67	11.65	10.17	5.43	9.08
41	HUB T-10	250.50	231.50	195.50	225.83	11.02	8.33	6.75	8.70
42	HUB T-06	253.50	205.00	173.00	210.50	10.49	8.90	7.46	8.95
43	HUB T-11	225.00	198.00	193.00	205.33	12.39	6.22	5.90	8.17
44	HUB T-05	261.00	217.50	190.00	222.83	12.08	8.70	7.07	9.28
45	HUB T-07	239.00	195.50	214.00	216.17	9.25	8.89	6.10	8.08
46	HUB T-04	264.00	212.00	188.50	221.50	9.95	7.31	7.02	8.09
47	HUB T-09	223.50	207.50	187.50	206.17	10.54	6.61	6.51	7.88
48	HUB T-12	251.50	199.50	195.50	215.50	11.05	7.98	5.45	8.16
49	HUB T-08	245.50	220.50	203.50	223.17	10.76	6.44	5.77	7.66
50	HUB T-13	248.00	201.00	187.50	212.17	11.57	8.55	5.29	8.47
Mean		248.28	214.28	198.16	220.24	10.72	8.09	6.36	8.39
Range		214.50	192.50	166.50	198.50	8.10	5.88	4.13	6.54
		275.00	242.50	237.00	248.83	12.72	10.45	7.92	9.92
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		6.70		18.73		0.50		1.40	
Irrigation		1.64		4.59		0.12		0.34	
G X I		11.61		NS		0.87		NS	

DAT= Days after transplanting NS= Non significant Control = Farmers practice

The transpiration rate varied from 8.10 to 12.72 at control, 5.88 to 10.45 at 1.2 IW/CPE ratio and it was 4.13 to 7.92 at 0.4 IW/CPE ratio. Among the different genotypes Kashi Anupam (9.92) had significantly higher rate of transpiration and this was on par with HUB T-18 (9.48) followed by HUB T-05 (9.28), EC 610661 (9.14) and significantly least rate of transpiration was exhibited by the genotype EC 686550 (6.54) irrespective of irrigation levels. With the increase in the stress from 1.2 to 0.4 IW/CPE ratio the rate of transpiration decreased. Interaction between genotype and irrigation schedule was not significant. However, the higher transpiration rate was recorded in the genotype HUB - 18 (12.72) at control and minimum was noticed in the genotype EC 686550 (4.13) at 0.4 IW/CPE ratio.

PCV was observed of 40.09 per cent at 75 DAT. GCV of 33.56 per cent, the broad sense heritability (70.08%), genetic advance (3.23) and GAM (57.88) were noticed at 75 DAT.

4.3.5 Stomatal conductance ($\text{m.mol.m}^{-2}.\text{S}^{-1}$)

The genotypes, pan evaporation ratios showed significant difference but their interaction effect exhibited non significance with respect to stomatal conductance (Table 18).

Stomatal conductance ranged from 0.67 to 1.15, 0.32 to 0.78 and 0.23 to 0.71 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, significantly higher stomatal conductance was recorded in the genotype EC 608362 (0.84) which was on par with EC 634394 (0.78) and EC 638557 (0.75). The genotype EC 686553 recorded least stomatal conductance (0.46).

There was significant difference between the pan evaporation ratios. Among the three irrigation levels, there was 51.68 per cent reduction in stomatal conductance when the stress was increased from control to 0.4 IW/CPE ratio. Interaction between genotype and irrigation schedule was not significant. However, the genotype EC 638577 (1.15) showed highest stomatal conductance under control and least was observed in EC 686553 (0.23) at 0.4 IW/CPE ratio.

PCV was observed of 58.89 per cent at 75 DAT. GCV of 47.29 per cent, the broad sense heritability (64.50%), genetic advance (0.32) and GAM (78.25) were noticed at 75 DAT.

4.3.6 Rate of photosynthesis ($\text{mmol CO}_2\text{.m.s}^{-1}$)

There was a significant difference between the different pan evaporation rates and tomato genotypes for the photosynthetic rate at 75 DAT (Table 18).

The rate of photosynthesis varied from 18.29 to 24.96 at control, 10.55 to 19.92 at 1.2 IW/CPE ratio and it was 6 to 15.48 at 0.4 IW/CPE ratio.

Among the genotypes EC 608348 had significantly more mean photosynthetic rate (18.26) and this was on par with EC 610661 (18.21) followed by EC 608271 (18.10), Megha (17.86). While, minimum photosynthetic rate was recorded in the genotype EC 608269 (12.15) irrespective of the irrigation levels.

As the stress increased from 1.2 IW/CPE ratio to 0.4 IW/CPE ratio, photosynthetic rate decreased to the extent of 50.34 per cent. Interaction between the different irrigation schedules of control, 1.2 and 0.4 IW/CPE ratio found non-significant. However, higher photosynthetic rate was observed in the genotype EC 677111 (24.96) at CONTROL and lower photosynthetic rate was exhibited by the genotype EC 686550 (6.00) at 0.4 IW/CPE ratio.

PCV was observed of 31.32 per cent at 75 DAT. GCV of 28.31 per cent, the broad sense heritability (81.72%), genetic advance (8.65) and GAM (52.73) were noticed at 75 DAT.

4.4 Biochemical parameters

4.4.1 Chlorophyll content (mg.g^{-1} of fresh weight)

4.4.1.1 Chlorophyll 'a' content (mg. g^{-1} of fresh weight)

Chlorophyll 'a' content between genotypes and interaction effects showed no significant difference but significance noticed among irrigation levels (Table 20).

Irrespective of the irrigation levels even though it was non-significant numerically genotypes EC 608368 (2.01) had higher chlorophyll 'a' content. The least content was observed in the genotype HUB T-07 (1.19). As the stress increased from control to 0.4 IW/CPE ratio chlorophyll 'a' content was increased significantly from

1.27 to 1.96. Chlorophyll 'a' content varied from 0.59 to 1.75, 1.03 to 2.38 and 1.45 to 2.63 at control, 1.2 and 0.4 IW/CPE ratio, respectively. There was no significant interaction effect among genotypes and different irrigation levels.

PCV was observed of 40.11 per cent at 75 DAT. GCV of 28.88 per cent, the broad sense heritability (49.71%), genetic advance (0.48) and GAM (41.08) were noticed at 75 DAT.

4.4.1.2 Chlorophyll 'b' content (mg.g⁻¹ of fresh weight)

Significant differences for chlorophyll 'b' content were observed among the genotypes, pan evaporation ratios and their interaction (Table 20).

Chlorophyll 'b' content ranged from 0.24 to 0.92, 0.39 to 1.49 and 0.57 to 1.57 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype EC 608368 (1.12) had significantly higher chlorophyll 'b' content and this was on par with EC 634394 (1.06), EC 608389 (1.04). The genotype HUB T-07 (0.53) showed significantly lower chlorophyll 'b' content. Among the three irrigation levels, maximum chlorophyll 'b' content was recorded in the 1.2 IW/CPE ratio (1.01) and compared to control. A significant interaction effect was observed between the genotypes and different pan evaporation ratios for chlorophyll 'b' content. Significantly maximum chlorophyll 'b' content was exhibited by the genotype EC 608368 (1.57) and this was on par with EC 610652 (1.50), EC 608389 (1.35) at 0.4 IW/CPE ratio and minimum was observed in the genotype HUB T-07 (0.24) at control.

PCV was observed of 58.11 per cent at 75 DAT. GCV of 42.52 per cent, the broad sense heritability (53.53%), genetic advance (0.36) and GAM (64.09) were noticed at 75 DAT.

4.4.1.3 Total chlorophyll content (mg.g⁻¹ of fresh weight)

There was no significant difference between the genotypes and their interaction effects except for among the irrigation levels. Among the three irrigation levels, there was 37.24 per cent total chlorophyll content was reduced when the stress was increased from control to 0.4 IW/CPE ratio. Interaction effects was observed non

Table 20. Chlorophyll a and Chlorophyll b contents (mg/g) of fresh weight as influenced by irrigation levels in tomato genotypes at 75 DAT

Sl. No.	Genotypes	Chlorophyll a				Chlorophyll b			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1.15	1.65	1.45	1.41	0.41	0.62	0.60	0.54
2	Arka Meghali	1.24	2.09	1.62	1.65	0.58	0.80	0.60	0.66
3	EC 608362	1.21	1.84	2.15	1.73	0.51	0.80	1.00	0.77
4	EC 608368	1.35	2.25	2.43	2.01	0.63	1.16	1.57	1.12
5	EC 608389	1.15	2.38	2.25	1.92	0.55	1.22	1.35	1.04
6	EC 610652	0.89	1.87	2.33	1.70	0.43	0.82	1.50	0.92
7	EC 634394	1.34	1.91	2.10	1.78	0.75	1.26	1.18	1.06
8	EC 638519	1.24	1.73	2.63	1.87	0.61	1.49	0.96	1.02
9	EC 610661	1.09	1.84	2.19	1.71	0.53	0.74	1.31	0.86
10	EC 632944	1.04	1.99	2.01	1.68	0.47	1.01	1.18	0.89
11	EC 630512	1.62	2.22	1.94	1.92	0.78	0.86	1.03	0.89
12	EC 631962	1.52	2.14	2.15	1.93	0.60	1.18	1.03	0.94
13	EC 654725	1.75	2.07	1.96	1.92	0.92	0.88	0.82	0.88
14	EC 654724	1.58	2.24	1.81	1.88	0.68	1.05	0.88	0.87
15	EC 654719	1.50	1.95	1.96	1.80	0.70	0.88	0.76	0.78
16	EC 638577	1.24	2.26	1.82	1.77	0.55	1.31	0.68	0.84
17	EC 608288	1.35	2.16	2.20	1.90	0.60	1.08	1.34	1.00
18	Kashi Hemanth	1.28	1.71	2.07	1.69	0.63	0.75	0.68	0.69
19	EC 686554	1.53	1.98	1.95	1.82	0.64	1.24	0.76	0.88
20	EC 686550	1.38	2.09	2.10	1.86	0.51	1.23	0.99	0.91
21	Kashi Anupam	1.49	1.92	1.95	1.79	0.65	0.88	0.87	0.80
22	EC 677111	1.33	2.22	1.86	1.80	0.68	1.38	0.82	0.96
23	SEL 12	1.13	2.30	1.66	1.70	0.58	1.44	0.81	0.94
24	EC 608348	1.32	2.26	2.08	1.89	0.69	1.08	0.93	0.90
25	EC 608320	1.41	2.09	2.20	1.90	0.63	0.86	1.28	0.92
26	EC 686548	1.31	2.07	2.12	1.83	0.60	1.04	0.99	0.88
27	Hissar Arun	1.32	2.09	1.98	1.80	0.58	1.06	0.95	0.87
28	EC 686542	1.37	2.12	1.92	1.80	0.71	1.20	0.92	0.94
29	EC 686543	1.49	2.01	1.62	1.71	0.55	0.85	0.66	0.69
30	EC 677044	1.41	1.98	1.88	1.76	0.61	0.89	0.74	0.75
31	EC 608269	1.51	2.04	2.04	1.86	0.65	1.22	1.09	0.99
32	Swarna Lalima	1.50	2.04	2.02	1.85	0.60	0.81	0.88	0.77
33	EC 686553	1.20	1.94	1.85	1.67	0.52	1.02	0.73	0.76
34	Pusa 120	1.32	1.14	2.03	1.50	0.53	0.57	0.84	0.65
35	Pusa Gaurav	1.07	1.96	1.71	1.58	0.36	0.96	0.83	0.72
36	HUB-18	1.09	2.04	1.84	1.66	0.49	0.79	0.57	0.62
37	Megha	1.37	2.12	2.30	1.93	0.59	1.05	1.21	0.95
38	Arka Abha	0.92	2.28	1.66	1.62	0.38	1.26	0.79	0.81
39	T-26	1.11	1.75	2.03	1.63	0.39	0.81	1.11	0.77
40	DMT-2	1.29	1.94	1.87	1.70	0.43	0.85	0.88	0.72
41	HUB T-10	0.97	2.11	1.68	1.59	0.41	1.19	0.75	0.78
42	HUB T-06	1.23	2.23	1.80	1.75	0.50	1.34	0.91	0.92
43	HUB T-11	0.96	2.31	1.80	1.69	0.32	1.07	0.71	0.70
44	HUB T-05	0.70	2.07	1.75	1.51	0.31	1.00	0.69	0.67
45	HUB T-07	0.59	1.10	1.88	1.19	0.24	0.39	0.95	0.53
46	HUB T-04	1.22	1.03	2.09	1.44	0.47	0.59	1.27	0.78
47	HUB T-09	1.20	1.91	1.81	1.64	0.42	1.09	0.91	0.81
48	HUB T-12	1.37	1.99	1.96	1.77	0.55	1.32	0.93	0.93
49	HUB T-08	1.49	2.20	1.85	1.85	0.65	1.19	0.86	0.90
50	HUB T-13	1.23	2.10	1.85	1.73	0.46	0.93	0.82	0.73
Mean		1.27	1.99	1.96	1.74	0.55	1.01	0.94	0.83
Range		0.59	1.03	1.45	1.19	0.24	0.39	0.57	0.53
		1.75	2.38	2.63	2.01	0.92	1.49	1.57	1.12
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.16		NS		0.91		0.26	
Irrigation		0.04		0.11		0.02		0.06	
G X I		0.28		NS		0.16		0.44	

DAT= Days after transplanting NS= Non significant control = Farmers practice

Table 21. Total Chlorophyll and carotenoid contents (mg/g of fresh weight) in leaves as influenced by irrigation levels in tomato genotypes at 75 DAT

Sl. No.	Genotypes	Total chlorophyll 75 DAT				Carotenoids at 75 DAT			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1.56	2.22	2.04	1.94	2.31	3.93	1.97	2.73
2	Arka Meghali	1.81	2.88	2.21	2.30	2.62	2.41	2.21	2.41
3	EC 608362	1.72	2.63	3.15	2.50	2.46	1.90	1.86	2.07
4	EC 608368	1.98	3.41	4.00	3.13	2.13	1.67	0.12	1.31
5	EC 608389	1.69	3.59	3.59	2.96	1.79	1.53	0.96	1.43
6	EC 610652	1.32	2.69	3.82	2.61	2.72	2.18	0.52	1.81
7	EC 634394	2.09	3.17	3.27	2.84	2.67	1.49	1.78	1.98
8	EC 638519	1.84	3.22	3.59	2.88	2.21	1.57	1.00	1.59
9	EC 610661	1.62	2.57	3.50	2.57	2.29	2.47	0.78	1.85
10	EC 632944	1.51	3.00	3.19	2.57	2.18	2.30	1.66	2.05
11	EC 630512	2.40	3.08	2.96	2.81	2.44	1.54	1.84	1.94
12	EC 631962	2.11	3.32	3.18	2.87	2.22	1.47	1.76	1.82
13	EC 654725	2.67	2.95	2.78	2.80	2.30	1.78	2.18	2.08
14	EC 654724	2.26	3.29	2.69	2.75	2.19	1.57	1.85	1.87
15	EC 654719	2.20	2.83	2.71	2.58	2.16	1.70	1.70	1.85
16	EC 638577	1.79	3.56	2.50	2.62	1.86	0.99	2.05	1.63
17	EC 608288	1.95	3.23	3.53	2.91	2.29	2.08	0.91	1.76
18	Kashi Hemanth	1.92	2.46	2.76	2.38	2.17	1.77	2.30	2.08
19	EC 686554	2.34	3.22	2.72	2.76	2.15	1.41	1.90	1.82
20	EC 686550	1.90	3.33	3.09	2.77	1.93	1.27	1.77	1.66
21	Kashi Anupam	2.14	2.80	2.82	2.58	1.91	2.33	1.96	2.07
22	EC 677111	2.01	3.59	2.68	2.76	1.87	1.26	1.85	1.66
23	SEL 12	1.70	3.74	2.47	2.64	1.99	0.63	1.85	1.49
24	EC 608348	2.01	3.35	3.02	2.79	1.92	1.71	1.95	1.86
25	EC 608320	2.04	2.95	3.48	2.82	1.80	1.99	1.00	1.60
26	EC 686548	1.92	3.11	3.11	2.71	1.67	1.62	1.66	1.65
27	Hissar Arun	1.91	3.15	2.93	2.66	1.96	1.60	1.79	1.78
28	EC 686542	2.08	3.32	2.83	2.74	1.73	1.78	2.19	1.90
29	EC 686543	1.87	2.86	2.28	2.34	1.85	2.63	2.05	2.18
30	EC 677044	1.99	2.87	2.61	2.49	1.52	2.31	1.96	1.93
31	EC 608269	2.16	3.26	3.13	2.85	2.16	1.80	1.80	1.92
32	Swarna Lalima	2.10	2.85	2.90	2.62	2.28	2.54	1.88	2.23
33	EC 686553	1.73	2.96	2.58	2.42	1.94	1.95	2.14	2.01
34	Pusa 120	1.85	3.00	2.87	2.57	2.12	0.83	1.92	1.62
35	Pusa Gaurav	1.44	2.91	2.54	2.30	1.76	1.69	1.95	1.80
36	HUB-18	1.58	2.83	2.41	2.28	1.49	2.36	2.23	2.03
37	Megha	1.96	3.17	3.51	2.88	1.81	1.74	1.06	1.54
38	Arka Abha	1.30	3.54	2.45	2.43	1.81	1.12	1.42	1.45
39	T-26	1.50	2.56	3.14	2.40	1.55	2.29	1.53	1.79
40	DMT-2	1.71	2.79	2.74	2.42	2.09	2.37	1.91	2.12
41	HUB T-10	1.39	3.30	2.42	2.37	1.95	1.08	1.57	1.53
42	HUB T-06	1.72	3.57	2.71	2.67	1.89	0.98	1.96	1.61
43	HUB T-11	1.28	3.38	2.51	2.39	1.76	1.67	1.96	1.80
44	HUB T-05	1.01	3.07	2.44	2.17	1.80	1.47	2.30	1.86
45	HUB T-07	0.84	2.46	2.83	2.04	1.47	1.14	2.07	1.56
46	HUB T-04	1.69	2.74	3.36	2.59	1.86	1.21	1.16	1.41
47	HUB T-09	1.61	3.00	2.73	2.45	1.77	1.34	2.14	1.75
48	HUB T-12	1.93	2.89	2.89	2.57	1.98	0.81	1.36	1.38
49	HUB T-08	2.15	3.39	2.71	2.75	2.13	1.34	1.64	1.70
50	HUB T-13	1.69	3.02	2.66	2.46	1.87	2.12	1.83	1.94
Mean		1.82	3.06	2.90	2.59	2.02	1.73	1.70	1.82
Range		0.84	2.22	2.04	1.94	1.47	0.63	0.12	1.31
		2.67	3.74	4.00	3.13	2.72	3.93	2.30	2.73
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.20		NS		0.25		0.17	
Irrigation		0.05		0.14		0.06		NS	
G X I		0.35		NS		0.43		NS	

DAT= Days after transplanting NS= Non significant control = Farmers practice

significance. However, maximum total chlorophyll content was observed in the genotype EC 608368 (4.00) at 0.4 IW/CPE ratio while, the genotype HUB T-07 at 0.4 IW/CPE ratio had lower total chlorophyll content (0.84) compared to other genotypes (Table 21).

PCV was observed of 43.56 per cent at 75 DAT. GCV of 32.61 per cent, the broad sense heritability (56.07%), genetic advance (0.87) and GAM (50.31) were noticed at 75 DAT.

4.4.1.4 Carotenoid content (mg. g-1 of fresh weight)

Carotenoid content varied significantly between the genotypes but there was no significant difference among the irrigation levels and their interaction effects. Irrespective of the irrigation levels, genotype EC 608271 (2.73) had significantly higher carotenoid content and the genotype EC 608368 (1.31) showed significantly lower carotenoid content (Table 21).

PCV was observed of 49.74 per cent at 75 DAT. GCV of 16.97 per cent, the broad sense heritability (11.64%), genetic advance (0.14) and GAM (11.92) were noticed at 75 DAT.

4.4.1.5 Relative water content (per cent) at 75 DAT

Relative water content (RWC) were significantly differed within genotypes, irrigation levels and their interaction at 75 DAT (Table 22).

During 75 DAT, irrespective of irrigation levels, significantly superior RWC was noticed in the genotype Arka Meghali (75.27) and was on par with Hisar Arun (72.61) and the least RWC was noticed in the genotype EC 686554 (37.82). Among the interaction, EC 634394 (104.78) showed significantly higher RWC which was on par with EC 608348 (98.82) at control and least RWC was noticed in the genotype HUB T-10 (21.75) at 0.4 IW/CPE ratio. Among the three irrigation levels, control had significantly highest RWC compared 0.4 IW/CPE ratio and it varied from 32.18 to 104.78 and 21.75 to 85.28, respectively. As the stress level increase from CONTROL to 0.4 IW/CPE ratio RWC decreased to the extent of 39.76 per cent at 75 DAT.

Table 22. Relative water content (RWC) (percent) as influenced by irrigation levels in tomato genotypes at 75 DAT

Sl. No.	Genotypes	RWC			
		Control	1.2	0.4	Mean
1	EC 608271	83.93	55.72	32.67	57.44
2	Arka Meghali	94.95	69.39	61.46	75.27
3	EC 608362	72.39	54.39	53.25	60.01
4	EC 608368	40.90	49.85	43.98	44.91
5	EC 608389	61.82	70.58	71.17	67.86
6	EC 610652	58.63	43.50	35.10	45.74
7	EC 634394	104.78	52.65	51.24	69.55
8	EC 638519	52.11	60.96	42.08	51.72
9	EC 610661	88.09	50.51	38.02	58.87
10	EC 632944	61.55	65.39	49.62	58.85
11	EC 630512	50.07	48.05	50.21	49.44
12	EC 631962	62.33	66.13	42.24	56.90
13	EC 654725	67.18	48.04	41.61	52.28
14	EC 654724	84.85	58.97	36.14	59.98
15	EC 654719	53.39	38.75	46.89	46.35
16	EC 638577	53.11	53.37	38.93	48.47
17	EC 608288	80.58	51.90	36.21	56.23
18	Kashi Hemanth	63.61	69.48	49.25	60.78
19	EC 686554	32.18	48.14	33.13	37.82
20	EC 686550	69.72	51.02	49.46	56.74
21	Kashi Anupam	81.29	51.97	36.16	56.47
22	EC 677111	62.06	37.74	42.93	47.58
23	SEL 12	77.78	42.14	34.28	51.40
24	EC 608348	98.82	32.85	70.46	67.38
25	EC 608320	82.65	34.81	43.51	53.65
26	EC 686548	70.57	60.32	26.64	52.51
27	Hissar Arun	86.57	45.97	85.28	72.61
28	EC 686542	75.04	42.31	26.33	47.89
29	EC 686543	63.36	44.51	43.28	50.38
30	EC 677044	57.05	35.02	33.95	42.00
31	EC 608269	77.05	54.10	27.36	52.83
32	Swarna Lalima	92.65	37.76	60.14	63.51
33	EC 686553	84.66	56.36	40.96	60.66
34	Pusa 120	86.57	34.98	43.00	54.85
35	Pusa Gaurav	74.17	80.47	38.78	64.47
36	HUB-18	62.88	53.96	61.27	59.37
37	Megha	95.40	41.97	61.84	66.41
38	Arka Abha	61.56	55.09	32.79	49.82
39	T-26	75.03	37.05	28.48	46.85
40	DMT-2	71.29	53.33	38.44	54.35
41	HUB T-10	75.03	51.45	21.75	49.41
42	HUB T-06	62.56	37.05	31.79	43.80
43	HUB T-11	57.91	45.64	44.57	49.37
44	HUB T-05	75.85	42.39	40.91	53.05
45	HUB T-07	94.82	62.42	32.72	63.32
46	HUB T-04	91.77	49.49	37.49	59.58
47	HUB T-09	70.83	53.92	37.83	54.19
48	HUB T-12	63.38	56.34	40.41	53.38
49	HUB T-08	86.48	63.66	43.54	64.56
50	HUB T-13	53.39	54.10	61.94	56.48
Mean		72.09	51.12	43.43	55.55
Range		32.18	32.85	21.75	37.82
		104.78	80.47	85.28	75.27
		S.Em ±		CD at 5%	
Genotypes		1.55		4.32	
Irrigation		0.38		1.06	
G X I		2.68		7.48	

DAT= Days after transplanting Control = Farmers practice

4.4.1.6 Proline ($\mu\text{g.g}^{-1}$ of fresh weight)

Proline content of leaf indicated significant difference only among the irrigation levels but there was no significance among genotypes and interaction effects. Proline content ranged from 98.18 to 487.29, 97.82 to 1537.60 and 98.55 to 1766.57 at control, 1.2 and 0.4 IW/CPE ratio. There was no significance among genotypes. However, EC 654719 observed higher proline content (1038.35) and least proline was found in the HUB- 18. Among the irrigation levels, as the stress increased from control to 0.4 IW/CPE ratio there was significant increase in proline content (58.09%). Interaction effect had no significance for proline content. However, maximum proline production was observed in EC610652 (1766.57) at 0.4 IW/CPE ratio and minimum was found in the Sel-12 (97.82) at 1.2 IW/CPE ratio (Table 23).

PCV was observed of 98.58 per cent at 75 DAT. GCV of 31.59 per cent, the broad sense heritability (10.27%), genetic advance (98.28) and GAM (20.85) were noticed at 75 DAT.

4.4.1.7 Total soluble solid ($^{\circ}\text{Brix}$)

Significant differences were observed for total soluble solid content among the genotypes, irrigation levels and their interaction (Table 23).

TSS content ranged from 3.82 to 9.05 at control. As the stress level increased it ranged from 4.49 to 9.55 at 1.2 IW/CPE ratio and 4.46 to 9.56 at 0.4 IW/CPE ratio. Irrespective of the irrigation levels, genotype EC 654725 had significantly higher TSS (9.22) and was least in genotype EC 610652 (4.39). Among irrigation levels, significantly maximum TSS recorded in the 0.4 IW/CPE ratio (7.30) when compared to 1.2 IW/CPE ratio. TSS was increased as stress level increased from control to 0.4 IW/CPE ratio, it increased to the extent of 18.13 per cent. There was significant difference in interaction effects. Among the genotypes more TSS was noticed in HUB T-11 (9.56) at 0.4 IW/CPE and this was on par with CE 686550 (9.45), EC 654725 (9.30) at 0.4 IW/CPE ratio and minimum was in HUB T-04 at control (3.82).

PCV was observed of 28.11 per cent and GCV of 27.82 per cent, the broad sense heritability (97.94%), genetic advance (2.61) and GAM (56.73) were noticed.

Table 23. Proline and TSS content as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Proline (µg/g of fresh leaf weight)				TSS (°Brix) (fruit)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	387.66	951.04	616.27	651.66	6.98	7.34	7.28	7.20
2	Arka Meghali	353.60	1316.05	805.03	824.90	6.25	6.29	6.61	6.39
3	EC 608362	253.97	864.45	222.45	446.96	7.11	7.42	7.37	7.30
4	EC 608368	413.38	1244.14	821.70	826.41	6.46	6.43	6.53	6.47
5	EC 608389	406.86	1093.78	652.86	717.84	6.60	6.82	7.04	6.82
6	EC 610652	224.63	455.41	1766.57	815.54	4.21	4.49	4.46	4.39
7	EC 634394	170.64	586.93	1491.95	749.84	6.27	6.79	6.73	6.60
8	EC 638519	395.27	885.82	202.53	494.54	5.53	5.33	5.34	5.40
9	EC 610661	239.48	324.62	664.10	409.40	5.35	6.32	6.32	6.00
10	EC 632944	421.35	1537.60	561.20	840.05	6.21	6.31	6.37	6.30
11	EC 630512	366.29	656.13	583.67	535.36	7.11	7.39	7.34	7.28
12	EC 631962	126.81	102.53	360.85	196.73	8.49	8.67	8.64	8.60
13	EC 654725	276.07	428.60	149.63	284.77	9.05	9.31	9.30	9.22
14	EC 654724	222.09	389.47	252.52	288.03	6.28	7.63	7.56	7.16
15	EC 654719	487.29	1348.48	1279.28	1038.35	6.12	6.50	6.29	6.30
16	EC 638577	326.43	482.58	256.87	355.30	6.06	7.63	7.47	7.05
17	EC 608288	312.30	677.50	458.31	482.70	7.03	7.37	7.36	7.25
18	Kashi Hemanth	339.11	902.85	385.49	542.48	6.80	8.43	8.27	7.83
19	EC 686554	333.32	626.42	101.08	353.60	6.95	8.20	8.00	7.71
20	EC 686550	279.33	592.36	559.75	477.15	6.32	9.55	9.45	8.44
21	Kashi Anupam	215.57	407.59	834.01	485.72	6.44	7.33	7.53	7.10
22	EC 677111	226.08	317.01	937.99	493.69	7.32	7.40	7.14	7.28
23	SEL 12	98.18	97.82	219.55	138.52	6.71	7.18	7.29	7.06
24	EC 608348	219.19	265.93	181.87	222.33	5.39	9.17	9.08	7.88
25	EC 608320	171.73	175.35	1007.92	451.67	4.91	8.82	8.57	7.43
26	EC 686548	251.07	426.79	552.51	410.12	5.22	8.94	9.03	7.73
27	Hissar Arun	267.38	443.46	414.83	375.22	7.02	6.35	6.61	6.66
28	EC 686542	254.33	605.77	1204.29	688.13	5.38	8.08	8.20	7.22
29	EC 686543	222.81	327.52	566.27	372.20	5.79	6.61	7.00	6.47
30	EC 677044	261.58	630.40	1268.41	720.13	6.28	5.34	5.68	5.76
31	EC 608269	438.75	1334.71	1257.54	1010.33	5.23	6.32	6.48	6.01
32	Swarna Lalima	251.07	340.92	244.19	278.73	5.08	5.25	5.30	5.21
33	EC 686553	263.75	398.53	744.53	468.94	6.06	6.57	6.37	6.33
34	Pusa 120	144.20	120.03	1243.78	502.67	5.37	5.52	5.75	5.55
35	Pusa Gaurav	202.89	289.84	685.83	392.85	6.09	5.29	5.67	5.69
36	HUB-18	124.32	138.88	148.66	137.29	6.83	7.29	7.29	7.14
37	Megha	180.79	212.31	502.87	298.66	7.67	8.65	8.82	8.38
38	Arka Abha	198.18	478.96	500.23	392.45	6.26	9.12	8.97	8.12
39	T-26	242.38	352.16	667.72	420.75	6.21	8.67	8.43	7.77
40	DMT-2	302.52	359.47	123.25	261.75	6.16	6.50	6.57	6.41
41	HUB T-10	264.84	459.76	649.97	458.19	4.60	9.25	9.23	7.69
42	HUB T-06	223.54	543.09	1095.23	620.62	4.51	5.26	5.17	4.98
43	HUB T-11	190.57	256.87	643.44	363.63	6.47	9.52	9.56	8.52
44	HUB T-05	117.02	414.11	98.55	209.89	6.35	8.67	8.77	7.93
45	HUB T-07	185.14	201.66	567.00	317.93	6.06	8.49	8.48	7.68
46	HUB T-04	318.46	204.37	274.62	265.82	3.82	6.61	6.46	5.63
47	HUB T-09	270.28	434.40	547.07	417.25	5.66	8.12	7.86	7.21
48	HUB T-12	182.85	268.83	643.44	365.04	6.23	6.31	6.69	6.41
49	HUB T-08	212.31	265.93	632.21	370.15	6.25	6.58	6.78	6.54
50	HUB T-13	278.25	208.47	607.58	364.76	6.34	6.48	6.59	6.47
Mean		261.38	528.42	623.72	471.17	6.18	7.28	7.30	6.92
Range		98.18	97.82	98.55	137.29	3.82	4.49	4.46	4.39
		487.29	1537.60	1766.57	1038.35	9.05	9.55	9.56	9.22
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		179.00		NS		0.08		0.21	
Irrigation		44.00		123.05		0.02		0.05	
G X I		311.13		NS		0.13		0.37	

DAT= Days after transplanting NS= Non significant control = Farmers practice

4.5 Yield and yield components

4.5.1 Yield (kg plant^{-1} and t ha^{-1})

Yield were significantly differed among the genotypes, irrigation levels and their interaction (Table 24).

Irrespective of the irrigation levels, significantly higher yield per plant was observed in the genotype HUB -18 ($1.61 \text{ kg plant}^{-1}$ and 59.78 t ha^{-1}) and least yield was recorded in the genotype EC 631962 ($0.20 \text{ kg plant}^{-1}$ and 7.39 t ha^{-1}). A significant interaction effect was noticed between the genotypes and irrigation levels wherein the highest yield was observed in the genotype HUB -18 ($2.07 \text{ kg plant}^{-1}$ and 76.55 t ha^{-1}) at control and the least yield was recorded in the genotype EC 631962 ($0.16 \text{ kg plant}^{-1}$ and 5.93 t ha^{-1}) at 0.4 IW/CPE ratio. As the stress increased from control to 0.4 IW/CPE ratio yield was reduced by 21.93 per cent. Among the irrigation levels, significantly highest yield was recorded control compared to 0.4 IW/CPE ratio and it varied from 0.25 to 2.07, 0.19 to 1.54 and 0.16 to 1.28 for yield per plant and for yield per hectare it varied from 9.25 to 76.55, 6.91 to 56.95 and 593. To 47.31, respectively.

PCV was observed of 30.50 per cent at yield per plant. GCV of 28.90 per cent, the broad sense heritability (89.76%), genetic advance (0.56) and GAM (56.40) were noticed at yield per plant.

4.5.2 Fruit parameters

4.5.2.1 Number of fruits per plant

In general, as the stress level increased there was significant decrease in number of fruits per plant was observed within the genotypes, different irrigation levels and their interaction (Table 25).

Irrespective of the irrigation levels, genotype EC 631962 had significantly greater number of fruits per plant (43.80). It was on par with EC 654725 (43.72) and minimum was observed in the genotype HUB T-08 (16.02). Among the three irrigation levels, control had significantly more number of fruits per plant compared to 0.4 IW/CPE ratio and it varied from 17.16 to 56.06, 17.33 to 42.50 and 12.67 to

Table 24. Yield per plant and yield per hectare as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Yield (kg/plant)				Yield (t/ha)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	1.03	0.92	0.88	0.94	37.97	34.03	32.47	34.82
2	Arka Meghali	1.31	1.23	1.15	1.23	48.62	45.48	42.56	45.55
3	EC 608362	1.09	1.04	1.01	1.05	40.32	38.70	37.33	38.78
4	EC 608368	1.18	0.97	0.95	1.03	43.71	36.00	35.06	38.26
5	EC 608389	0.86	0.89	0.88	0.88	31.80	33.08	32.52	32.47
6	EC 610652	1.49	1.29	1.17	1.31	55.07	47.62	43.18	48.62
7	EC 634394	1.21	1.23	1.09	1.18	44.78	45.44	40.38	43.53
8	EC 638519	1.31	1.18	1.04	1.17	48.34	43.54	38.62	43.50
9	EC 610661	1.01	0.93	0.89	0.94	37.35	34.32	32.89	34.85
10	EC 632944	1.59	1.35	1.24	1.39	58.96	49.93	45.80	51.56
11	EC 630512	0.93	0.88	0.77	0.86	34.62	32.73	28.58	31.98
12	EC 631962	0.25	0.19	0.16	0.20	9.32	6.91	5.93	7.39
13	EC 654725	0.25	0.22	0.20	0.22	9.25	8.28	7.36	8.30
14	EC 654724	1.06	1.01	0.94	1.01	39.31	37.55	34.97	37.28
15	EC 654719	1.06	1.07	1.02	1.05	39.25	39.48	37.75	38.83
16	EC 638577	0.73	0.84	0.76	0.77	27.01	31.01	28.04	28.69
17	EC 608288	1.18	1.07	0.97	1.07	43.71	39.70	35.77	39.73
18	Kashi Hemanth	1.18	1.12	1.03	1.11	43.74	41.48	38.07	41.10
19	EC 686554	1.10	0.83	0.82	0.92	40.82	30.67	30.52	34.00
20	EC 686550	1.36	1.01	0.95	1.11	50.39	37.47	35.16	41.01
21	Kashi Anupam	1.64	1.30	1.19	1.38	60.67	48.24	44.25	51.05
22	EC 677111	1.03	0.77	0.70	0.83	38.13	28.45	26.03	30.87
23	SEL 12	1.20	1.06	1.03	1.09	44.27	39.31	38.00	40.52
24	EC 608348	1.01	0.90	0.83	0.91	37.40	33.45	30.58	33.81
25	EC 608320	1.41	1.25	1.17	1.28	52.32	46.30	43.43	47.35
26	EC 686548	1.14	0.90	0.84	0.96	42.14	33.32	31.22	35.56
27	Hissar Arun	0.80	0.75	0.59	0.71	29.79	27.84	21.71	26.44
28	EC 686542	1.00	0.90	0.86	0.92	36.90	33.50	31.71	34.04
29	EC 686543	1.38	0.97	0.91	1.09	50.94	35.97	33.80	40.24
30	EC 677044	0.95	0.86	0.80	0.87	35.34	31.96	29.49	32.26
31	EC 608269	1.51	1.00	0.91	1.14	55.83	36.96	33.67	42.15
32	Swarna Lalima	1.73	1.36	1.15	1.41	64.01	50.19	42.56	52.25
33	EC 686553	0.78	0.69	0.62	0.70	28.82	25.56	22.99	25.79
34	Pusa 120	1.53	1.43	1.28	1.41	56.69	52.88	47.31	52.29
35	Pusa Gaurav	1.09	1.01	0.93	1.01	40.36	37.27	34.45	37.36
36	HUB-18	2.07	1.54	1.24	1.61	76.55	56.95	45.84	59.78
37	Megha	1.30	1.16	1.01	1.16	48.30	42.86	37.27	42.81
38	Arka Abha	0.99	0.96	0.94	0.96	36.65	35.51	34.71	35.62
39	T-26	1.34	1.04	0.93	1.10	49.50	38.51	34.43	40.81
40	DMT-2	1.45	1.21	1.08	1.25	53.67	44.85	40.17	46.23
41	HUB T-10	0.85	0.84	0.73	0.81	31.53	31.15	26.86	29.85
42	HUB T-06	1.31	0.98	0.68	0.99	48.68	36.45	25.14	36.76
43	HUB T-11	1.25	1.20	0.96	1.14	46.30	44.50	35.49	42.10
44	HUB T-05	1.39	1.30	1.06	1.25	51.63	48.19	39.08	46.30
45	HUB T-07	0.87	0.80	0.61	0.76	32.11	29.55	22.64	28.10
46	HUB T-04	1.13	0.94	0.80	0.96	41.90	34.65	29.75	35.43
47	HUB T-09	1.04	0.89	0.74	0.89	38.46	32.79	27.55	32.93
48	HUB T-12	1.49	1.19	0.97	1.22	55.36	44.23	36.01	45.20
49	HUB T-08	0.66	0.67	0.56	0.63	24.32	24.88	20.69	23.30
50	HUB T-13	0.60	0.57	0.48	0.55	22.10	20.93	17.71	20.25
Mean		1.14	0.99	0.89	1.01	42.30	36.81	32.95	37.35
Range		0.25	0.19	0.16	0.20	9.25	6.91	5.93	7.39
		2.07	1.54	1.28	1.61	76.55	56.95	47.31	59.78
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.04		0.11		1.49		4.16	
Irrigation		0.01		0.03		0.36		1.02	
G X I		0.07		0.19		2.58		7.20	

DAT= Days after transplanting control = Farmers practice

36.83 at control, 1.2 and 0.4 IW/CPE ratio respectively. Among the interaction, genotypes EC 631962 (56.06) had significantly maximum number of fruits per plant under the control and minimum number of fruits per plant was observed in the genotype HUB T-08 (12.67) at 0.4 IW/CPE ratio.

PCV was observed of 27.16 per cent at yield per plant. GCV of 26.25 per cent, the broad sense heritability (93.42%), genetic advance (13.06) and GAM (52.28) were noticed.

4.5.2.2 Fruit weight (g)

In general, as the stress level increased there was significant decrease in fruit weight was observed within the genotypes, different irrigation levels and their interaction (Table 26).

Irrespective of the irrigation levels, genotype HUB -18 had significantly greater fruit weight (69.70) it was on par with Megha (66.40), Pusa 120 (64.42) and minimum was observed in the genotype EC 631962 (12.07). Among the three irrigation levels, 1.2 IW/CPE ratio had significantly more fruit weight compared to 0.4 IW/CPE ratio and it varied from 12.12 to 74.75 and 11.84 to 68.92, respectively. Among the interaction effects fruit weight was found non significant. However, genotypes HUB T-12 (74.75) had significantly maximum fruit weight at 1.2 IW/CPE ratio and minimum fruit weight was observed in the genotype EC 631962 (11.84) at 0.4 IW/CPE ratio.

PCV was observed of 25.35 per cent at yield per plant. GCV of 22.89 per cent, the broad sense heritability (81.55%), genetic advance (21.16) and GAM (42.59) were noticed.

4.5.2.2 Polar diameter of fruit (mm)

Polar diameter of fruit had significant difference among the genotypes, irrigation levels and for interaction effect (Table 26).

Among the different genotypes, EC 610652 had significantly maximum polar diameter (41.84) and significantly minimum polar diameter was observed in the genotype EC 654725 (11.20). Among Irrigation schedules significantly higher polar

Table 25. Number of fruits per plant and average fruit weight as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	No. of fruits per plant				Average fruit weight (g)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	26.82	22.67	20.17	23.22	47.22	49.63	48.18	48.34
2	Arka Meghali	27.06	23.67	22.77	24.50	58.89	60.20	54.59	57.89
3	EC 608362	28.49	28.16	23.50	26.72	45.13	48.68	46.85	46.89
4	EC 608368	20.17	21.24	20.00	20.47	58.31	61.88	54.68	58.29
5	EC 608389	17.67	23.39	19.00	20.02	48.39	57.59	49.91	51.96
6	EC 610652	23.62	27.44	22.00	24.36	62.70	66.28	56.31	61.76
7	EC 634394	23.67	25.50	24.17	24.44	57.64	61.85	48.40	55.96
8	EC 638519	27.96	28.17	22.33	26.15	50.42	57.40	49.65	52.49
9	EC 610661	28.57	29.11	26.33	28.01	41.87	42.56	39.00	41.14
10	EC 632944	29.84	24.94	24.17	26.32	62.43	61.37	57.71	60.50
11	EC 630512	20.81	21.33	15.00	19.05	50.64	60.56	49.46	53.55
12	EC 631962	56.06	40.67	34.66	43.80	12.25	12.12	11.84	12.07
13	EC 654725	51.83	42.50	36.83	43.72	12.39	12.85	12.80	12.68
14	EC 654724	21.72	21.83	15.50	19.68	55.05	67.30	57.08	59.81
15	EC 654719	22.17	20.50	18.33	20.33	57.91	62.63	57.47	59.34
16	EC 638577	18.85	25.17	20.74	21.58	42.69	47.43	40.80	43.64
17	EC 608288	25.56	25.67	27.83	26.35	51.26	47.57	46.27	48.37
18	Kashi Hemanth	25.17	24.61	21.67	23.81	56.32	55.69	50.54	54.18
19	EC 686554	32.83	26.00	23.33	27.39	39.70	42.77	40.93	41.13
20	EC 686550	37.39	29.50	24.00	30.30	43.11	44.84	44.98	44.31
21	Kashi Anupam	27.39	25.00	22.17	24.85	64.35	67.78	56.61	62.91
22	EC 677111	40.06	30.50	22.83	31.13	32.42	36.83	34.87	34.71
23	SEL 12	33.39	29.17	25.16	29.24	43.03	47.56	44.90	45.16
24	EC 608348	27.93	23.50	20.50	23.98	46.90	47.22	43.55	45.89
25	EC 608320	32.57	26.83	24.83	28.08	52.74	55.54	51.83	53.37
26	EC 686548	30.66	24.50	22.50	25.88	44.99	47.02	42.19	44.73
27	Hissar Arun	24.33	24.33	17.16	21.94	38.93	48.61	33.52	40.35
28	EC 686542	21.89	19.50	21.16	20.85	54.24	50.46	50.35	51.68
29	EC 686543	38.90	29.83	22.50	30.41	40.71	46.14	44.13	43.66
30	EC 677044	31.39	27.33	20.83	26.52	38.93	42.51	41.19	40.88
31	EC 608269	47.33	35.17	28.33	36.94	37.39	40.83	36.63	38.28
32	Swarna Lalima	33.72	29.50	25.00	29.41	56.16	58.82	50.56	55.18
33	EC 686553	31.17	29.50	26.66	29.11	31.76	34.49	28.28	31.51
34	Pusa 120	25.68	25.33	23.33	24.78	65.34	67.52	60.40	64.42
35	Pusa Gaurav	24.61	23.33	22.17	23.37	52.01	50.93	49.04	50.66
36	HUB-18	34.78	24.17	17.50	25.48	69.62	70.55	68.92	69.70
37	Megha	22.44	21.17	14.17	19.26	62.73	71.63	64.82	66.40
38	Arka Abha	20.79	24.17	20.00	21.65	50.74	56.22	49.83	52.27
39	T-26	27.39	21.50	19.33	22.74	58.25	58.84	50.93	56.01
40	DMT-2	31.12	26.83	23.00	26.99	53.23	59.75	48.91	53.96
41	HUB T-10	26.67	26.50	19.33	24.17	38.46	46.91	38.40	41.26
42	HUB T-06	26.12	23.00	13.67	20.93	54.00	64.54	42.38	53.64
43	HUB T-11	23.05	26.67	20.33	23.35	57.06	63.00	48.55	56.20
44	HUB T-05	22.43	25.83	23.00	23.75	65.55	65.63	49.99	60.39
45	HUB T-07	17.73	19.00	14.33	17.02	51.34	60.00	44.27	51.87
46	HUB T-04	26.50	20.83	17.50	21.61	52.41	55.01	48.83	52.08
47	HUB T-09	21.79	21.33	17.83	20.32	52.23	59.07	43.20	51.50
48	HUB T-12	25.00	25.17	17.00	22.39	58.98	74.75	54.57	62.77
49	HUB T-08	18.05	17.33	12.67	16.02	44.49	60.10	39.72	48.10
50	HUB T-13	17.16	18.50	14.50	16.72	40.24	50.04	33.41	41.23
Mean		27.97	25.55	21.43	24.98	49.27	53.59	46.24	49.70
Range		17.16	17.33	12.67	16.02	12.25	12.12	11.84	12.07
		56.06	42.50	36.83	43.80	69.62	74.75	68.92	69.70
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.71		1.99		2.21		6.17	
Irrigation		0.17		0.49		0.54		1.51	
G X I		1.23		3.44		3.83		NS	

DAT= Days after transplanting NS= Non significant control = Farmers practice (FP)

diameter was observed in control, compared to 1.2 and 0.4 IW/CPE ratio and it varied from 14.00 to 48.83, 10.22 to 42.94 and 9.00 to 40.29, respectively. Interaction effect had significance difference among the genotypes and irrigation levels. Significantly highest polar diameter was observed in the genotype EC 610652 (48.83) at control and minimum was observed in the genotype EC 631962 (9.00) at 0.4 IW/CPE ratio.

PCV was observed of 38.52 per cent at yield per plant. GCV of 37.89 per cent, the broad sense heritability (96.81%), genetic advance (15.54) and GAM (76.81) were noticed.

4.5.2.3 Equatorial diameter of fruit (mm)

In general, equatorial diameter of fruit showed significant difference among genotypes, pan evaporation ratios and their interactions (Table 26).

Irrespective of the irrigation levels, among the genotype HUB T-07 showed highest equatorial diameter of fruit (39.95) and Genotype EC 654725 recorded least equatorial diameter of fruit (11.32). Among the pan evaporation ratios, significantly maximum equatorial diameter was observed in control (32.74) and minimum was observed at 0.4 IW/CPE ratio (26.70). Interaction had significant difference, wherein the genotype HUB T-07 had significantly higher equatorial diameter of the fruit (45.33) and this was on par with DMT -2 (45.00), EC 608368 (42.67) under control condition and minimum was observed in the genotype EC 654725 (10.08) at 0.4 IW/CPE ratio.

PCV was observed of 36.47 per cent at yield per plant. GCV of 35.55 per cent, the broad sense heritability (95.00%), genetic advance (13.88) and GAM (71.38) were noticed.

4.5.2.4. Pericarp thickness (mm)

Pericarp thickness had significant difference among the genotypes, irrigation levels and their interaction (Table 27).

Among different the genotype Pusa 120 had significantly maximum pericarp thickness (5.84) and while minimum pericarp thickness was observed in the genotype EC 631962 (1.12). Among the three irrigation levels, significantly higher pericarp

Table 26. Fruit dimension as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Polar Diameter (mm)				Equatorial Diameter (mm)			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	29.00	22.74	23.26	25.00	27.00	24.94	25.43	25.79
2	Arka Meghali	38.17	34.96	32.28	35.14	37.33	30.61	32.11	33.35
3	EC 608362	30.00	27.29	27.78	28.36	21.50	26.55	23.29	23.78
4	EC 608368	44.33	31.24	31.94	35.84	42.67	32.77	32.49	35.98
5	EC 608389	32.83	31.96	27.13	30.64	36.50	34.94	30.56	34.00
6	EC 610652	48.83	39.79	36.91	41.84	40.17	33.11	32.95	35.41
7	EC 634394	38.67	32.68	31.76	34.37	35.50	29.11	25.58	30.06
8	EC 638519	35.67	25.00	23.94	28.20	28.83	28.11	24.24	27.06
9	EC 610661	26.33	27.23	26.99	26.85	29.83	26.44	25.61	27.29
10	EC 632944	39.33	31.63	32.28	34.41	30.00	29.67	28.08	29.25
11	EC 630512	35.83	30.07	24.61	30.17	34.67	32.28	27.79	31.58
12	EC 631962	14.00	10.66	9.00	11.22	15.83	12.11	10.91	12.95
13	EC 654725	14.33	10.22	9.05	11.20	13.67	10.22	10.08	11.32
14	EC 654724	41.83	33.11	30.41	35.12	37.00	32.77	26.73	32.17
15	EC 654719	38.17	27.79	28.24	31.40	37.83	29.39	26.62	31.28
16	EC 638577	30.67	30.33	33.28	31.43	37.67	30.28	27.79	31.91
17	EC 608288	36.17	23.18	24.23	27.86	34.50	20.78	21.78	25.69
18	Kashi Hemanth	36.83	30.11	27.41	31.45	34.33	28.11	26.91	29.78
19	EC 686554	24.50	17.83	19.96	20.76	22.50	16.27	17.83	18.87
20	EC 686550	34.00	29.08	25.59	29.56	26.33	27.67	26.91	26.97
21	Kashi Anupam	43.67	38.29	37.78	39.91	34.33	23.77	27.93	28.68
22	EC 677111	21.17	16.07	15.62	17.62	19.67	18.72	13.79	17.39
23	SEL 12	25.67	28.61	31.41	28.56	25.83	22.83	22.24	23.64
24	EC 608348	31.17	22.13	20.96	24.75	36.00	17.39	17.79	23.73
25	EC 608320	35.50	39.50	40.29	38.43	37.67	38.44	34.46	36.86
26	EC 686548	31.50	29.28	28.78	29.85	28.33	22.61	22.12	24.35
27	Hissar Arun	25.50	27.74	31.07	28.10	23.67	24.77	24.59	24.34
28	EC 686542	38.17	26.00	25.06	29.74	36.67	27.11	26.89	30.22
29	EC 686543	31.17	29.22	26.58	28.99	33.33	33.11	25.29	30.58
30	EC 677044	25.33	22.00	19.91	22.41	33.00	25.44	25.11	27.85
31	EC 608269	25.17	34.50	33.63	31.10	30.83	36.46	34.94	34.08
32	Swarna Lalima	39.50	31.11	28.58	33.06	39.33	30.17	29.89	33.13
33	EC 686553	21.50	16.11	16.75	18.12	23.83	24.78	18.73	22.45
34	Pusa 120	42.83	34.78	32.93	36.85	38.33	34.55	34.73	35.87
35	Pusa Gaurav	34.33	28.83	23.59	28.92	30.00	23.61	25.46	26.35
36	HUB-18	43.67	22.78	20.09	28.84	30.83	28.23	23.07	27.38
37	Megha	42.83	40.78	36.09	39.90	33.67	27.07	28.73	29.82
38	Arka Abha	36.67	36.79	35.28	36.25	36.33	22.58	23.76	27.56
39	T-26	37.17	30.94	33.29	33.80	40.33	31.79	24.89	32.34
40	DMT-2	36.67	32.29	26.28	31.75	45.00	35.13	33.94	38.02
41	HUB T-10	25.00	31.55	32.09	29.55	26.00	40.94	37.58	34.84
42	HUB T-06	37.83	29.94	30.74	32.84	32.33	32.89	33.79	33.01
43	HUB T-11	40.83	28.66	25.59	31.70	38.83	23.28	24.38	28.83
44	HUB T-05	45.33	32.77	32.24	36.78	42.00	32.11	34.26	36.12
45	HUB T-07	36.17	42.94	39.44	39.52	45.33	38.28	36.23	39.95
46	HUB T-04	34.83	41.44	39.73	38.67	35.83	30.18	33.41	33.14
47	HUB T-09	35.17	34.44	32.40	34.00	40.83	32.11	32.58	35.17
48	HUB T-12	42.00	36.61	32.08	36.90	34.33	32.95	32.61	33.30
49	HUB T-08	27.17	22.44	20.75	23.45	28.67	25.76	22.97	25.80
50	HUB T-13	30.17	25.83	23.63	26.54	32.00	30.45	25.28	29.24
Mean		33.86	29.23	27.97	30.35	32.74	28.07	26.70	29.17
Range		14.00	10.22	9.00	11.20	13.67	10.22	10.08	11.32
		48.83	42.94	40.29	41.84	45.33	40.94	37.58	39.95
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.57		1.59		0.65		1.81	
Irrigation		0.14		0.39		0.16		0.44	
G X I		0.98		2.75		1.12		3.14	

DAT= Days after transplanting control = Farmers practice

Table 27. Pericarp thickness (mm) and number of locules per fruit of tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Pericarp thickness (mm)				No. of locules/ fruit			
		IW/CPE ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	EC 608271	2.83	2.55	2.65	2.68	3.00	2.56	2.91	2.82
2	Arka Meghali	2.92	2.56	2.38	2.62	2.67	2.34	2.27	2.43
3	EC 608362	2.72	2.44	2.60	2.59	2.83	2.39	2.24	2.49
4	EC 608368	2.13	2.18	2.11	2.14	3.17	2.51	2.60	2.76
5	EC 608389	2.35	2.18	2.26	2.26	3.00	2.73	2.29	2.67
6	EC 610652	4.30	3.04	3.24	3.53	3.17	2.23	2.29	2.56
7	EC 634394	4.01	3.32	3.44	3.59	3.17	3.12	2.96	3.08
8	EC 638519	2.65	2.55	2.52	2.57	2.83	2.77	2.29	2.63
9	EC 610661	3.66	3.10	3.33	3.36	2.00	2.50	2.34	2.28
10	EC 632944	4.20	3.84	4.01	4.01	2.67	3.08	3.13	2.96
11	EC 630512	4.03	3.70	3.78	3.84	2.67	2.56	2.65	2.63
12	EC 631962	1.31	1.03	1.03	1.12	2.17	2.06	1.38	1.87
13	EC 654725	1.41	1.20	1.20	1.27	2.17	2.21	2.00	2.13
14	EC 654724	3.94	3.37	3.32	3.54	3.17	2.49	2.55	2.73
15	EC 654719	4.81	4.53	4.39	4.58	3.17	3.06	3.08	3.10
16	EC 638577	3.81	2.32	2.32	2.82	3.67	2.11	2.08	2.62
17	EC 608288	4.31	2.35	2.31	2.99	2.83	2.39	2.28	2.50
18	Kashi Hemanth	4.35	3.53	3.36	3.75	2.17	3.13	2.98	2.76
19	EC 686554	3.86	2.21	2.31	2.79	2.83	2.23	2.34	2.47
20	EC 686550	4.71	3.12	3.13	3.65	2.50	2.56	2.45	2.50
21	Kashi Anupam	4.11	3.39	3.48	3.66	3.17	3.24	3.27	3.23
22	EC 677111	1.50	1.48	1.37	1.45	2.00	2.08	2.06	2.04
23	SEL 12	2.60	3.29	3.37	3.09	2.50	2.24	2.33	2.36
24	EC 608348	4.55	1.89	1.59	2.67	3.00	2.34	2.33	2.56
25	EC 608320	4.77	3.80	3.70	4.09	3.17	3.39	3.50	3.35
26	EC 686548	3.39	2.30	2.19	2.62	2.67	2.49	2.29	2.48
27	Hissar Arun	2.55	4.37	4.42	3.78	2.83	2.24	2.29	2.46
28	EC 686542	4.28	3.50	3.40	3.73	2.83	2.29	2.24	2.46
29	EC 686543	3.47	3.06	2.55	3.02	3.17	2.50	2.73	2.80
30	EC 677044	2.39	2.26	2.28	2.31	3.00	2.39	2.29	2.56
31	EC 608269	2.52	4.63	4.68	3.94	2.50	3.24	3.24	3.00
32	Swarna Lalima	4.56	4.04	3.97	4.19	3.50	3.24	3.28	3.34
33	EC 686553	1.80	1.53	1.44	1.59	2.50	3.41	2.56	2.82
34	Pusa 120	6.36	5.61	5.56	5.84	2.83	3.24	3.27	3.12
35	Pusa Gaurav	4.67	4.20	4.18	4.35	3.17	2.55	2.56	2.76
36	HUB-18	5.48	3.31	3.56	4.12	2.83	2.50	2.29	2.54
37	Megha	5.22	5.22	5.03	5.16	3.17	3.24	3.23	3.21
38	Arka Abha	3.09	3.45	3.57	3.37	3.83	3.24	3.29	3.46
39	T-26	4.39	3.74	3.64	3.92	3.50	3.44	3.55	3.50
40	DMT-2	4.25	4.08	4.06	4.13	3.17	2.39	2.34	2.63
41	HUB T-10	3.16	3.66	3.29	3.37	2.83	2.08	2.08	2.33
42	HUB T-06	1.36	3.41	3.36	2.71	2.83	3.24	2.29	2.79
43	HUB T-11	5.82	3.29	3.31	4.14	3.17	3.06	3.08	3.10
44	HUB T-05	5.48	3.13	3.13	3.91	2.83	3.91	3.91	3.55
45	HUB T-07	4.71	4.11	3.86	4.23	4.17	2.33	2.78	3.09
46	HUB T-04	3.72	5.12	4.62	4.48	3.00	3.11	3.82	3.31
47	HUB T-09	4.85	4.19	4.03	4.36	3.67	3.17	3.08	3.30
48	HUB T-12	1.93	2.43	2.38	2.25	2.67	3.11	2.92	2.90
49	HUB T-08	2.37	2.47	2.22	2.35	3.00	2.24	2.49	2.58
50	HUB T-13	3.09	2.59	2.38	2.69	2.50	2.22	2.34	2.35
Mean		3.61	3.17	3.13	3.30	2.92	2.70	2.66	2.76
		1.31	1.03	1.03	1.12	2.00	2.06	1.38	1.87
Range		6.36	5.61	5.56	5.84	4.17	3.91	3.91	3.55
		S.Em ±		CD at 5%		S.Em ±		CD at 5%	
Genotypes		0.09		0.25		0.07		0.19	
Irrigation		0.02		0.06		0.02		0.05	
G X I		0.15		0.43		0.12		0.34	

DAT= Days after transplanting control = Farmers practice

thickness was observed at under control condition (3.61) as against the least at 1.2 and 0.4 IW/CPE ratio (3.12). Ranged between 1.31 to 6.36, 1.03 to 5.61 and 1.03 to 5.56, respectively. Interaction between the genotypes and irrigation levels was significant. Significantly highest pericarp thickness was observed in the genotype Pusa 120 (6.36) under control and the least was observed in the genotype EC 631962 (1.03) both at 1.2 and 0.4 IW/CPE ratio.

PCV was observed of 50.81 per cent at yield per plant. GCV of 49.84 per cent, the broad sense heritability (96.24%), genetic advance (2.21) and GAM (100.74) were noticed.

4.5.2.5 Number of locules per fruit

Significant differences among the genotypes, pan evaporation ratios and their interaction was observed for number of locules per fruit (Table 27).

Among the genotypes, HUB T-05 had significantly higher number of locules per fruit (3.55) it was on par with T-26 (3.50) and the lower number (1.87) was found in the genotype EC 631962. Significant difference was observed for the interaction effect. Genotype HUB T-07 had significantly higher locules per fruit (4.17) under control condition and it was on par with HUB T-05 (3.91) at both 1.2 and 0.4 IW/CPE ratio and significantly minimum was found in EC 631962 (1.38) at 0.4 IW/CPE ratio. As the stress level increased, number of locules were reduced.

PCV was observed of 27.33 per cent at yield per plant. GCV of 25.72 per cent, the broad sense heritability (88.62%), genetic advance (0.91) and GAM (49.89) were noticed.

4.6 Character association and Path-coefficient analysis

Selection for specific character is known to result in correlated response in certain other characters. Generally, plant breeders make selection for one or two attributes at a time. Then it becomes important to know the effect on other characters. Improvement on yield, the most important target character in many crops, it can be achieved by direct selection through other easily observable characters. But, this needs a good understanding of association of different traits with yield and their possible associations among themselves.

Table 28. Per cent reduction of yield in 0.4 IW/CPE ratio over 1.2 IW/CPE ratio

Sl. No.	Genotypes	Yield per plant (kg/plant)		Percent reduction in yield
		IW/CPE ratio		
		1.2	0.4	
1	EC 608271	0.92	0.88	4.58
2	Arka Meghali	1.23	1.15	6.41
3	EC 608362	1.04	1.01	3.54
4	EC 608368	0.97	0.95	2.62
5	EC 608389	0.89	0.88	1.68
6	EC 610652	1.29	1.17	9.32
7	EC 634394	1.23	1.09	11.14
8	EC 638519	1.18	1.04	11.31
9	EC 610661	0.93	0.89	4.15
10	EC 632944	1.35	1.24	8.28
11	EC 630512	0.88	0.77	12.67
12	EC 631962	0.19	0.16	14.20
13	EC 654725	0.22	0.20	11.15
14	EC 654724	1.01	0.94	6.86
15	EC 654719	1.07	1.02	4.40
16	EC 638577	0.84	0.76	9.56
17	EC 608288	1.07	0.97	9.88
18	Kashi Hemanth	1.12	1.03	8.23
19	EC 686554	0.83	0.82	0.49
20	EC 686550	1.01	0.95	6.18
21	Kashi Anupam	1.30	1.19	8.27
22	EC 677111	0.77	0.70	8.52
23	SEL 12	1.06	1.03	3.33
24	EC 608348	0.90	0.83	8.58
25	EC 608320	1.25	1.17	6.19
26	EC 686548	0.90	0.84	6.33
27	Hissar Arun	0.75	0.59	22.01
28	EC 686542	0.90	0.86	5.36
29	EC 686543	0.97	0.91	6.03
30	EC 677044	0.86	0.80	7.71
31	EC 608269	1.00	0.91	8.89
32	Swarna Lalima	1.36	1.15	15.20
33	EC 686553	0.69	0.62	10.08
34	Pusa 120	1.43	1.28	10.54
35	Pusa Gaurav	1.01	0.93	7.56
36	HUB-18	1.54	1.24	19.52
37	Megha	1.16	1.01	13.04
38	Arka Abha	0.96	0.94	2.23
39	T-26	1.04	0.93	10.60
40	DMT-2	1.21	1.08	10.42
41	HUB T-10	0.84	0.73	13.78
42	HUB T-06	0.98	0.68	31.03
43	HUB T-11	1.20	0.96	20.25
44	HUB T-05	1.30	1.06	18.90
45	HUB T-07	0.80	0.61	23.37
46	HUB T-04	0.94	0.80	14.16
47	HUB T-09	0.89	0.74	16.00
48	HUB T-12	1.19	0.97	18.58
49	HUB T-08	0.67	0.56	16.85
50	HUB T-13	0.57	0.48	15.41
Mean		0.99	0.89	10.51
Range		0.19	0.16	0.49
		1.54	1.28	31.03

Table 29. Estimates of components of variance, heritability and genetic advance for growth and earliness parameters in Tomato genotypes

Sl. No.	Character	GV	PV	GCV (%)	PCV (%)	h^2	GA	GAM
Morphological charecters								
1	Plant height 45 DAT (cm)	71.50	99.94	24.97	29.52	71.54	14.73	43.50
2	Plant height 90 DAT (cm)	177.72	258.71	30.89	37.27	68.69	22.76	52.74
3	Plant spread from north to south 45 DAT (cm)	53.20	94.78	24.15	32.24	56.14	11.25	37.25
4	Plant spread from north to south 90 DAT (cm)	114.74	178.73	27.57	34.41	64.19	17.68	45.50
5	Plant spread from east to west 45 DAT (cm)	57.95	86.68	27.61	33.77	66.86	12.82	46.50
6	Plant spread from east to west 90 DAT (cm)	115.66	152.81	30.16	34.66	75.69	19.27	54.05
7	Stem girth (cm) (45 DAT)	0.26	0.72	10.88	17.97	36.68	0.63	13.57
8	Stem girth (cm) (90 DAT)	2.10	2.84	17.58	20.42	74.13	2.57	31.18
Growth parameters								
1	Leaf area 45 DAT (cm ²)	66256.44	72694.6	48.89	51.21	91.14	506.22	96.15
2	Leaf area 90 DAT (cm ²)	249629.49	265477.2	48.32	49.83	94.03	998.04	96.51
3	Leaf area ratio 45 DAT (cm ² g ⁻¹)	48.59	68.08	24.90	29.47	71.38	12.83	12.13
4	Leaf area ratio 90 DAT	79.18	98.11	27.67	30.81	80.71	16.46	51.22
5	Leaf area index 45 DAT (cm ²)	0.0090	0.0099	32.59	34.14	91.14	0.18	64.10
6	Leaf area index 90 DAT (cm ²)	0.034	0.036	35.21	33.22	94.03	0.36	64.34
7	Specific leaf weight 45 DAT (g.cm ⁻²)	0.11	0.32	23.3	38.73	36.30	0.42	28.95
8	Specific leaf weight 90 DAT (g.cm ⁻²)	0.12	0.30	28.56	44.76	40.69	0.46	37.53
9	Specific leaf area 45 DAT (cm ² g ⁻¹)	245.10	424.91	20.87	27.49	57.68	24.49	32.66
10	Specific leaf area 90 DAT (cm ² g ⁻¹)	477.82	1145.00	23.32	36.11	41.73	29.08	31.03
11	Biomass 45 DAT (g)	71.99	83.50	44.36	47.78	86.22	16.22	84.85
12	Biomass 90 DAT (g)	352.66	375.81	55.34	57.14	93.84	37.47	110.45
13	Absolute growth rate 45-90 DAT (g.plant ⁻¹ day ⁻¹)	0.079	0.091	57.22	61.36	86.95	0.54	109.91
14	Crop growth rate 45-90 DAT (g.m ⁻² day ⁻¹)	0.14	0.16	57.22	61.36	86.95	0.72	109.91
15	Relative growth rate 45-90 DAT (g.g ⁻¹ day ⁻¹)	3.94	5.16	38.03	43.49	76.43	3.57	68.48
16	Net assimilation rate 45-90 DAT (g.cm ⁻² day ⁻¹)	0.0071	0.0097	44.70	52.33	72.98	1.48	78.67

Contd.....

Sl. No.	Character	GV	PV	GCV (%)	PCV (%)	h^2	GA	GAM
Biophysical parameters								
1	Photo synthetically active radiation (lux)	113771.3	118455.8	51.88	52.94	96.04	680.96	104.75
2	Leaf temperature ($^{\circ}\text{C}$)	3.88	16.86	9.15	19.07	23.02	1.94	9.04
3	Intercellular CO_2 level (ppm)	515.29	784.69	15.46	19.07	65.66	37.89	25.80
4	Transpiration rate ($\text{mmol. H}_2\text{O.m}^{-2}.\text{S}^{-1}$)	3.52	5.02	33.56	40.09	70.08	3.23	57.88
5	Stomatal conductance ($\text{mmol.m}^{-2}.\text{S}^{-1}$)	0.039	0.061	47.29	58.89	64.50	0.32	78.25
6	Photo synthetic rate ($\text{mmol. CO}_2.\text{m}^{-2}.\text{S}^{-1}$)	21.58	26.41	28.31	31.32	81.72	8.65	52.73
Biochemical parameters								
1	Chlorophyll "a" 75 DAT (mg.g^{-1})	0.110	0.22	28.28	40.11	49.71	0.48	41.08
2	Chlorophyll "b" 75 DAT (mg.g^{-1})	0.057	0.10	42052	58.11	53.53	0.36	64.09
3	Total Chlorophyll 75 DAT (mg.g^{-1})	0.31	0.56	32.61	43.56	56.07	0.87	50.31
4	Carotenoid 75 DAT (mg.g^{-1})	0.043	0.37	16.97	49.74	11.64	0.14	11.92
5	Proline 75 ($\mu\text{g.g}^{-1}$)	22162.26	215762.8	31.59	98.58	10.27	98.28	20.85
6	Polar diameter (mm)	58.81	60.75	37.89	38.52	96.81	15.54	76.81
7	Equatorial diameter (mm)	47.79	50.31	35.55	36.47	95.00	13.88	71.38
8	Pericarp thickness (mm)	1.20	1.25	49.84	50.81	96.24	2.21	100.74
9	Number of locules	0.22	0.25	25.72	27.33	88.62	0.91	49.89
10	Average fruit weight (g)	129.49	158.77	22.89	25.35	81.55	21.16	42.59
11	Number of fruits per plant	43.02	46.05	26.25	27.16	93.42	13.06	52.28
12	Yield per plant (kg)	0.084	0.094	28.90	30.50	89.76	0.56	56.40
13	Yield per hectare	116.54	129.83	28.90	30.50	89.76	21.06	56.40

4.6.1 Correlation between yield with morphological, biochemical, growth and biophysical parameters

At control, highly significant positive correlation for yield was noticed with average fruit weight (0.760), fruit polar diameter (0.703), pericarp thickness (0.500) and fruit equatorial diameter (0.436) and TSS (-0.387) was negatively significant correlated with yield. Plant height, relative leaf water content, LAR at 45 DAT, SLW at 90 DAT, AGR, CGR, RGR, NAR 45 to 90 DAT, PAR, leaf temperature, transpiration and photosynthesis were positively and non-significantly correlated with yield (Table 30 and 31).

At 1.2 IW/CPE ratio, average fruit weight (0.781), fruit polar diameter (0.587), pericarp thickness (0.510), number of locules (0.496), fruit equatorial diameter (0.467) had positive and highly significant association with yield and positive with significant correlate for yield with, AGR 45 to 90 DAT (0.293) and CGR 45 to 90 DAT (0.293) and number of fruits per plant (-0.288) had negatively significant association for yield.

At 0.4 IW/CPE ratio, highly significant positive correlation for yield, was noticed with average fruit weight (0.870), fruit polar diameter (0.543), pericarp thickness (0.500), number of locules (0.489), fruit equatorial diameter (0.478) and Positive with significant correlate for yield with, Leaf temperature (0.325), AGR 45 to 90 DAT (0.309) and CGR 45 to 90 DAT (0.309) and SLW at 45 DAT (-0.281) had negatively significant association for yield.

4.6.2 Identification of drought resistant tomato genotypes based on various methods of screening

In order to select tolerant and consistent genotypes, different screening methods were employed based on (1) mean of 0.4 & 1.2 IW/CPE ratio (2) per cent reduction at 0.4 over 1.2 IW/CPE ratio (3) yield at 0.4 IW/CPE ratio (which yields more than 1 kg/plant). Genotypes were selected based on their performance in all these techniques. Top eight ranked resistant genotypes EC 608362, EC 610 652, EC 634394, EC 638519, EC 610661, EC 631962 Kashi Anupam and Pusa 120, four susceptible genotypes EC 686550, EC 686543, EC 608269 and EC 686553 and one check (Arka Meghali) are used for the further studies (Table 32).

Table 30. Correlation of yield with morphological, biochemical and fruit parameters at three irrigation levels

Sl N0.	Parameters	Correlation co-efficient (r) at different IW/CPE ratio		
		Control	IW/CPE ratio	
			1.2	0.4
1	Plant height at 45 DAT	0.037	-0.012	-0.009
2	Plant height at 90 DAT	0.140	0.095	-0.013
3	Plant spread (NS) at 45 DAT	-0.268	0.068	-0.194
4	Plant spread (EW) at 45 DAT	0.211	0.099	-0.083
5	Plant spread (NS) at 90 DAT	-0.268	0.127	-0.045
6	Plant spread (EW) at 90 DAT	0.196	0.125	0.051
7	Stem girth at 45 DAT	-0.008	-0.192	0.052
8	Stem Girth at 90 DAT	-0.239	-0.211	-0.158
9	Chlorophyll "A"	-0.152	-0.160	0.129
10	Chlorophyll "B"	-0.210	-0.168	0.101
11	Total chlorophyll	-0.185	-0.202	0.122
12	Carotenoids	-0.034	0.156	-0.166
13	Proline	-0.104	0.135	0.177
14	Relative leaf water content	0.085	-0.151	0.050
15	Fruit polar diameter	0.703**	0.587**	0.543**
16	Fruit equatorial diameter	0.436**	0.467**	0.478**
17	Pericarp thickness	0.500**	0.510**	0.500**
18	Number of locules	0.176	0.496**	0.489**
19	TSS	-0.387**	-0.271	-0.249
20	Average fruit weight	0.760**	0.781**	0.870**
21	Number of fruits per plant	-0.042	-0.288*	-0.103

* indicates correlation co-efficient (r) significant at 5 % (0.278) and

** indicates correlation co-efficient (r) significant at 1 % (0.361), Sample size = 50

Table 31. Correlation of yield with physiological and biophysical parameters at three irrigation levels

Sl. NO.	Parameters	Correlation co-efficient (r) at different IW/CPE ratio		
		Control	IW/CPE ratio	
			1.2	0.4
1	Leaf area at 45 DAT	-0.075	0.201	0.240
2	Leaf area at 90 DAT	-0.105	0.094	0.184
3	Biomass at 45 DAT	-0.062	0.023	0.122
4	Biomass at 90 DAT	-0.011	0.212	0.263
5	LAI at 45 DAT	-0.075	0.201	0.240
6	LAI at 90 DAT	-0.105	0.094	0.184
7	LAR at 45 DAT	0.128	0.232	0.123
8	LAR at 90 DAT	-0.091	-0.138	-0.056
9	SLA at 45 DAT	-0.065	0.178	0.231
10	SLA at 90 DAT	-0.119	0.026	0.101
11	SLW at 45 DAT	-0.175	-0.195	-0.281
12	SLW at 90 DAT	0.096	-0.020	-0.138
13	AGR 45-90 DAT	0.030	0.293*	0.309*
14	CGR 45-90 DAT	0.030	0.293*	0.309*
15	RGR 45-90 DAT	0.056	0.265	0.240
16	NAR 45-90 DAT	0.048	0.120	0.181
17	PAR	0.216	0.083	0.183
18	Leaf temperature	0.010	0.224	0.325*
19	Intercellular CO ₂	-0.236	0.270	0.054
20	Transpiration	0.064	0.212	0.175
21	Stomatal conductance	-0.178	0.149	0.189
22	Photosynthesis	0.100	-0.030	-0.056

* indicates correlation co-efficient (r) significant at 5 % (0.278) and

** indicates correlation co-efficient (r) significant at % (0.361), Sample size = 50

Table 32. Criteria to categorize tomato genotypes for drought tolerance

Sl. No.	Genotypes	Mean of 0.4 & 1.2 IW/CPE ra		Based on per cent reduction at 0.4 over 1.2 IW/CPE ra											No of fruits	yield at 0.4 IW/CPE(>1kg/plant)	Frequency of all criteria
		Biomass	Yield	Per cent reduction yield	Specific leaf area	Specific leaf weight	Leaf area/yield	Stem girth	Total chlorophyll	Chlorophyll "a"	Proline	Leaf area	Plant height	RWC			
1	EC 608271	-	-	□+				□+									2
2	Arka Meghali	□+	□+										□+		□+	□+	5
3	EC 608362	□+		□+				□+	□+	□+			□+				6
4	EC 608368			□+					□+				□+		□+		4
5	EC 608389			□+	□+		□+					□+					4
6	EC 610652		□+		□+		□+		□+	□+	□+	□+				□+	8
7	EC 634394		□+							□+	□+		□+		□+	□+	6
8	EC 638519				□+		□+		□+	□+		□+	□+				6
9	EC 610661	□+					□+		□+	□+		□+	□+				6
10	EC 632944	□+	□+										□+		□+	□+	5
11	EC 630512	□+				□+											2
12	EC 631962				□+		□+	□+			□+	□+	□+				6
13	EC 654725	□+					□+						□+	□+			4
14	EC 654724	□+															1
15	EC 654719			□+										□+			2
16	EC 638577	□+			□+		□+					□+					4
17	EC 608288	□+				+									□+		3
18	Kashi Hemanth								□+	□+							2
19	EC 686554			□+	□+		□+	□+				□+					5
20	EC 686550																0
21	Kashi Anupam		□+		□+		□+	□+				□+				□+	6
22	EC 677111										□+			□+			2
23	SEL 12			□+	□+												2
24	EC 608348					□+								□+			2
25	EC 608320		□+						□+		□+			□+	□+		5
26	EC 686548							□+								□+	2
27	Hissar Arun					□+								□+			2
28	EC 686542			□+	□+		□+					□+			□+		5
29	EC 686543																0
30	EC 677044							□+									1
31	EC 608269																0
32	Swarna Lalima		□+			□+								□+		□+	4
33	EC 686553																0
34	Pusa 120		□+							□+	□+			□+	□+	□+	6
35	Pusa Gaurav	□+				□+		□+							□+		4
36	HUB-18		□+										□+	□+		□+	4
37	Megha							□+						□+			2
38	Arka Abha			□+													1
39	T-26					□+			□+	□+							3
40	DMT-2		□+													□+	2
41	HUB T-10					□+											1
42	HUB T-06																0
43	HUB T-11										□+						1
44	HUB T-05		□+			□+										□+	3
45	HUB T-07								□+	□+	□+						3
46	HUB T-04				□+			□+	□+	□+							4
47	HUB T-09					□+											1
48	HUB T-12							□+			□+						2
49	HUB T-08										□+						1
50	HUB T-13										□+			□+			2

Experiment-II: Physiological traits associated with drought tolerance mechanism among the selected genotypes

Eight tomato genotypes which performed better in experiment I with reference to drought tolerance along with four susceptible and one check variety (resistant) were selected for screening in Experiment II. Results of experiment II are presented as under.

4.2 Morphological characters of tomato genotypes

4.2.1 Plant height (cm)

Significant difference were noticed among genotypes, irrigations level and their interaction during 45 and 90 DAT (Table 33).

During 45 DAT, significantly maximum plant height was observed in the genotype EC 638519 (58.66) and which was on par with Arka Mghali (57.47), EC 634394 (56.18) and EC 608362 (56.14). Significantly minimum plant height was recorded in EC 608269 (43.77) irrespective of the genotypes. Among the irrigation schedules, control had significantly higher plant height, when compared to 1.2 and 0.4 IW/CPE ratio and it varied from 58.57 to 61.80, 39.90 to 58.47 and 32.17 to 56.60, respectively. Interaction between the genotypes and irrigation levels Kashi Anupam (61.80) had significantly higher plant height at control and this was on par with Arka Meghali (58.47), EC 610652 (58.40), EC 608362 (58.07) at 1.2 IW/CPE ratio and least plant height was in genotype EC 608269 (32.17) at 0.4 IW/CPE ratio.

During 90 DAT, among the genotypes, significantly maximum plant height was observed in the genotype EC 610661 (82.23) and significantly minimum plant height was recorded in EC686553 (51.87). Among the irrigation schedules plant height decreased as there is increase in stress level, control had significantly higher plant height, when compared to 1.2 and 0.4 IW/CPE ratio and it varied from 66.5 to 94.67, 48.44 to 79.18 and 34.61 to 72.85, respectively. Interaction between the genotypes and irrigation levels EC 610661 (94.67) had significantly higher plant height at control and least plant height was in genotype EC 608269 (34.61) at 0.4 IW/CPE ratio.

PCV was observed to be 8.20 per cent and 20.85 per cent at 45 and 90 DAS respectively. GCV of 7.75 per cent and 20.63 per cent, the broad sense heritability (88.92% and 97.87%), genetic advance (17.22 and 27.83) and GAM (15.03 and 42.04) were noticed at 45 and 90 DAS respectively.

4.2.2 Plant spread (cm)

4.2.2.1 North – South

Plant spread towards North to South during 90 DAT was found significant among the genotypes, irrigation levels and their interaction. Irrespective of the irrigation levels, genotype EC 610661 recorded significantly maximum plant spread (71.20 cm), compared to all other genotypes, Whereas EC 608269 exhibited minimum plant spread (44.66 cm). Among the irrigation levels, significantly highest plant spread was noticed in control compare to other irrigation levels. With respect to interaction between genotypes and different irrigation levels, significantly maximum plant spread was recorded in EC 610661 (79.75 cm) at control, and minimum plant spread was recorded in the genotype EC 608269 (30.43 cm) at 0.4 IW/CPE ratio (Table 34).

PCV varied between of 32.23 per cent and 34.40 per cent at 45 and 90 DAT respectively. GCV of 24.15 per cent and 27.56 per cent, the broad sense heritability (56.13% and 64.19.69%), genetic advance (11.25 and 17.68) and GAM (37.28, and 45.50) were noticed at 45 and 90 DAS respectively.

4.2.2.2 East – West

Plant spread towards East to West during 90 DAT found significant among the genotypes, irrigation levels and their interaction (Table 34).

During 90 DAT irrespective of the irrigation levels, genotype EC 634394 recorded significantly highest um plant spread (67.29) compared to all other genotypes, however, it was on par with Kashi Anupam (66.88), Arka Meghali (66.82). Whereas EC 686553 exhibited lowest plant spread (48.37). Among the different types of irrigation level, significantly superior plant spread of 74.71 cm and inferior was noticed water stress level of 0.4 IW/CPE. The interaction effect between the genotype

Table 33. Plant height (cm) as influenced by irrigation levels in tomato genotypes

Sl. No.	Genotypes	Plant height at 45 DAT				Plant height at 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	61.33	58.47	52.61	57.47	81.99	74.28	61.92	72.73
2	EC 608362	61.07	58.07	49.30	56.14	77.05	68.70	62.77	69.51
3	EC 610652	60.93	58.40	48.33	55.89	73.72	71.51	64.15	69.79
4	EC 634394	60.40	57.67	50.47	56.18	78.14	70.05	62.11	70.10
5	EC 638519	61.51	57.87	56.60	58.66	87.52	74.61	69.51	77.21
6	EC 610661	61.63	51.77	53.83	55.75	94.67	79.18	72.85	82.23
7	EC 631962	60.60	53.03	43.97	52.53	73.38	70.99	62.40	68.92
8	EC 686550	59.70	41.33	36.70	45.91	66.50	55.05	37.70	53.08
9	Kashi Anupam	61.80	56.23	47.23	55.09	79.20	72.69	63.58	71.82
10	EC 686543	60.07	39.90	36.07	45.34	71.37	53.46	36.10	53.64
11	EC 608269	58.83	40.30	32.17	43.77	69.99	52.91	34.61	52.50
12	EC 686553	58.57	40.70	32.53	43.93	71.19	48.44	35.99	51.87
13	PUSA 120	60.13	55.47	47.00	54.20	72.90	67.65	61.29	67.28
Mean		60.51	51.48	45.14	52.37	76.74	66.12	55.77	66.21
Range		61.80	58.47	56.60	58.66	94.67	79.18	72.85	82.23
		58.57	39.90	32.17	43.77	66.50	48.44	34.61	51.87
		S.Em $\pm$		CD @ 5%		S.Em $\pm$		CD @ 5%	
Genotypes		1.04		2.94		0.67		1.89	
Irrigation		0.50		1.41		0.32		0.91	
G X I		1.81		5.09		1.16		3.28	

DAT = Days after transplanting

Control = Farmers practice

Table 34. Plant spread (cm) as influenced by irrigation levels in tomato genotypes

Sl. No	Genotypes	North – South				East – West			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	69.66	63.33	60.03	64.34	71.55	66.65	62.25	66.82
2	EC 608362	69.60	62.31	57.98	63.29	74.71	65.04	58.98	66.25
3	EC 610652	69.60	62.98	56.99	63.19	70.73	63.83	55.39	63.32
4	EC 634394	71.33	63.68	59.80	64.94	73.19	66.78	61.91	67.29
5	EC 638519	74.24	63.00	60.38	65.87	67.40	60.13	53.98	60.50
6	EC 610661	79.75	69.33	64.52	71.20	70.03	63.52	60.66	64.74
7.	EC 631962	68.90	62.92	59.87	63.90	69.34	60.94	58.97	63.08
8	EC 686550	66.22	42.13	34.25	47.53	68.35	49.64	31.45	49.82
9	Kashi Anupam	70.29	63.87	59.12	64.43	73.47	66.08	61.08	66.88
10	EC 686543	72.05	41.99	33.92	49.32	67.94	49.84	35.78	51.19
11	EC 608269	64.09	39.46	30.43	44.66	69.00	48.31	33.33	50.21
12	EC 686553	69.85	39.19	34.66	47.90	69.45	44.40	31.27	48.37
13	PUSA 120	70.98	62.86	57.95	63.93	73.01	63.12	59.95	65.36
Mean		70.50	56.70	51.53	59.58	70.63	59.10	51.15	60.29
Range		79.75	69.33	64.52	71.20	74.71	66.78	62.25	67.29
		64.09	39.19	30.43	44.66	67.40	44.40	31.27	48.37
		S.Em $\pm$		CD @ 5%		S.Em $\pm$		CD @ 5%	
Genotypes		0.47		1.31		0.56		1.57	
Irrigation		0.22		0.63		0.27		0.76	
G X I		0.81		2.27		0.97		2.72	

DAT = Days after transplanting

Control = Farmers practice

and irrigation levels, was found significantly maximum plant spread was recorded in EC 608362 (74.71) it was on par with Kashi Anupam (73.47 cm), EC 634394 (73.19) and Pusa 120 (73.01) at control. and minimum plant spread was recorded in the genotype EC 686553 (31.27) at 0.4 IW/CPE ratio.

PCV was observed of 33.76 per cent and 34.66 per cent at 45 and 90 DAT respectively. GCV of 27.60 per cent and 30.15 per cent, the broad sense heritability (66.85 and 75.69), genetic advance (12.82 and 19.27) and GAM (46.50 and 54.05) were noticed at 45 and 90 DAS respectively.

4.2.2.3 Days to first flowering

The number of days taken for first flowering varied significantly among the genotypes, irrigation levels and their interaction effects (Table 35).

Genotype EC 638519 (30.17) took maximum days for first flowering and this was on par with EC 610661 (30.49), followed by EC 610652 (30.03) and Significantly minimum days for first flowering was recorded in EC 608269 (26.42) irrespective of the genotypes. Among the irrigation schedules, control took significantly maximum days for first flowering, when compared to 1.2 and 0.4 IW/CPE ratio and it varied from 30.33 to 32.07, 27.03 to 30.90 and 20.87 to 29.93, respectively.

Interaction between the genotypes and irrigation levels, genotype EC 610661 (32.07) took maximum days to first flowering under control and this was on par with EC 638519 (29.93) at 0.4 IW/CPE ratio, which was followed by EC 631962 (30.90), EC 638519 and EC 610661 (30.53) at 1.2 IW/CPE ratio and minimum days for first flowering was in genotype EC 686553 (20.87) at 0.4 IW/CPE ratio.

PCV was observed of 11.66 per cent at yield per plant. GCV of 10.34 per cent, the broad sense heritability (78.59%), genetic advance (5.43) and GAM (18.87) were noticed.

4.2.2.4 Days to 50 per cent flowering

The number of days taken to 50 per cent flowering varied significantly among the genotypes, irrigation levels and their interaction effects (Table 35).

Genotype EC 638519 and EC 610661 (39.22) took maximum days for 50 per cent flowering and this was on par with EC 610652 (38.78), EC 608362 and EC634394 (38.56) and Significantly minimum days for 50 per cent flowering was recorded in EC 608269 (35.11) irrespective of the genotypes. Among the irrigation schedules, control took significantly maximum days for 50 per cent flowering, when compared to 1.2 and 0.4 IW/CPE ratio and it varied from 39.67 to 42.33, 36.00 to 39.33 and 28.67 to 38.00, respectively. Interaction between the genotypes and irrigation levels EC 610661 (42.33) took maximum days to 50 per cent flowering at control and this was on par with EC 608362 and EC 610652 (39.33), EC 638519 (39.00) at 1.2 IW/CPE ratio, and minimum days for 50 per cent flowering was in genotype EC 608269 (28.67) at 0.4 IW/CPE ratio.

PCV was observed of 10.32 per cent at yield per plant. GCV of 8.70 per cent, the broad sense heritability (71.02%), genetic advance (5.67) and GAM (15.10) were noticed.

4.2.2.5 Stem girth (mm)

There were significant differences among the genotypes, different pan evaporation ratio and their interaction at both 45 and 90 DAT for stem girth (Table 36).

During 45 DAT, irrespective of irrigation levels, maximum stem girth was observed in the genotype Kashi Anupam (5.56) and this was on par EC 610661 (5.49), EC 608362 (5.33) and Arka Meghali (5.21) while, minimum was in the genotype EC 608269 (3.95). Among the genotypes, Kashi Anupam observed significantly higher stem girth (6.16) and this was on par with the genotype EC 610661 (6.12), Pusa 120 (6.07) and EC 608362 (5.93) at 0.4IW/CPE ratio and least was in genotype EC 608269 (3.63) at 0.4 IW/CPE ratio.

Irrespective of the irrigation levels, significantly maximum stem girth was observed in the genotype EC 608362 (8.01) it was on par with Arka Meghali (7.83), EC638519 and EC 631962 (7.81, each) during 75 DAT and minimum was recorded in EC 686553 (6.07). Among the genotypes EC 608362 showed significantly better stem girth (9.67) and this was on par with EC 610652 (9.13), EC 631962 (9.05) and EC 634394 (8.93) at 0.4 IW/CPE ratio. Least stem girth was in EC 686543 (5.10) at 0.4 IW/CPE ratio.

Table 35. Days to first flowering and days to 50 % flowering in tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Days to first flowering				Days to 50% flowering			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	31.91	30.00	25.40	29.10	40.67	38.00	36.00	38.22
2	EC 608362	31.93	28.73	27.20	29.29	41.67	39.33	34.67	38.56
3	EC 610652	31.33	29.80	28.97	30.03	41.67	39.33	35.33	38.78
4	EC 634394	31.80	30.07	26.13	29.33	40.67	38.67	36.33	38.56
5	EC 638519	31.67	30.53	29.93	30.71	40.67	39.00	38.00	39.22
6	EC 610661	32.07	30.53	28.87	30.49	42.33	38.00	37.33	39.22
7	EC 631962	31.47	30.90	26.67	29.68	39.67	38.67	35.00	37.78
8	EC 686550	31.13	28.56	22.90	27.53	41.67	38.33	29.67	36.56
9	Kashi Anupam	31.80	29.53	25.93	29.09	42.00	38.00	35.00	38.33
10	EC 686543	30.33	27.91	21.17	26.47	39.67	36.67	30.00	35.44
11	EC 608269	30.60	27.03	21.63	26.42	39.67	37.00	28.67	35.11
12	EC 686553	30.73	27.87	20.87	26.49	40.00	36.00	29.67	35.22
13	PUSA 120	32.07	30.27	26.20	29.51	39.67	37.67	34.67	37.33
Mean		31.45	29.36	25.53	28.78	40.77	38.05	33.87	37.56
Range		32.07	30.90	29.93	30.71	42.33	39.33	38.00	39.22
		30.33	27.03	20.87	26.42	39.67	36.00	28.67	35.11
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes Irrigation G X I		0.25		0.70		0.70		1.96	
		0.52		1.46		0.33		0.94	
		0.90		2.52		1.21		3.40	

DAT = Days after transplanting

Control = Farmers practice

Table 36. Stem girth (mm) as influenced by irrigation levels in tomato genotypes

Sl. No	Genotypes	Girth 45 DAT				Girth 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	4.50	5.34	5.86	5.21	7.19	7.43	8.88	7.83
2	EC 608362	4.49	5.57	5.93	5.33	7.10	7.25	9.67	8.01
3	EC 610652	4.29	5.43	5.76	5.16	6.60	7.36	9.13	7.70
4	EC 634394	4.56	5.15	5.60	5.10	6.66	7.40	8.93	7.66
5	EC 638519	4.26	5.38	5.45	5.03	7.12	7.50	8.83	7.81
6	EC 610661	4.60	5.74	6.12	5.49	6.95	7.43	8.90	7.76
7	EC 631962	4.15	5.67	5.64	5.16	6.95	7.43	9.05	7.81
8	EC 686550	4.50	4.35	3.81	4.22	7.50	6.38	5.80	6.56
9	Kashi Anupam	4.83	5.68	6.16	5.56	7.06	7.00	8.12	7.39
10	EC 686543	4.52	4.08	3.74	4.17	7.36	6.53	5.10	6.33
11	EC 608269	4.21	3.99	3.63	3.95	7.06	6.37	5.34	6.26
12	EC 686553	4.35	4.12	3.64	4.04	6.62	6.28	5.30	6.07
13	PUSA 120	4.02	5.46	6.07	5.18	6.86	7.87	8.77	7.83
Mean		4.41	5.07	5.19	4.89	7.00	7.09	7.83	7.31
Range		4.83	5.74	6.16	5.56	7.50	7.87	9.67	8.01
		4.02	3.99	3.63	3.95	6.60	6.28	5.1	6.07
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes Irrigation G X I		0.17		0.48		0.21		0.59	
		0.08		0.23		0.10		0.28	
		0.29		0.83		0.36		1.02	

DAT = Days after transplanting

Control = Farmers practice

PCV was observed of 18.27 per cent and 16.55 per cent at 45 and 90 DAS respectively. GCV of 15.03 per cent and 14.17 per cent, the broad sense heritability (67.72% and 73.30%), genetic advance (1.24 and 1.82) and GAM (25.48 and 24.99) were noticed at 45 and 90 DAS respectively.

4.2.2.6 Number of pubescence count

There was significance difference for the number of pubescence count among genotypes and irrigation levels and their interaction were observed both on upper and lower leaf surface (Table 37).

On abaxial and adaxial surface of the leaf, irrespective of irrigation levels, genotype EC 684394 recorded significantly maximum number of pubescence (149.86 and 374.59) it was on par with EC 610652 while, minimum was in EC 686550 (27.36 and 68.39), respectively. Among the interaction effect between the genotypes and irrigation levels also, genotype EC 634394 exhibited maximum pubescence number (237.06 and 592.64) at 0.4 IW/CPE ratio while, least was observed in EC 608269 (20.51 and 51.28) at control, respectively. Among the irrigation levels, significantly maximum pubescence were at 0.4 IW/CPE ratio recorded maximum number of pubescences compared to control ratio and it ranged from 20.51 to 79.40 and 35.28 to 237.06, respectively.

PCV was observed of 65.81 per cent and 65.81 per cent on abaxial and adaxial respectively. GCV of 64.42 per cent and 64.42 per cent, the broad sense heritability (95.82 %), genetic advance (121.61 and 303.01) and GAM (129.91 and 129.91) were noticed in abaxial adaxial respectively.

4.2.3 Growth parameters

4.2.3.1. Leaf area ($\text{cm}^2 \cdot \text{plant}^{-1}$) at different crop growth stages

Significant differences in leaf area were observed among the genotypes and irrigation schedules at different growth stages during 45 and 90 DAT. With regard to the interaction effects of genotype and irrigation schedule, significant differences were observed during only 45 DAT (Table 38).

At 45 DAT, genotype EC 634394 (1089.74) recorded significantly more leaf area it was on par with EC 631962 (1040.33) and minimum was observed in the genotype EC 686553 (477.43) irrespective of irrigation levels. There was significant interaction effects between genotypes and irrigation levels. However, maximum leaf area was noticed in the genotype EC 634394 (1281.38) it was on par with Arka Meghali (1228.01) and EC 608362 (1177.25) at control and minimum was observed in the genotype EC 686553 (294.25) at 0.4 IW/CPE ratio.

During 90 DAT, genotype EC 638519 observed significantly maximum leaf area (1998.29) and this was on par with EC 634394 (1767.37) while, minimum was in the genotype EC 686553 (661.73) irrespective of irrigation levels. There were no significance interaction effects between genotypes and irrigation levels. However, maximum leaf area was noticed in the genotype EC 638519 (2497.22) at control and minimum was observed in the genotype EC 686553 (285.99) at 0.4 IW/CPE ratio. Among the irrigation levels at 45 and 90 DAT, maximum leaf area was recorded under control (959.25 and 1747.72, respectively) and minimum leaf area was noticed in the 0.4 IW/CPE ratio (623.45 and 888.05, respectively).

PCV was observed of 32.80 per cent and 46.90 per cent at 45 and 90 DAS respectively. GCV of 31.60 per cent and 42.79 per cent, the broad sense heritability (92.81% and 83.21%), genetic advance (500.18 and 105.45) and GAM (62.73 and 80.41) were noticed at 45 and 90 DAS respectively.

4.2.3.2 Leaf area index (LAI) at different crop growth stages

Significant difference for LAI was noticed for genotypes and different irrigation schedules at all the growth stage during 45 and 90 DAT. Interaction effects of genotypes and irrigation levels influenced LAI at the growth stage of 45 DAT only (Table 39).

At 45 DAT, irrespective of irrigation levels, genotype EC 634394 had significantly maximum LAI (0.40) it was on par with EC 631962 and minimum was noticed in the genotype EC 608269 and EC 686553 (0.18, each). Among the three irrigation schedules, control had significantly maximum LAI compared to 1.2 and 0.4 IW/CPE ratio and it varied from 0.22 to 0.47, 0.18 to 0.42 and 0.11 to 0.33, respectively. There was significance difference for interaction, genotype EC 634394

Table 37. Number of pubescence as influenced by irrigation levels in tomato genotypes

Sl. No	Genotypes	Abaxial				Adaxial			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	44.79	119.01	205.64	123.15	111.97	297.53	514.10	307.87
2	EC 608362	76.83	103.20	166.59	115.54	192.07	258.01	416.47	288.85
3	EC 610652	54.94	106.57	231.15	130.89	137.36	266.43	577.88	327.22
4	EC 634394	56.16	156.29	237.06	149.84	140.40	390.73	592.64	374.59
5	EC 638519	79.40	132.92	166.46	126.26	198.50	332.30	416.16	315.65
6	EC 610661	70.03	97.50	169.05	112.19	175.08	243.76	422.63	280.49
7.	EC 631962	58.56	86.31	159.10	101.32	146.39	215.77	397.76	253.31
8	EC 686550	23.00	21.70	37.37	27.36	57.50	54.25	93.43	68.39
9	Kashi Anupam	72.58	84.91	148.05	101.85	181.46	212.28	370.13	254.62
10	EC 686543	27.81	32.19	35.28	31.76	69.53	80.48	88.21	79.40
11	EC 608269	20.51	32.35	47.90	33.58	51.28	80.87	119.74	83.96
12	EC 686553	46.14	52.80	60.94	53.29	115.35	132.00	152.34	133.23
13	PUSA 120	35.31	130.07	152.06	105.81	88.27	325.18	380.14	264.53
Mean		51.23	88.91	139.74	93.30	128.09	222.27	349.36	233.24
Range		79.40	156.29	237.06	149.84	198.50	390.73	592.64	374.59
		20.51	21.70	35.28	27.36	51.28	54.25	88.21	68.39
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		4.18		11.78		10.45		29.44	
Irrigation		2.01		5.66		5.02		14.10	
G X I		7.24		20.40		18.11		51.00	

DAT = Days after transplanting

Control = Farmers practice

Table 38. Influence of irrigation levels on leaf area (cm²) of tomato genotypes at 45 and 90 DAT

Sl. No.	Genotypes	Leaf area at 45 DAT				Leaf area at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	1228.01	784.15	607.54	873.23	2066.44	1796.37	1166.47	1676.43
2	EC 608362	1177.26	696.47	678.71	850.81	2213.82	1669.00	1276.39	1719.74
3	EC 610652	1038.48	883.16	690.52	870.72	1870.68	1236.74	1035.49	1380.97
4	EC 634394	1281.38	1144.62	843.23	1089.74	2249.86	1675.17	1377.08	1767.37
5	EC 638519	899.6	823.74	776.88	833.41	2497.22	2086.22	1411.42	1998.29
6	EC 610661	981.13	919.48	871.22	923.94	1557.3	1354.16	998.86	1303.44
7	EC 631962	1140.13	1069.25	911.61	1040.33	1694.61	1332.77	966.32	1331.24
8	EC 686550	717.77	673.28	348.9	579.98	1113.9	765.26	335.54	738.23
9	Kashi Anupam	1107.09	981.42	825.17	971.23	2166.13	1392.28	1077.38	1545.27
10	EC 686543	672.75	526.11	336.35	511.74	989.14	710.243	332.55	677.31
11	EC 608269	680.08	490.24	324.58	498.3	1124.05	781.77	345.20	750.34
12	EC 686553	612.47	525.58	294.25	477.43	1029.62	669.60	285.99	661.73
13	PUSA 120	934.03	886.18	712.94	844.38	2147.64	1410.19	935.98	1497.94
Mean		959.25	800.28	632.45	797.33	1747.72	1298.44	888.05	1311.41
Range		1281.38	1144.62	911.61	1089.74	2497.22	2086.22	1411.42	1998.29
		612.47	490.24	294.25	477.44	989.14	669.60	285.98	661.73
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		23.37		65.81		84.01		236.63	
Irrigation		11.22		31.62		40.36		113.67	
G X I		40.47		113.99		145.51		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

had maximum LAI at control (0.47) on par with Arka Meghali (0.45), EC 608362 (0.44) and minimum was observed in the genotype EC 686553 (0.11) at 0.4 IW/CPE ratio.

During 90 DAT, genotype EC 638519 had significantly higher LAI (0.74) and this was on par with EC 634394 (0.65) and minimum LAI was recorded in the genotype EC 686543 and EC 686553 (0.25) irrespective of irrigation levels. Among the three irrigation schedules, significantly maximum LAI was noticed at control compared to 1.2 and 0.4 IW/CPE ratio and it varied from 0.36 to 0.93, 0.24 to 0.77 and 0.11 to 0.52, respectively. There was no significance difference for interaction. However, genotype EC 638519 had maximum LAI at control (0.93) and minimum was observed in the genotype EC 686553 (0.11) at 0.4 IW/CPE ratio.

PCV was observed of 32.80 per cent and 46.90 per cent at 45 and 90 DAS respectively. GCV of 31.60 per cent and 42.79 per cent, the broad sense heritability (92.81% and 83.21%), genetic advance (0.81 and 0.39) and GAM (62.73 and 80.41) were noticed at 45 and 90 DAS respectively.

4.2.3.4 Leaf area ratio (LAR) at different crop growth period

Significant difference in leaf area ratio was observed among the genotypes but different irrigation schedules and their interaction exhibited non significance at 45 and 90 DAT (Table 40).

During 45 DAT, irrespective of the irrigation levels, genotype EC 634394 had significantly maximum leaf area ratio (38.87) and was on par with EC 631962 (36.74) and minimum was in the genotype EC 686543 (22.73). Among the different types of irrigation level found non significance. There were no significant between the interaction effects. However, maximum leaf area ratio was noticed in the genotype EC 634394 (42.72) at 1.2 IW/CPE ratio and least was in the genotype EC 686543 (20.38) at control.

During 90 DAT, irrespective of the irrigation levels, genotype EC 634394 had significantly maximum leaf area ratio (35.26) and was on par with EC 608362 (32.48), Arka Meghali (32.38) and EC 638519 (31.48) and minimum was in the genotype EC 686553 (16.01). Among the different types of irrigation level found non

Tables 39. Leaf area index of tomato genotypes as influenced by irrigation levels at 45 and 90 DAT

Sl. No.	Genotypes	LAI at 45 DAT				LAI at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	0.45	0.29	0.23	0.32	0.77	0.67	0.43	0.62
2	EC 608362	0.44	0.26	0.25	0.32	0.82	0.62	0.47	0.64
3	EC 610652	0.38	0.33	0.26	0.32	0.69	0.46	0.38	0.51
4	EC 634394	0.47	0.42	0.31	0.4	0.83	0.62	0.51	0.65
5	EC 638519	0.33	0.31	0.29	0.31	0.93	0.77	0.52	0.74
6	EC 610661	0.36	0.34	0.32	0.34	0.58	0.50	0.37	0.48
7	EC 631962	0.42	0.4	0.34	0.39	0.63	0.49	0.36	0.49
8	EC 686550	0.27	0.25	0.13	0.21	0.41	0.28	0.12	0.27
9	Kashi Anupam	0.41	0.36	0.31	0.36	0.80	0.52	0.40	0.57
10	EC 686543	0.25	0.19	0.12	0.19	0.37	0.26	0.12	0.25
11	EC 608269	0.25	0.18	0.12	0.18	0.42	0.29	0.13	0.28
12	EC 686553	0.23	0.19	0.11	0.18	0.38	0.25	0.11	0.25
13	PUSA 120	0.35	0.33	0.26	0.31	0.80	0.52	0.35	0.55
Mean		0.36	0.3	0.23	0.3	0.65	0.48	0.33	0.49
Range		0.47	0.42	0.33	0.4	0.92	0.77	0.52	0.74
		0.22	0.18	0.1	0.17	0.36	0.24	0.1	0.24
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.009		0.024		0.03		0.09	
		0.004		0.012		0.01		0.04	
		0.015		0.042		0.05		NS	
Irrigation									
G X I									

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice (FP)

Table 40. Leaf area ratio (cm²/g) of tomato genotypes as influenced by irrigation levels at 45 and 90 DAT

Sl. No.	Genotypes	LAR at 45 DAT				LAR at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	40.29	30.05	28.37	32.90	32.61	34.79	29.75	32.38
2	EC 608362	38.17	24.71	29.66	30.85	34.60	31.48	31.37	32.48
3	EC 610652	27.95	28.47	28.90	28.44	25.37	20.97	22.70	23.01
4	EC 634394	39.81	42.72	34.09	38.87	36.06	33.35	36.36	35.26
5	EC 638519	22.10	25.23	29.22	25.52	33.83	33.35	27.26	31.48
6	EC 610661	26.58	27.63	32.34	28.85	18.74	21.37	19.15	19.75
7	EC 631962	32.06	37.28	40.86	36.74	27.04	25.65	24.04	25.58
8	EC 686550	26.11	34.41	27.27	29.26	19.57	21.38	16.19	19.05
9	Kashi Anupam	29.81	31.66	32.72	31.40	26.50	24.44	24.56	25.16
10	EC 686543	20.38	23.60	24.21	22.73	18.79	21.90	16.09	18.93
11	EC 608269	21.04	22.68	27.05	23.59	19.83	21.82	17.06	19.57
12	EC 686553	21.50	23.47	23.90	22.96	17.44	18.31	12.27	16.01
13	PUSA 120	25.81	30.70	27.07	27.86	33.25	26.63	23.65	27.84
Mean		28.58	29.43	29.67	29.23	26.43	25.80	23.11	25.12
Range		40.29	42.72	40.86	38.87	36.06	34.79	36.36	35.26
		20.38	22.68	23.90	22.73	17.44	18.31	12.27	16.01
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		1.68		4.71		1.78		5.01	
		0.80		NS		0.85		NS	
		2.90		NS		3.08		NS	
Irrigation									
G X I									

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

significance and There were no significant between the interaction effects. However, maximum leaf area ratio was noticed in the genotype EC634394 (36.36) at 0.4 IW/CPE ratio and least was in the genotype EC 686553 (12.27) at 0.4 IW/CPE ratio.

PCV was observed of 24.36 per cent and 31.27 per cent at 45 and 90 DAS respectively. GCV of 17.26 per cent and 22.97 per cent, the broad sense heritability (50.18% and 53.94%), genetic advance (7.36 and 8.73) and GAM (25.18 and 34.75) were noticed at 45 and 90 DAS respectively.

4.2.3.5 Specific leaf weight (mg.cm^{-2}) at different crop growth stages

Specific leaf weight (SLW) differed significantly only among genotypes but not among the irrigation levels and their interactions at At 45 DAT. Irrespective of irrigation levels, among genotypes EC 686553 recorded higher SLW (2.01) it was on par with EC 608269 (1.87) and least was in EC 634394 (0.99). SLW varied from 0.99 to 2.22, 0.90 to 1.72 and 0.95 to 2.19 at control, 1.2 and 0.4 IW/CPE ratio. There was no significant difference in the interactions. However, EC 608269 had higher SLW (2.22) at control and lesser SLW was observed in the genotype EC 634394 (0.90) at 1.2 IW/CPE ratio (Table 41).

At 90 DAT significant difference was observed for the irrigation levels, among the genotypes and interaction effects. As the stress levels increased from control to 1.2 and 0.4 IW/CPE ratio SLW was significantly increased to the extent of 27.67 per cent at 90 DAT. Irrespective of the irrigation levels, genotype, EC 686550 at 90 DAT had maximum SLW (2.74) it was on par with EC 686553 (2.70), EC 686543 (2.64) and EC 608269 (2.52) and minimum was recorded in the genotype EC 638519 (1.05). Among the irrigation levels higher SLW was noticed at 0.4 IW/CPE ratio and it varied from 0.97 to 2.4, 0.95 to 2.49 and 1.08 to 4.04 at control, 1.2 and 0.4 IW/CPE respectively. Among the interaction effect, genotype EC 686550 recorded significantly higher SLW (4.04) 0.4 IW/CPE ratio and least was noticed in the genotype EC 638519 (0.95) at 1.2 IW/CPE ratio.

PCV was observed of 25.45 per cent and 45.19 per cent at 45 and 90 DAS respectively. GCV of 20.48 per cent and 38.72 per cent, the broad sense heritability (64.74% and 73.41%), genetic advance (0.49 and 1.19) and GAM (33.94 and 68.34) were noticed at 45 and 90 DAS respectively.

4.2.3.6 Specific leaf area ($\text{cm}^2.\text{g}^{-1}$) at different crop growth period

Specific leaf area (SLA) was significantly differed among the genotypes at the growth stage during 45 and 90 DAT, but non significance was observed for irrigation levels and only significant difference was observed in their interaction effect at 45 DAT (Table 42).

At 45 DAT, irrespective of the irrigation levels, genotype EC 634394 (102.47) recorded higher SLA and it was on par with EC 631962 (95.60) while, least was noticed in the genotype EC 686553 (50.78). Among the different stress levels was found no significance difference were observed. Among the interaction effect, genotype EC 634394 recorded significantly higher SLW (111.28) 1.2 IW/CPE ratio and it was on par with EC 631962 (105.60) at 0.4 IW/CPE ratio and least was noticed in the genotype EC 608269 (46.55) at control.

During 90 DAT, Irrespective of the irrigation levels, genotype EC 638519 exhibited higher SLA (104.17) which was on par with EC 608362 (90.75) and the least was noticed in the genotype EC 686553 (39.61). Among the interaction effect found a non significance. however, genotype EC 638519 recorded significantly higher SLA (112.88) at 1.2 IW/CPE ratio and least was noticed in the genotype EC 686550 (27.96) both at 0.4 IW/CPE ratio.

PCV was observed of 25.03 per cent and 37.68 per cent at 45 and 90 DAS respectively. GCV of 20.99 per cent and 29.64 per cent, the broad sense heritability (70.34% and 61.88%), genetic advance (26.30 and 32.36) and GAM (36.27 and 48.04) were noticed at 45 and 90 DAS respectively.

4.2.3.7 Total biomass (g/plant)

Significant differences were observed for total biomass among the genotypes, irrigation levels and non significance observed only their interactions at both 45 and 90 DAT (Table 43).

At 45 DAT, irrespective of the irrigation levels, genotype EC638519 had significantly higher total biomass (33.33), which was on par with EC 610661 (32.78), EC 610652 and Kashi Anupam (31.56, each). Whereas the least total biomass was

Table 41. Specific leaf weight (g/cm² X 10⁻²) as influenced by irrigation levels in tomato genotypes at 45 and 90 DAT

Sl. No.	Genotypes	SLW at 45 DAT				SLW at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	1.14	1.40	1.50	1.35	1.42	1.19	1.41	1.34
2	EC 608362	1.15	1.68	1.52	1.45	1.09	1.16	1.10	1.11
3	EC 610652	1.60	1.44	1.48	1.50	1.38	1.69	1.52	1.53
4	EC 634394	0.99	0.90	1.08	0.99	1.20	1.31	1.08	1.20
5	EC 638519	1.81	1.57	1.42	1.60	0.97	0.95	1.23	1.05
6	EC 610661	1.39	1.27	1.12	1.26	1.78	1.56	1.77	1.70
7	EC 631962	1.18	1.06	0.95	1.06	1.33	1.25	1.42	1.33
8	EC 686550	1.77	1.33	1.63	1.58	2.02	2.17	4.04	2.74
9	Kashi Anupam	1.34	1.22	1.17	1.25	1.25	1.51	1.59	1.45
10	EC 686543	1.80	1.65	1.69	1.71	2.39	2.25	3.27	2.64
11	EC 608269	2.22	1.58	1.82	1.87	2.36	2.25	2.93	2.52
12	EC 686553	2.12	1.72	2.19	2.01	2.27	2.49	3.34	2.70
13	PUSA 120	1.57	1.32	1.36	1.42	1.19	1.46	1.64	1.43
Mean		1.55	1.39	1.46	1.47	1.59	1.63	2.03	1.75
Range		2.22	1.72	2.19	2.01	2.4	2.49	4.04	2.74
		0.99	0.90	0.95	0.99	0.97	0.95	1.08	1.05
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.07		0.21		0.14		0.38	
Irrigation		0.04		NS		0.07		0.18	
G X I		0.13		NS		0.24		0.66	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

Table 42. Influence of irrigation levels on specific leaf area (cm²/g) of tomato genotypes at 45 and 90 DAT

Sl. No.	Genotypes	SLA at 45 DAT				SLA at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	89.96	71.56	67.03	76.18	75.04	85.53	72.54	77.70
2	EC 608362	91.15	59.68	65.72	72.18	94.33	86.35	91.56	90.75
3	EC 610652	64.14	69.68	70.97	68.26	74.88	60.37	67.77	67.67
4	EC 634394	102.45	111.28	93.69	102.47	85.07	78.64	99.67	87.79
5	EC 638519	55.39	63.82	70.53	63.25	106.67	112.88	92.95	104.17
6	EC 610661	71.90	78.92	90.54	80.45	57.68	66.62	59.71	61.33
7	EC 631962	86.75	94.45	105.60	95.60	75.41	80.14	74.08	76.54
8	EC 686550	56.82	76.52	61.92	65.09	49.81	47.77	27.96	41.84
9	Kashi Anupam	75.41	82.08	85.56	81.02	86.75	70.06	67.03	74.61
10	EC 686543	56.56	60.95	59.70	59.07	42.07	46.82	30.89	39.93
11	EC 608269	46.55	63.78	59.81	56.72	42.91	47.60	34.54	41.68
12	EC 686553	47.20	58.40	46.74	50.78	45.22	42.73	30.89	39.61
13	PUSA 120	63.96	76.17	74.36	71.50	85.74	69.34	61.17	72.08
Mean		69.86	74.41	73.24	72.50	70.89	68.83	62.37	67.36
Range		102.45	111.28	105.60	102.47	106.67	112.88	99.67	104.17
		46.55	58.40	46.74	50.78	42.07	42.73	27.96	39.61
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		3.29		9.28		5.22		14.72	
Irrigation		1.58		NS		2.51		NS	
G X I		5.71		16.07		9.05		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

recorded in the genotype EC 686550 (20.44). Among the irrigation levels, significantly maximum total biomass ranged from 28 to 40.67 at control compared to 1.2 IW/CPE ratio 20.00 to 33.67 and 12.00 to 27.33 was noticed in 0.4 IW/CPE ratio. Non Significant interaction was observed at 45 DAT. However, the genotype EC 638519 had maximum biomass (40.67) and minimum total biomass had in the genotype EC 608269 (12.00)

During 90 DAT, genotype, EC 610661 had significantly maximum biomass (66.00) and was on par with EC 638519 (62.56) and Kashi Anupam (62.33), while minimum was recorded in the genotype EC 686543 (35.44). Among the irrigation levels, as the irrigation frequency decreased control to 0.4 IW/CPE ratio biomass was reduced to the extent of 44.02 per cent. Among the irrigation levels significantly varied from 52.67 to 82.3, 32.67 to 63.33 and 20.33 to 52.33 at control, 1.2 and 0.4 IW/CPE ratio. The interaction effects between genotypes and irrigation levels found to be non significant. However, EC610661 had higher total biomass (82.33) at control and the genotype EC 608269 had the least biomass (20.33) at 0.4 IW/CPE ratio.

PCV was observed of 28.11 per cent and 32.94 per cent at 45 and 90 DAS respectively. GCV of 24.45 per cent and 30.15 per cent, the broad sense heritability (75.65% and 83.80%), genetic advance (12.15 and 29.10) and GAM (43.81 and 56.81) were noticed at 45 and 90 DAS respectively.

4.2.3.8 Biomass duration (g/day) at different crop growth period

Biomass duration (BMD) was significantly differed within the genotypes, irrigation levels and their interaction effect at 45 to 90 DAT growth stage (Table 44).

During 45 to 90 DAT, genotype EC 610661 had significantly higher BMD (2.22), and it was on par with EC 638519 (2.16), Kashi Anupam (2.11) and EC 610652 (2.05) while, the least BMD was noticed in the genotype EC 686543 and EC 686550 (1.32) irrespective of irrigation levels. Interaction between genotypes and irrigation schedule was found significant. Significantly higher BMD was observed in the genotype EC 610661 and Kashi Anupam (2.69, each), which was on par with EC 638519 (2.58) and EC 610652 (2.52), wherein the BMD ranged between 1.91 to 2.69, 1.25 to 2.18 and 0.73 to 1.79 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Significantly lesser BMD was exhibited by the genotype EC 608269 (0.73) at 0.4 IW/CPE ratio.

Table 43. Influence of irrigation levels on total dry matter (g/plant) of tomato genotypes at 45 and 90 DAT

Sl. No.	Genotypes	Total dry matter at 45 DAT				Total dry matter at 90 DAT			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	32.00	26.67	21.67	26.78	63.33	54.67	41.33	53.11
2	EC 608362	32.00	28.67	24.00	28.22	67.67	55.33	41.33	54.78
3	EC 610652	38.33	31.67	24.67	31.56	73.67	59.00	46.00	59.56
4	EC 634394	32.67	27.00	25.00	28.22	62.00	50.33	38.00	50.11
5	EC 638519	40.67	32.67	26.67	33.33	74.00	62.33	51.33	62.56
6	EC 610661	37.33	33.67	27.33	32.78	82.33	63.33	52.33	66.00
7	EC 631962	35.67	29.00	23.00	29.22	62.67	52.00	40.33	51.67
8	EC 686550	28.00	20.00	13.33	20.44	57.00	36.00	21.33	38.11
9	Kashi Anupam	37.33	31.67	25.67	31.56	82.00	58.33	46.67	62.33
10	EC 686543	33.00	22.67	14.00	23.22	52.67	32.67	21.00	35.44
11	EC 608269	33.00	22.33	12.00	22.44	58.33	36.00	20.33	38.22
12	EC 686553	30.67	23.00	12.33	22.00	61.33	37.00	23.33	40.56
13	PUSA 120	36.33	29.00	27.00	30.78	65.67	53.33	39.67	52.89
Mean		34.38	27.54	21.28	27.74	66.36	50.03	37.15	51.18
Range		40.67	33.67	27.33	33.33	82.3	63.33	52.33	66.00
		28.00	20.00	12.00	20.44	52.67	32.67	20.33	35.44
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		1.28		3.61		2.26		6.37	
Irrigation		0.62		1.74		1.09		3.06	
G X I		2.22		NS		3.92		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

Table 44. Influence of irrigation levels on Biomass duration of tomato genotypes at 45 to 90 DAT

Sl. No.	Genotypes	Biomass duration			
		IW/CPE Ratio			
		Control	1.2	0.4	Mean
1	Arka Meghali	2.15	1.83	1.42	1.80
2	EC 608362	2.24	1.89	1.47	1.87
3	EC 610652	2.52	2.04	1.59	2.05
4	EC 634394	2.13	1.74	1.42	1.76
5	EC 638519	2.58	2.14	1.76	2.16
6	EC 610661	2.69	2.18	1.79	2.22
7	EC 631962	2.21	1.82	1.43	1.82
8	EC 686550	1.91	1.26	0.78	1.32
9	Kashi Anupam	2.69	2.03	1.63	2.11
10	EC 686543	1.93	1.25	0.79	1.32
11	EC 608269	2.06	1.31	0.73	1.37
12	EC 686553	2.07	1.35	0.80	1.41
13	PUSA 120	2.30	1.85	1.50	1.88
Mean		2.27	1.75	1.31	1.78
Range		2.69	2.18	1.79	2.22
		1.91	1.25	0.73	1.32
		S.Em±		CD at 5%	
Genotypes		0.07		0.18	
Irrigation		0.03		0.09	
G X I		0.11		0.32	

DAT = Days after transplanting

Control = Farmers practice

As the stress level increased from control to 0.4 IW/CPE ratio, BMD decreased significantly to the extent of 42.29 per cent at 45-90 DAT.

4.2.3.9 Absolute growth rate (g day^{-1}) at different crop growth period

There was significant difference for absolute growth rate (AGR) among the genotypes and irrigation levels during 45 to 90 DAT and the interaction effect was found non significant during 45 to 90 DAT crop growth period (Table 45).

Between 45 to 90 DAT, irrespective of the irrigation levels, genotype EC 610661 had significantly maximum AGR (0.74) and this was on par with Kashi Anupam (0.68), EC 638519 (0.65) and EC 610652 (0.62) and minimum was exhibited by the genotype EC 686543 (0.27). Significantly higher AGR was recorded in the control and it ranged from 0.44 to 1.00, while in 1.2 IW/CPE ratio ranged from 0.22 to 0.66 and least was observed at 0.4 IW/CPE ratio it varied from 0.16 to 0.56. Among the interaction effects found to a non significant. However, the maximum AGR was noticed in the genotype EC 610661 (1.00). The genotype EC 686543 (0.16) recorded the least AGR (0.09) at 0.4 IW/CPE ratio.

PCV was observed of 46.29 per cent at 45-90 DAT growth stage. GCV of 36.28 per cent, the broad sense heritability (61.44%), genetic advance (0.30) and GAM (58.59) were noticed at 45-90 DAT growth stage.

4.2.3.10 Crop growth rate ($\text{g.m}^{-2}.\text{day}^{-1}$) at different crop growth stages

There was significant difference for crop growth rate (CGR) among the genotypes and different pan evaporation ratios between the crop growth period of 45 to 90 DAT. Interaction between the genotypes and pan evaporation ratio was showed non significant at 45 to 90 DAT crop growth period (Table 45).

At 45 to 90 DAT, the genotype EC 610661 had significantly higher CGR (0.98) it was on par with Kashi Anupam (0.91), EC 638519 (0.87) and EC 610652 (0.83) whereas, EC 686543 showed significantly lesser CGR (0.36) irrespective of the irrigation levels. There was no significance difference in interaction effects. However, maximum CGR was observed in the genotype EC 610661 (1.33) at control and minimum was in EC 686543 (0.21) at 0.4 IW/CPE ratio. Irrespective of the different

growth stages at 45-75 DAT, irrigation levels showed significant difference with respect to CGR. Significantly higher CGR was observed in the control ranged from (0.58 to 1.33) compared to 1.2 IW/CPE ratio (0.30 to 0.88) and 0.4 IW/CPE ratio (0.21 to 0.74).

PCV was observed of 46.20 per cent at 45-90 DAT growth stage. GCV of 37.15 per cent, the broad sense heritability (64.67%), genetic advance (0.41) and GAM (61.55) were noticed at 45-90 DAT growth stage.

4.2.3.11 Relative growth rate ($\text{g/g/day} \times 10^2$) at various crop growth stages

There were non-significant differences for relative growth rate (RGR) among genotypes, pan evaporation and their interaction effects at 45-90 DAT (Table 46).

During 45 – 90 DAT there was no significant for RGR within the genotypes, pan evaporation ratios and their interaction effects. However, maximum RGR was noticed in EC 610661 among the genotypes and for interaction effect at control (0.67 and 0.77, respectively). Minimum RGR was noticed in the genotype EC 686543 (0.40) among the genotypes and EC 686543 at 1.2 IW/CPE ratio (1.2). Among the pan evaporation ratios, maximum RGR was exhibited at 1.2 IW/CPE ratio and minimum was noticed at 0.4 IW/CPE ratio and it varied from 0.36 0.68 and 0.38 to 0.64, respectively.

PCV was observed of 27.79 per cent at 45-90 DAT growth stage. GCV of 7.02 per cent, the broad sense heritability (6.38%), genetic advance (0.02) and GAM (3.65) were noticed at 45-90 DAT growth stage.

4.2.3.12 Net assimilation rate ($\text{g.cm}^{-2}/\text{day} \times 10^3$) during 45 to 90 DAT

Net assimilation rate (NAR) was significantly differed within genotypes but no significance for different irrigation levels and for interaction effects at growth stages during 45 to 90 DAT (Table 46).

At 45 to 90 DAT, irrespective of irrigation levels, significantly maximum NAR was observed in the genotype EC 686553 (0.33) and this was on par with EC 610661 (0.29) and significantly minimum was noticed in the genotype EC 634394 (0.15). Among the irrigation levels NAR exhibit a non significant. Interaction effect

Table 45. Influence of irrigation levels on crop growth rate ($\text{g/m}^2/\text{day}^1$) and absolute growth rate (g/day) of tomato genotypes between 45-90 DAT

Sl. No.	Genotypes	CGR 45-90 DAT				AGR 45-90 DAT			
		IW/CPE Ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	0.93	0.83	0.58	0.78	0.70	0.62	0.44	0.59
2	EC 608362	1.06	0.79	0.51	0.79	0.79	0.59	0.39	0.59
3	EC 610652	1.05	0.81	0.63	0.83	0.79	0.61	0.47	0.62
4	EC 634394	0.87	0.69	0.39	0.65	0.65	0.52	0.29	0.49
5	EC 638519	0.99	0.88	0.73	0.87	0.74	0.66	0.55	0.65
6	EC 610661	1.33	0.88	0.74	0.98	1.00	0.66	0.56	0.74
7	EC 631962	0.80	0.68	0.51	0.67	0.60	0.51	0.39	0.50
8	EC 686550	0.86	0.47	0.24	0.52	0.64	0.36	0.18	0.39
9	Kashi Anupam	1.32	0.79	0.62	0.91	0.99	0.59	0.47	0.68
10	EC 686543	0.58	0.30	0.21	0.36	0.44	0.22	0.16	0.27
11	EC 608269	0.75	0.40	0.25	0.47	0.56	0.30	0.19	0.35
12	EC 686553	0.91	0.41	0.33	0.55	0.68	0.31	0.24	0.41
13	PUSA 120	0.87	0.72	0.38	0.66	0.65	0.54	0.28	0.49
Mean		0.95	0.67	0.47	0.69	0.71	0.50	0.35	0.52
Range		1.33	0.88	0.74	0.98	1.0	0.66	0.56	0.74
		0.58	0.30	0.21	0.36	0.44	0.22	0.16	0.27
		S.Em $\pm$		CD at 5%		S.Em $\pm$		CD at 5%	
Genotypes		0.07		0.19		0.05		0.14	
Irrigation		0.03		0.09		0.02		0.07	
G X I		0.12		NS		0.09		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

Table 46. Relative growth rate ($\text{g/g/day} \times 10^2$) and Net assimilation rate ($\text{g/cm}^2/\text{day} \times 10^3$) of tomato genotypes influenced by irrigation levels

Sl. No	Genotypes	RGR				NAR			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	0.65	0.68	0.62	0.65	0.19	0.22	0.22	0.21
2	EC 608362	0.72	0.63	0.54	0.63	0.22	0.23	0.18	0.21
3	EC 610652	0.63	0.60	0.62	0.62	0.24	0.25	0.24	0.24
4	EC 634394	0.62	0.60	0.41	0.55	0.17	0.16	0.12	0.15
5	EC 638519	0.58	0.63	0.64	0.61	0.21	0.21	0.23	0.21
6	EC 610661	0.77	0.62	0.64	0.67	0.35	0.25	0.26	0.29
7	EC 631962	0.54	0.57	0.55	0.56	0.19	0.19	0.18	0.18
8	EC 686550	0.69	0.58	0.46	0.58	0.31	0.22	0.23	0.25
9	Kashi Anupam	0.77	0.59	0.58	0.65	0.28	0.22	0.22	0.24
10	EC 686543	0.45	0.36	0.39	0.40	0.23	0.16	0.21	0.20
11	EC 608269	0.55	0.46	0.51	0.51	0.28	0.21	0.25	0.24
12	EC 686553	0.69	0.47	0.62	0.59	0.38	0.24	0.37	0.33
13	PUSA 120	0.57	0.59	0.38	0.51	0.20	0.21	0.15	0.19
Mean		0.63	0.57	0.54	0.58	0.25	0.21	0.22	0.23
Range		0.77	0.68	0.64	0.67	0.4	0.25	0.37	0.33
		0.45	0.36	0.38	0.40	0.17	0.16	0.12	0.15
		S.Em $\pm$		CD at 5%		S.Em $\pm$		CD at 5%	
Genotypes		0.05		NS		0.02		0.07	
Irrigation		0.02		NS		0.01		NS	
G X I		0.09		NS		0.04		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

of genotypes and irrigation schedules were found to be non significant for NAR. However, higher NAR was in the genotype EC 686553 at CONTROL (0.40) and minimum in the EC 634394 (0.12) at 0.4 IW/CPE ratio.

PCV was observed of 35.95 per cent at 45-90 DAT growth stage. GCV of 16.26 per cent, the broad sense heritability (20.46%), genetic advance (0.03) and GAM (15.16) were noticed at 45-90 DAT growth stage.

4.2.4 Biophysical parameters

4.2.4.1. PAR (Lux)

There was a significant difference between the different irrigation levels, tomato genotypes and their interactions for the PAR at 75 DAT (Table 47).

The PAR varied from 1029.16 to 1492.57 at control, 1101.17 to 1517.01 at 1.2 IW/CPE ratio and 1067.43 to 1494.35 at 0.4 IW/CPE ratio. Among the genotypes EC 634394 had significantly maximum PAR (1370.75) and this was on par with EC 686553 (1348.65), EC 610652 (1319.09) and EC 686550 (1309.40). While, minimum PAR was recorded in the genotype EC 610661 (1181.78) irrespective of the irrigation levels. Interaction between the different irrigation schedules found significantly higher PAR was observed in the genotype EC 686550 (1517.01) at 1.2 IW/CPE ratio it was on par with EC 610652 (1494.35) and EC 634394 (1471.99) at 0.4 IW/CPE ratio and lower PAR was exhibited by the genotype EC 610661 (1029.16) at control.

PCV was observed of 124.02 per cent at 75 DAT. GCV of 92.81 per cent, the broad sense heritability (55.99%), genetic advance (163.82) and GAM (143.06) were noticed at 75 DAT.

4.2.4.2 Leaf temperature (°C)

There was significant difference in the leaf temperature between the genotypes, irrigation levels and their interaction effects at 75 DAT (Table 47).

Leaf temperature ranged from 30.54 to 35.52, 29.19 to 37.23 and 27.67 to 39.11 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, EC631962 (36.83) had significantly higher leaf temperature and was on par

with Arka Meghali (36.48) and EC 608362 (35.88). Minimum leaf temperature was noticed in the genotype EC 686550 (30.3). There was significant difference between the irrigation levels. Significantly higher leaf temperature was recorded in the 0.4 IW/CPE ratio (35.35) compared to control (32.34). Interaction of genotypes and irrigation levels the genotype Arka Meghali significantly maximum leaf temperature was recorded (39.11) at 0.4 IW/CPE ratio, it was on par with EC608362 (38.89), EC 610652 (38.19) and EC 634394 (38.05) at 0.4 IW/CPE ratio and minimum leaf temperature was recorded in the genotype EC 686550 (27.67) at 0.4 IW/CPE ratio.

PCV was observed of 2.86 per cent at 75 DAT. GCV of 2.71 per cent, the broad sense heritability (89.65%), genetic advance (6.06) and GAM (5.29) were noticed at 75 DAT.

4.2.4.3 Intercellular CO₂ content of the leaf (ppm)

In general, all the genotypes of tomato and pan evaporation ratios were significantly differed for intercellular CO₂ content of the leaf, but there was no significant interaction effects at 75 DAT (Table 48).

The internal CO₂ concentration ranged from 343.05 to 497.52, 367.06 to 505.67 and 355.81 to 498.12 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Among all the genotypes EC 634394 had significantly higher mean intercellular CO₂ level (456.92) it was on par with EC 686553 (449.55) and minimum was recorded in the genotype EC 610661 (393.93) irrespective of irrigation levels. Among the different pan evaporation ratios, significantly higher intercellular CO₂ was recorded in the 1.2 IW/CPE ratio (424.42) over 0.4 IW/CPE ratio (418.75). Interaction of genotypes and different pan evaporation ratios was non significant. However, maximum intercellular CO₂ content was exhibited by the genotype EC686550 (505.67) at 1.2 IW/CPE ratio and the minimum was found in the genotype EC 610661 (343.05) at control.

PCV was observed of 35.30 per cent at 75 DAT. GCV of 33.04 per cent, the broad sense heritability (85.89%), genetic advance (72.95) and GAM (63.71) were noticed at 75 DAT.

4.2.4.4 Rate of Transpiration ($\text{m.mol H}_2\text{O.m}^{-2}/\text{S}$)

Rate of transpiration significantly differed among the tomato genotypes and between the irrigation schedules and their interaction effects at 75 DAT (Table 48).

The transpiration rate varied from 7.26 to 11.84, 5.23 to 9.29 and 3.60 to 8.36 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Among the different genotypes EC 610661 (9.78) had significantly higher rate of transpiration and this was on par with EC 638519 (9.72) and significantly least rate of transpiration was exhibited by the genotype EC 686550 (6.09) irrespective of irrigation levels. With the increase in the stress from control to 0.4 IW/CPE ratio the rate of transpiration decreased 61.69 per cent. Interaction of genotypes and irrigation levels the genotype EC 638519 significantly maximum rate transpiration was recorded (11.84) at control. it was on par with EC 610661 (11.70), EC 686543 (11.39) and EC 608269 (10.95) at control and minimum rate transpiration was recorded in the genotype EC 608269 (3.60) at 0.4 IW/CPE ratio.

PCV was observed of 1.97 per cent at 75 DAT. GCV of 1.82 per cent, the broad sense heritability (89.35%), genetic advance (3.98) and GAM (3.47) were noticed at 75 DAT.

4.2.4.5 Stomatal conductance ($\text{m.mol.m}^{-2}/\text{s}$)

The genotypes, pan evaporation ratios and their interaction effects showed significant difference with respect to stomatal conductance (Table 49).

Stomatal conductance ranged from 0.65 to 1.05, 0.22 to 0.79 and 0.20 to 0.66 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, significantly higher stomatal conductance was recorded in the genotype Arka Meghali (0.83), which was on par with EC 638519 (0.81), EC 610661 (0.78) and EC 608362 (0.75) and The genotype EC 608269 recorded least stomatal conductance (0.37). There was significant difference between the pan evaporation ratios. Among the three irrigation levels, there was 71.74 per cent reduction in stomatal conductance when the stress was increased from control to 0.4 IW/CPE ratio. Interaction of genotypes and irrigation levels the genotype EC 638519 significantly higher stomatal conductance was recorded (1.05) at control. it was on par with Arka Meghali (1.03)

Table 47. Photosynthetic assimilation rate and leaf temperature of tomato genotypes as influenced by irrigation levels

Sl No.	Genotypes	PAR (Lux)				Leaf temperature (°C)			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	1305.88	1278.15	1254.92	1279.65	34.12	36.22	39.11	36.48
2	EC 608362	1232.63	1106.92	1295.05	1211.53	32.77	35.97	38.89	35.88
3	EC 610652	1256.57	1206.35	1494.35	1319.09	32.51	34.71	38.19	35.14
4	EC 634394	1181.41	1458.85	1471.99	1370.75	32.74	35.40	38.05	35.40
5	EC 638519	1192.91	1209.13	1298.67	1233.57	30.54	37.04	37.26	34.94
6	EC 610661	1029.16	1343.94	1172.22	1181.78	33.09	34.13	37.95	35.06
7	EC 631962	1341.27	1297.48	1191.68	1276.81	35.52	37.23	37.75	36.83
8	EC 686550	1343.75	1517.01	1067.43	1309.40	32.51	29.89	27.67	30.03
9	Kashi Anupam	1095.50	1233.11	1312.66	1213.76	33.92	35.93	37.59	35.81
10	EC 686543	1377.80	1293.10	1150.96	1273.95	33.75	29.19	30.45	31.13
11	EC 608269	1291.88	1238.99	1095.56	1208.81	32.01	30.86	28.57	30.48
12	EC 686553	1492.57	1268.37	1285.01	1348.65	31.70	30.57	30.32	30.86
13	PUSA 120	1253.25	1101.17	1240.74	1198.39	33.08	36.50	37.81	35.80
Mean		1261.12	1273.27	1256.25	1263.55	32.94	34.13	35.35	34.14
Range		1492.57	1517.01	1494.35	1370.75	35.52	37.23	39.11	36.83
		1029.16	1101.17	1067.43	1181.78	30.54	29.19	27.67	30.03
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		31.40		88.46		0.35		0.99	
Irrigation		15.09		42.49		0.17		0.48	
G X I		54.39		153.21		0.61		1.72	

DAT = Days after transplanting

Control = Farmers practice

Table 48. Transpiration rate and Inter cellular CO₂ level of tomato genotypes as influenced by irrigation levels

Sl No.	Genotypes	Transpiration rate (mmol H ₂ O/m ² /s)				Inter cellular CO ₂ level (ppm)			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	8.62	7.07	5.73	7.14	435.29	426.05	418.31	426.55
2	EC 608362	8.30	6.42	6.23	6.98	410.88	368.97	431.68	403.84
3	EC 610652	9.42	7.27	7.30	8.00	418.86	402.12	498.12	439.70
4	EC 634394	7.26	8.45	7.46	7.72	393.80	486.28	490.66	456.92
5	EC 638519	11.84	9.28	8.04	9.72	397.64	403.04	432.89	411.19
6	EC 610661	11.70	9.29	8.36	9.78	343.05	447.98	390.74	393.93
7	EC 631962	9.51	7.61	6.41	7.84	447.09	432.49	397.23	425.60
8	EC 686550	9.28	5.33	3.67	6.09	447.92	505.67	355.81	436.47
9	Kashi Anupam	10.00	7.89	6.94	8.27	365.17	411.04	437.55	404.59
10	EC 686543	11.39	5.31	4.89	7.20	459.27	431.03	383.65	424.65
11	EC 608269	10.95	5.23	3.60	6.59	430.63	413.00	365.19	402.94
12	EC 686553	9.22	5.41	3.97	6.20	497.52	422.79	428.34	449.55
13	PUSA 120	9.21	6.85	5.79	7.28	417.75	367.06	413.58	399.46
Mean		9.75	7.03	6.03	7.60	420.37	424.42	418.75	421.18
Range		11.84	9.29	8.36	9.78	497.52	505.67	498.12	456.92
		7.26	5.23	3.60	6.09	343.05	367.06	355.81	393.93
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.29		0.81		4.75		13.37	
Irrigation		0.14		0.39		2.28		6.42	
G X I		0.50		1.41		8.22		NS	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

and EC 610661 (0.96) at control and lower stomatal conductance was recorded in the genotype EC 686553 (0.20) at 0.4 IW/CPE ratio.

PCV was observed of 0.21 per cent at 75 DAT. GCV of 0.19 per cent, the broad sense heritability (84.74%), genetic advance (0.41) and GAM (0.36) were noticed at 75 DAT.

4.2.4.6 Rate of photosynthesis (m.mol CO₂/m/S)

There was a significant difference between the different pan evaporation rates, tomato genotypes and their interaction effects for the photosynthetic rate at 75 DAT (Table 49).

The rate of photosynthesis varied from 17.33 to 22.92 at control, 9.44 to 19.11 at 1.2 IW/CPE ratio and it was 3.89 to 13.68 at 0.4 IW/CPE ratio. Among the genotypes Arka Meghali had significantly more mean photosynthetic rate (18.50) and While, minimum photosynthetic rate was recorded in the genotype EC 686543 (11.20) irrespective of the irrigation levels. As the stress increased from control to 0.4 IW/CPE ratio, photosynthetic rate decreased. Interaction of genotypes and irrigation levels the genotype Arka Meghali significantly higher photosynthetic rate was recorded (22.92) at control. it was on par with EC 610661 (22.18), EC 631962 (21.64) and EC 638519 (21.60) at control and lower photosynthetic rate was exhibited by the genotype EC 686543 (3.89) at 0.4 IW/CPE ratio.

PCV was observed of 4.63 per cent at 75 DAT. GCV of 4.55 per cent, the broad sense heritability (96.43%), genetic advance (10.54) and GAM (9.20) were noticed at 75 DAT.

4.2.5 Biochemical parameters

4.2.5.1 Chlorophyll a content (mg. g-1of fresh weight)

Chlorophyll 'a' content significantly varied for genotypes, irrigation levels and interaction effects at 45 and 90 DAT, except interaction effects at 45 DAT (Table 50).

During 45 DAT, Irrespective of the irrigation levels, genotypes EC 638519 (1.77) had significantly higher chlorophyll 'a' content, it was on par with Kashi

Table 49. Photosynthesis and Stomatal conductance of tomato genotypes as influenced by irrigation levels

Sl No.	Genotypes	Photosynthesis (mmol CO ₂ /m ² /s)				Stomatal conductance (mmol /m ² /s)			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	22.92	18.91	13.68	18.50	1.03	0.79	0.66	0.83
2	EC 608362	18.18	16.78	12.81	15.92	0.89	0.74	0.63	0.75
3	EC 610652	19.20	16.57	12.71	16.16	0.72	0.71	0.61	0.68
4	EC 634394	20.07	16.66	12.43	16.39	0.65	0.64	0.57	0.62
5	EC 638519	21.60	17.21	11.56	16.79	1.05	0.75	0.62	0.81
6	EC 610661	22.18	19.11	10.12	17.13	0.96	0.73	0.65	0.78
7	EC 631962	21.64	16.77	7.99	15.47	0.76	0.64	0.49	0.63
8	EC 686550	19.06	12.81	5.29	12.39	0.69	0.27	0.29	0.42
9	Kashi Anupam	17.33	16.27	9.36	14.32	0.69	0.41	0.52	0.54
10	EC 686543	17.92	11.95	3.89	11.25	0.73	0.26	0.22	0.40
11	EC 608269	20.52	9.44	4.22	11.39	0.67	0.22	0.23	0.37
12	EC 686553	19.67	11.55	4.57	11.93	0.68	0.27	0.20	0.38
13	PUSA 120	17.69	15.68	10.98	14.78	0.71	0.50	0.34	0.52
Mean		19.85	15.36	9.20	14.80	0.79	0.53	0.46	0.59
Range		22.92	19.11	13.68	18.50	1.05	0.79	0.66	0.83
		17.33	9.44	3.89	11.25	0.65	0.22	0.20	0.37
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.33		0.94		0.03		0.09	
		0.16		0.45		0.02		0.04	
		0.58		1.63		0.05		0.15	
Irrigation									
G X I									

DAT = Days after transplanting

Control = Farmers practice (FP)

Table 50. Chlorophyll a (mg/g of fresh weight) contents as influenced by irrigation levels in tomato genotypes at 45 days and 90 DAT

Sl No.	Genotypes	Chlorophyll a 45 DAT				Chlorophyll a 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	2.07	1.46	1.31	1.61	1.54	1.27	0.98	1.26
2	EC 608362	1.85	1.50	1.46	1.60	1.77	1.36	1.03	1.39
3	EC 610652	2.21	1.51	1.40	1.71	1.81	1.20	0.64	1.22
4	EC 634394	1.79	1.43	1.27	1.50	1.35	1.21	1.06	1.20
5	EC 638519	2.32	1.48	1.51	1.77	1.59	1.59	0.68	1.29
6	EC 610661	2.12	1.56	1.32	1.67	1.81	0.97	0.69	1.15
7	EC 631962	2.06	1.63	1.37	1.69	1.83	1.14	0.94	1.30
8	EC 686550	1.42	1.05	0.83	1.10	1.44	0.47	0.26	0.73
9	Kashi Anupam	2.15	1.49	1.53	1.73	1.62	1.21	0.98	1.27
10	EC 686543	1.44	1.06	0.76	1.09	1.33	0.71	0.33	0.79
11	EC 608269	1.53	1.07	0.76	1.12	1.26	0.58	0.27	0.70
12	EC 686553	1.37	0.92	0.58	0.96	0.97	0.74	0.23	0.65
13	PUSA 120	1.91	1.40	1.29	1.53	1.42	1.17	1.07	1.22
Mean		1.87	1.35	1.18	1.47	1.52	1.05	0.70	1.09
Range		2.32	1.63	1.53	1.77	1.83	1.59	1.07	1.39
		1.37	0.92	0.58	0.96	0.97	0.47	0.23	0.65
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.06		0.16		0.07		0.19	
		0.03		0.08		0.03		0.09	
		0.10		NS		0.12		0.34	
Irrigation									
G X I									

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

Anupam (1.73), EC 610652 (1.71) and EC 631962 (1.69). The least content was observed in the genotype EC 686553 (0.96). As the stress increased from control to 0.4 IW/CPE ratio chlorophyll 'a' content was decreased significantly from 1.87 to 1.88. Chlorophyll 'a' content varied from 1.37 to 2.32, 0.92 to 1.63 and 0.58 to 1.53 at control, 1.2 and 0.4 IW/CPE ratio, respectively. There was no significant difference among the interaction effects. However, the genotype EC 638519 (2.32) had maximum Chlorophyll 'a' content and minimum was recorded in EC 686553 (0.58).

During 90 DAT, Irrespective of the irrigation levels, genotypes EC 608362 (1.39) had significantly higher chlorophyll 'a' content, it was on par with EC 631962 (1.30), EC 638519 (1.29) and Kashi Anupam (1.27). The least content was observed in the genotype EC 686553 (0.65). With the increase in the stress from control to 0.4 IW/CPE ratio the chlorophyll 'a' content decreased 53.95 per cent.

A significant interaction effect was observed between the genotypes and different pan evaporation ratios for chlorophyll 'a' content. Significantly maximum chlorophyll 'a' content was exhibited by the genotype EC 631962 (1.83) and this was on par with EC 610652 and EC 610661 (1.81, each), EC 608362 (1.77), Kashi Anupam (1.62) at control and minimum was observed in the genotype EC 686553 (0.23) at 0.4 IW/CPE ratio.

PCV was observed of 29.88 per cent and 44.29 per cent at 45 and 90 DAS respectively. GCV of 27.45 per cent and 40.00 per cent, the broad sense heritability (84.40% and 81.54%), genetic advance (0.76 and 0.18) and GAM (51.96 and 74.41) were noticed at 45 and 90 DAS respectively.

4.2.5.2 Chlorophyll 'b' content (mg.g-1of fresh weight)

Chlorophyll 'b' content significantly varied for genotypes, irrigation levels and interaction effects at 45 and 90 DAT. Except interaction effects at 45 DAT (Table 51).

During 45 DAT, Chlorophyll 'b' content ranged from 0.58 to 0.80, 0.22 to 0.53 and 0.13 to 0.44 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype EC 638519 (0.57) had significantly higher chlorophyll 'b' content and this was on par with Kashi Anupam (0.53) and EC 634394 (0.52). The genotype EC 686550 (0.31) showed significantly lower chlorophyll 'b' content.

Among the three irrigation levels, maximum chlorophyll 'b' content was recorded in the control (0.68) and compared to 0.4 IW/CPE ratio (0.30). There was no significant difference among the interaction effects. However, the genotype Kashi Anupam (0.80) had maximum Chlorophyll 'b' content and minimum was recorded in EC 686550 (0.13).

During 90 DAT, Chlorophyll 'b' content ranged from 0.51 to 0.83, 0.23 to 0.50 and 0.15 to 0.36 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype EC 631962 (0.54) had significantly higher chlorophyll 'b' content and the genotype EC 686543 (0.30) showed significantly lower chlorophyll 'b' content. Among the three irrigation levels, maximum chlorophyll 'b' content was recorded in the control (0.63) and compared to 0.4 IW/CPE ratio (0.25). A significant interaction effect was observed between the genotypes and different pan evaporation ratios for chlorophyll 'b' content. Significantly maximum chlorophyll 'b' content was exhibited by the genotype EC 634394 (0.83) and this was on par with EC 631962 (0.77) at control and minimum was observed in the genotype EC 686553 (0.15) at 0.4 IW/CPE ratio.

PCV was observed of 44.27 per cent and 44.55 per cent at 45 and 90 DAS respectively. GCV of 42.24 per cent and 43.70 per cent, the broad sense heritability (91.03% and 96.22%), genetic advance (0.36 and 0.36) and GAM (83.03 and 88.31) were noticed at 45 and 90 DAS respectively.

4.2.5.3 Total chlorophyll content (mg/gof fresh weight)

Total chlorophyll content significantly varied for genotypes, irrigation levels and interaction effects at 45 and 90 DAT, except interaction effects at 45 DAT (Table 52).

During 45 DAT, among the three irrigation levels, there was 71.62 per cent total chlorophyll content was reduced when the stress was increased from control to 0.4 IW/CPE ratio. Irrespective irrigation level, the genotypes EC 638519 (2.34) recorded significantly higher total chlorophyll content compared to other genotypes and lower was recorded in the EC 608269 (1.29). Interaction effects was observed non significance. However, maximum total chlorophyll content was observed in the genotype EC 638519 (3.09) at control while, the genotype EC 686553 at 0.4 IW/CPE ratio had lower total chlorophyll content (0.75) compared to other genotypes.

Table 51. Chlorophyll b contents (mg/g of fresh weight) as influenced by irrigation levels in tomato genotypes at 45 and 90 DAT

Sl No.	Genotypes	Chlorophyll b 45 DAT				Chlorophyll b 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	0.64	0.34	0.27	0.42	0.71	0.38	0.28	0.46
2	EC 608362	0.73	0.39	0.27	0.46	0.66	0.34	0.29	0.43
3	EC 610652	0.67	0.38	0.31	0.45	0.62	0.34	0.27	0.41
4	EC 634394	0.70	0.49	0.38	0.52	0.83	0.39	0.26	0.49
5	EC 638519	0.76	0.53	0.40	0.57	0.62	0.43	0.25	0.43
6	EC 610661	0.67	0.38	0.33	0.46	0.60	0.47	0.36	0.48
7	EC 631962	0.65	0.43	0.29	0.46	0.77	0.50	0.36	0.54
8	EC 686550	0.59	0.22	0.13	0.31	0.58	0.26	0.20	0.35
9	Kashi Anupam	0.80	0.39	0.39	0.53	0.65	0.49	0.24	0.46
10	EC 686543	0.58	0.22	0.21	0.34	0.52	0.23	0.16	0.30
11	EC 608269	0.67	0.27	0.24	0.39	0.56	0.26	0.16	0.33
12	EC 686553	0.60	0.22	0.17	0.33	0.62	0.25	0.15	0.34
13	PUSA 120	0.72	0.34	0.44	0.50	0.51	0.36	0.28	0.38
Mean		0.68	0.35	0.30	0.44	0.63	0.36	0.25	0.42
Range		0.80	0.53	0.44	0.57	0.83	0.50	0.36	0.54
		0.58	0.22	0.13	0.31	0.51	0.23	0.15	0.30
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.02		0.06		0.01		0.03	
Irrigation		0.01		0.03		0.01		0.02	
G X I		0.03		NS		0.02		0.06	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

Table 52. Total Chlorophyll content (mg/g of fresh weight) as influenced by irrigation levels in tomato genotypes at 45 and 90 DAT

Sl No.	Genotypes	Total chlorophyll 45 DAT				Total Chlorophyll 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	2.72	1.79	1.58	2.03	2.25	1.65	1.26	1.72
2	EC 608362	2.58	1.89	1.73	2.07	2.42	1.70	1.33	1.82
3	EC 610652	2.87	1.90	1.71	2.16	2.43	1.54	0.91	1.63
4	EC 634394	2.49	1.92	1.65	2.02	2.17	1.60	1.31	1.69
5	EC 638519	3.09	2.01	1.91	2.34	2.21	2.03	0.92	1.72
6	EC 610661	2.79	1.94	1.65	2.13	2.41	1.44	1.05	1.63
7	EC 631962	2.71	2.07	1.66	2.15	2.60	1.64	1.30	1.84
8	EC 686550	2.01	1.27	0.95	1.41	2.03	0.73	0.46	1.07
9	Kashi Anupam	2.96	1.89	1.92	2.26	2.28	1.70	1.22	1.73
10	EC 686543	2.02	1.29	0.97	1.43	1.85	0.94	0.49	1.09
11	EC 608269	2.20	1.34	1.00	1.51	1.82	0.83	0.44	1.03
12	EC 686553	1.98	1.13	0.75	1.29	1.59	0.99	0.38	0.99
13	PUSA 120	2.63	1.74	1.73	2.03	1.93	1.53	1.35	1.61
Mean		2.54	1.70	1.48	1.91	2.15	1.41	0.96	1.51
Range		3.09	2.07	1.92	2.34	2.60	2.03	1.35	1.84
		1.98	1.13	0.75	1.29	1.59	0.73	0.38	0.99
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.06		0.17		0.07		0.20	
Irrigation		0.03		0.08		0.03		0.10	
G X I		0.11		NS		0.12		0.35	

DAT = Days after transplanting

NS = Non Significant

Control = Farmers practice

During 90 DAT, among the irrigation level significantly highest was recorded in the control (2.15) compared to the high stress level of 0.4 IW/CPE ratio (0.96). Among the genotypes significantly maximum total chlorophyll was recorded in EC 631962 (1.84) which is on par with EC 608362 and minimum was recorded in the EC 686533 (0.99). A significant interaction effect of maximum total chlorophyll content was exhibited by the genotype EC 631962 (2.60) and this was on par with EC 610652 (2.43), EC 608362 (2.42), EC 610661 (2.41) and Kashi Anupam (2.28) at control and minimum was observed in the genotype EC 686553 (0.38) at 0.4 IW/CPE ratio.

PCV was observed of 31.73 per cent and 42.23 per cent at 45 and 90 DAS respectively. GCV of 30.22 per cent and 39.82 per cent, the broad sense heritability (90.72% and 88.81%), genetic advance (1.13 and 1.16) and GAM (59.29 and 77.27) were noticed at 45 and 90 DAS respectively.

4.2.5.4 Carotenoid content (mg/g of fresh weight)

Carotenoid content significantly varied for genotypes, irrigation levels and interaction effects at both 45 and 90 DAT (Table 53).

During 45 DAT, carotenoid content ranged from 1.18 to 2.72, 1.70 to 5.55 and 1.07 to 4.73 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype EC 631962 (3.77) had significantly higher carotenoid content and which was on par with EC 610661 (3.67), EC 638519 (3.57) and Pusa 120 (3.52) and the genotype EC 608269 (1.43) showed significantly lower carotenoid content. Among the three irrigation levels, maximum carotenoid content was recorded in the 1.2 IW/CPE ratio (3.34) and compared to control (2.04). A significant interaction effect was observed, maximum carotenoid content was exhibited by the genotype EC 631962 (5.55) and this was on par with EC 610661 (5.14) at 1.2 IW/CPE ratio and minimum was observed in the genotype EC 686553 (1.07) at 0.4 IW/CPE ratio.

During 90 DAT, carotenoid content ranged from 1.25 to 3.23, 0.98 to 3.62 and 0.71 to 4.27 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype EC 634394 (3.68) had significantly higher carotenoid content, it was on par with EC 610661 (3.59) and the genotype EC 686553 (0.98) showed significantly lower carotenoid content. Among the three irrigation levels,

Table 53. Carotenoid contents (mg/g) in leaves of tomato genotypes as influenced by irrigation levels

Sl No.	Genotypes	Carotenoid content at 45 DAT				Carotenoid content at 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	2.72	3.15	3.56	3.14	1.81	2.17	2.84	2.27
2	EC 608362	2.42	3.26	3.76	3.15	1.53	2.41	3.37	2.44
3	EC 610652	2.44	2.64	2.79	2.63	2.42	3.28	3.95	3.22
4	EC 634394	1.66	3.59	3.56	2.94	3.23	3.55	4.27	3.68
5	EC 638519	1.44	4.55	4.73	3.57	2.59	3.42	3.81	3.27
6	EC 610661	2.03	5.14	3.84	3.67	3.03	3.62	4.13	3.59
7	EC 631962	1.43	5.55	4.35	3.77	3.11	3.31	3.80	3.40
8	EC 686550	1.83	2.05	1.56	1.81	1.30	1.09	0.75	1.05
9	Kashi Anupam	2.50	4.09	2.77	3.12	2.38	2.89	3.52	2.93
10	EC 686543	1.66	2.28	1.12	1.69	1.25	1.16	0.78	1.06
11	EC 608269	1.18	1.79	1.31	1.43	1.55	1.14	0.85	1.18
12	EC 686553	2.69	1.70	1.07	1.82	1.26	0.98	0.71	0.98
13	PUSA 120	2.55	3.62	4.40	3.52	1.99	2.73	3.53	2.75
Mean		2.04	3.34	2.99	2.79	2.11	2.44	2.79	2.45
Range		2.72	5.55	4.73	3.77	3.23	3.62	4.27	3.68
		1.18	1.70	1.07	1.43	1.25	0.98	0.71	0.98
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		0.11		0.32		0.09		0.25	
Irrigation		0.05		0.15		0.04		0.12	
G X I		0.20		0.55		0.15		0.43	

DAT = Days after transplanting

Control = Farmers practice (FP)

Table 54. Influence of irrigation levels on proline (µg/g of fresh leaf weight) contents of tomato genotypes

Sl No.	Genotypes	Proline 45 DAT				Proline 90 DAT			
		IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	179.19	242.12	336.78	252.69	220.25	319.11	380.84	306.73
2	EC 608362	220.35	256.91	338.58	271.94	241.64	351.84	423.47	338.98
3	EC 610652	259.71	301.91	404.95	322.19	300.71	378.90	474.31	384.64
4	EC 634394	177.94	221.79	297.98	232.57	184.35	303.60	370.24	286.06
5	EC 638519	220.33	264.58	424.73	303.21	230.90	350.54	498.59	360.01
6	EC 610661	195.00	273.41	372.10	280.17	226.43	329.01	418.63	324.69
7	EC 631962	182.91	255.92	351.58	263.47	192.20	302.91	341.95	279.02
8	EC 686550	130.64	113.88	91.61	112.04	131.44	124.09	87.27	114.27
9	Kashi Anupam	156.57	207.06	281.43	215.02	164.48	239.09	325.08	242.88
10	EC 686543	109.63	115.57	107.68	110.96	115.31	123.35	95.20	111.29
11	EC 608269	101.80	101.57	93.91	99.09	93.04	97.20	89.38	93.21
12	EC 686553	82.05	89.24	98.10	89.80	118.67	95.11	87.74	100.51
13	PUSA 120	126.40	214.37	257.58	199.45	168.00	261.72	310.85	246.85
Mean		164.81	204.49	265.92	211.74	183.65	252.04	300.27	245.32
Range		259.71	301.91	424.73	322.19	300.71	378.90	498.59	384.64
		82.05	89.24	91.61	89.80	93.04	95.11	87.27	93.21
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes		4.23		11.91		4.63		13.05	
Irrigation		2.03		5.72		2.23		6.27	
G X I		7.33		20.63		8.03		22.60	

DAT = Days after transplanting

Control = Farmers practice

maximum carotenoid content was recorded in the 0.4 IW/CPE ratio (2.79) compared to control (2.11). A significant interaction effect was observed between the genotypes and different pan evaporation ratios for carotenoid content. Significantly maximum carotenoid content was exhibited by the genotype EC 634394 (4.27) and this was on par with EC 610661 (4.13) and EC 610652 (3.95) at 0.4 IW/CPE ratio and minimum was observed in the genotype EC 686553 (0.71) at 0.4 IW/CPE ratio.

PCV was observed of 44.18 per cent and 46.34 per cent at 45 and 90 DAS respectively. GCV of 42.45 per cent and 45.06 per cent, the broad sense heritability (92.33% and 94.56%), genetic advance (2.34 and 2.21) and GAM (84.04 and 90.26) were noticed at 45 and 90 DAS respectively.

4.2.5.4 Proline ($\mu\text{g/g}$ of fresh weight)

Proline content of leaf indicated significant difference among the genotypes and irrigation levels and their interaction effects at 45 and 90 DAT (Table 54).

During 45 DAT, proline content ranged from 82.05 to 259.71, 89.24 to 301.91 and 91.61 to 424.73 at control, 1.2 and 0.4 IW/CPE ratio respectively. Irrespective of the irrigation levels, genotype EC 610652 observed significantly higher proline content (322.19) while, least proline was found in the genotype EC 686553 (89.80). Among the irrigation levels, as the stress increased from control to 0.4 IW/CPE ratio there was significant increase in proline content (38.02 %). A significant interaction effect was observed between the genotypes and different pan evaporation ratios for proline content. Significantly maximum proline content was exhibited by the genotype EC 638519 (424.73) and this was on par with EC 610652 (404.95) at 0.4 IW/CPE ratio and minimum was observed in the genotype EC 686553 (82.05) at 0.4 IW/CPE ratio.

During 90 DAT, Proline content ranged from 93.04 to 300.71, 95.11 to 378.90 and 87.27 to 498.59 at control, 1.2 and 0.4 IW/CPE ratio respectively. Irrespective of the irrigation levels, genotype EC 610652 observed significantly higher proline content (384.64) while, least proline was found in the genotype EC 608269 (93.21). Among the irrigation levels, as the stress increased from control to 0.4 IW/CPE ratio there was significant increase in proline content (38.83 %).

A significant interaction effect was observed between the genotypes and different pan evaporation ratios for proline content. Significantly maximum proline content was exhibited by the genotype EC 638519 (498.59) and minimum was observed in the genotype EC 686550 (87.27) at 0.4 IW/CPE ratio.

PCV was observed of 45.83 per cent and 49.48 per cent at 45 and 90 DAS respectively. GCV of 45.44 per cent and 49.16 per cent, the broad sense heritability (98.29% and 98.68%), genetic advance (196.51 and 246.82) and GAM (92.81 and 100.61) were noticed at 45 and 90 DAS respectively.

4.2.5.5 Ascorbic acid (mg/100 g of fruit)

Ascorbic acid content varied significantly among the genotypes, pan evaporation rates and their interaction (Table 56).

Ascorbic acid content varied from 13.49 to 16.7, 15.24 to 29.47 and 18.43 to 34.73 at control, 1.2 and 0.4 IW/CPE ratio, respectively. Irrespective of the irrigation levels, genotype Pusa 120 had significantly higher ascorbic acid content (25.90) it was on par with EC 610661 (25.39), EC 634394 (25.09), Kashi Anupam (24.98), EC 610652 (24.81) and EC 638519 (23.80) while, least was found in the genotype EC 686553 (16.27). As stress increased from control to 0.4 IW/CPE, there was significant increase in ascorbic acid content (46.88 %) was noticed. A significant interaction effect was observed between the genotypes and different pan evaporation ratios for ascorbic acid content. Significantly maximum Ascorbic acid content was exhibited by the genotype Pusa 120 (34.73) it was on par with EC 610661 (34.16), EC 634394 (32.90) and EC 610652 (31.73) at 0.4 IW/CPE ratio and minimum was observed in the genotype Pusa 120 (13.49) at control.

PCV was observed of 34.15 per cent and GCV of 30.62 per cent, the broad sense heritability (80.39%), genetic advance (12.47) and GAM (56.55) were noticed.

4.2.5.6 Lycopene (mg/100 g fruit weight)

There was a significance difference was noticed for lycopene content among the genotypes, irrigation levels and their interaction (Table 56).

Genotype EC 610661 recorded significantly highest lycopene content (2.77) and this was on par with EC 638519 (2.51), while, least was observed in EC 608269 (1.23) irrespective of the irrigation schedules. Among the irrigation levels, 0.4 IW/CPE ratio recorded maximum lycopene content of 2.58 compared to 1.2 IW/CPE ratio (2.23) and control (1.28). Among the interaction effects of genotypes and irrigation levels, EC 638519 recorded higher lycopene content (3.15) at 0.4 IW/CPE ratio it was on par with EC 610661 (3.11), EC 608362 and EC 610652 (3.02) and least was noticed in EC 686550 (0.80) at control.

PCV was observed of 40.49 per cent and GCV of 35.82 per cent, the broad sense heritability (78.24%), genetic advance (1.34) and GAM (65.27) were noticed.

4.2.5.7 Total soluble solid (TSS) (°Brix)

Total soluble solid varied significantly among the genotypes, irrigation schedules and their interaction (Table 55).

Genotype EC 638519 recorded significantly maximum °Brix of TSS (7.54) and this was on par with EC 610652 and EC 610661 (7.33, each), EC 634394 (7.18) and genotype EC 686550 observed least TSS (5.84) irrespective of the irrigation levels. Among the irrigation schedules 0.4 IW/CPE ratio showed maximum TSS compared to other irrigation levels. Among the interaction effects of genotypes and irrigation levels, EC 638519 exhibited higher TSS (9.10) and this on par with EC 610661 (9.04), EC 610652 (8.93) and EC 634934 (8.38) at 0.4 IW/CPE ratio and lesser TSS was noticed in the genotype EC 608362 (3.99) at control.

PCV was observed of 21.00 per cent and GCV of 17.33 per cent, the broad sense heritability (68.13%), genetic advance (1.94) and GAM (29.47) were noticed.

4.2.6 Yield and yield components

4.2.6.1 Yield (kg/plant and t/ha)

There was significant difference for yield per plant and yield per hectare among genotypes, irrigation levels and interaction effects (Table 57).

Table 55. Influence of irrigation levels on TSS content of Tomato genotypes

Sl. No.	Genotypes	TSS			
		IW/CPE Ratio			
		Control	1.2	0.4	Mean
1	Arka Meghali	5.72	6.51	7.85	6.70
2	EC 608362	3.99	7.18	7.23	6.13
3	EC 610652	5.83	7.23	8.92	7.33
4	EC 634394	6.01	7.15	8.38	7.18
5	EC 638519	5.48	8.05	9.10	7.54
6	EC 610661	5.23	7.73	9.04	7.33
7	EC 631962	5.63	7.54	6.80	6.66
8	EC 686550	4.53	7.23	5.75	5.84
9	Kashi Anupam	4.99	7.21	6.84	6.35
10	EC 686543	5.20	6.30	6.23	5.91
11	EC 608269	5.92	5.79	6.97	6.23
12	EC 686553	5.37	6.10	6.39	5.95
13	PUSA 120	5.39	6.21	7.74	6.44
Mean		5.33	6.94	7.48	6.58
Range		6.01	8.05	9.10	7.54
		3.99	5.79	5.75	5.84
		S.Em±		CD at 5%	
Genotypes		0.26		0.73	
Irrigation		0.12		0.35	
G X I		0.45		0.32	

DAT = Days after transplanting

Control = Farmers practice

Table 56. Lycopene (mg/100 g fruit weight) and Ascorbic acid (mg/100 g fresh leaf weight) content of tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Ascorbic acid content				Lycopene content			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	13.74	27.22	29.17	23.38	1.53	2.45	2.87	2.28
2	EC 608362	13.89	24.39	27.11	21.79	1.43	2.66	3.02	2.37
3	EC 610652	16.68	26.03	31.73	24.81	1.24	2.81	3.02	2.36
4	EC 634394	16.67	25.69	32.90	25.09	0.93	2.55	2.74	2.07
5	EC 638519	15.50	25.05	30.86	23.80	1.45	2.94	3.15	2.51
6	EC 610661	15.15	26.85	34.16	25.39	2.24	2.97	3.11	2.77
7	EC 631962	14.18	26.08	30.78	23.68	0.96	2.42	2.85	2.08
8	EC 686550	14.47	18.09	20.68	17.75	0.80	1.85	1.86	1.50
9	Kashi Anupam	15.42	28.34	31.19	24.98	1.34	2.71	2.93	2.33
10	EC 686543	13.73	17.94	20.20	17.29	1.64	1.96	1.93	1.84
11	EC 608269	14.19	15.89	19.99	16.69	0.98	1.21	1.49	1.23
12	EC 686553	15.13	15.24	18.43	16.27	1.14	1.42	1.59	1.38
13	PUSA 120	13.49	29.47	34.73	25.90	0.91	2.43	2.98	2.11
Mean		14.79	23.56	27.84	22.06	1.28	2.34	2.58	2.07
Range		16.70	29.47	34.73	25.90	2.24	2.97	3.15	2.77
		13.49	15.24	18.43	16.27	0.80	1.21	1.49	1.23
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		1.11		3.13		0.13		0.37	
Irrigation		0.53		1.50		0.06		0.18	
G X I		1.93		5.43		0.23		0.63	

DAT = Days after transplanting

Control = Farmers practice

Irrespective of irrigation levels, genotype EC631962 had significantly maximum yield ($1.65 \text{ kg plant}^{-1}$ and 49.83 t ha^{-1}) and this was on par with Arka Meghali ($1.62 \text{ kg plant}^{-1}$ and 48.97 t ha^{-1}) and EC 634394 ($1.55 \text{ kg plant}^{-1}$ and 46.22 t ha^{-1}). Significantly minimum yield was found in EC 608269 ($1.17 \text{ kg plant}^{-1}$ and 32.06 t ha^{-1}). Among the different irrigation levels, control recorded significantly highest yield compared to 0.4 IW/CPE ratio. As the stress level increased, yield was reduced to 34.68 per cent. Among the interaction effects of genotypes and irrigation levels, genotype EC 631962 had significantly maximum yield ($1.95 \text{ kg plant}^{-1}$ and 61.30 t ha^{-1}) and this was on par with Arka Meghali ($1.89 \text{ kg plant}^{-1}$ and 58.83 t ha^{-1}) and EC 686550 ($1.79 \text{ kg plant}^{-1}$ and 55.25 t ha^{-1}). Significantly minimum yield was found in EC 608269 ($0.66 \text{ kg plant}^{-1}$ and 13.41 t ha^{-1}).

PCV was observed of 22.37 per cent and GCV of 21.12 per cent, the broad sense heritability (89.12%), genetic advance (0.58) and GAM (41.05) were noticed at yield per plant.

4.2.6.2 Fruit parameters

4.2.6.2.1 No. of fruits per plant

In general, as the stress level increased there was significant decrease in number of fruits per plant was observed within the genotypes, different irrigation levels and their interaction (Table 58).

Irrespective of the irrigation levels, genotype EC 638519 had significantly greater number of fruits per plant (111.91) and minimum was observed in the genotype EC 608269 (20.75). Among the three irrigation levels, control had significantly more number of fruits per plant compared to 0.4 IW/CPE ratio and it varied from 24.71 to 128.27, 19.83 to 113.63 and 15.48 to 93.82 at control, 1.2 and 0.4 IW/CPE ratio respectively. Among the interaction, genotypes EC 638519 (128.27) had significantly maximum number of fruits per plant at control and minimum number of fruits per plant was observed in the genotype EC 608269 (15.48) at 0.4 IW/CPE ratio.

PCV was observed of 82.64 per cent and GCV of 82.33 per cent, the broad sense heritability (99.25%), genetic advance (61.85) and GAM (168.98) were noticed.

Table 57. Yield per plant (kg/plant) and yield per hectare (t/ha) in tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Yield/plant				Yield/ hectare			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	1.89	1.65	1.33	1.62	58.83	49.95	38.14	48.97
2	EC 608362	1.77	1.50	1.28	1.52	54.48	44.33	36.21	45.01
3	EC 610652	1.65	1.44	1.22	1.44	49.98	42.19	34.19	42.12
4	EC 634394	1.79	1.52	1.33	1.55	55.10	45.25	38.33	46.22
5	EC 638519	1.67	1.46	1.27	1.47	50.83	42.94	36.03	43.27
6	EC 610661	1.59	1.31	1.21	1.37	47.61	37.55	33.76	39.64
7	EC 631962	1.95	1.62	1.37	1.65	61.29	48.73	39.48	49.83
8	EC 686550	1.79	1.24	0.95	1.33	55.25	34.72	24.07	38.01
9	Kashi Anupam	1.66	1.39	1.24	1.43	50.48	40.55	34.98	42.01
10	EC 686543	1.69	1.21	0.82	1.24	51.33	33.74	19.25	34.77
11	EC 608269	1.62	1.22	0.66	1.17	48.75	33.99	13.41	32.05
12	EC 686553	1.64	1.20	0.70	1.18	49.49	33.32	14.70	32.50
13	PUSA 120	1.77	1.39	1.27	1.48	54.36	40.36	35.85	43.52
Mean		1.73	1.40	1.13	1.42	52.91	40.59	30.65	41.38
Range		1.95	1.65	1.37	1.65	61.3	49.95	39.48	49.83
		1.59	1.20	0.66	1.17	47.61	33.32	13.41	32.05
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.04		0.1		1.29		3.64	
Irrigation		0.02		0.05		0.62		1.75	
G X I		0.06		0.17		2.24		6.30	

DAT = Days after transplanting

Control = Farmers practice

Table 58. Number of fruits and average fruit weight (g) in tomato genotypes as influenced by irrigation levels

Sl. No.	Genotypes	Number of fruits / plant				Average fruit weight			
		IW/CPE Ratio							
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	29.41	26.89	25.58	27.29	65.35	61.36	52.03	59.58
2	EC 608362	27.32	26.07	23.25	25.55	70.54	57.50	55.38	61.14
3	EC 610652	29.46	26.04	25.31	26.93	56.09	55.50	48.38	53.32
4	EC 634394	27.36	25.10	22.14	24.86	67.95	60.75	60.40	63.03
5	EC 638519	128.27	113.63	93.82	111.91	13.06	12.86	13.58	13.17
6	EC 610661	108.03	96.57	89.01	97.87	14.68	13.61	13.62	13.97
7	EC 631962	24.71	25.54	23.75	24.67	79.28	64.84	56.08	66.73
8	EC 686550	26.74	21.63	16.68	21.68	67.24	59.51	38.32	55.02
9	Kashi Anupam	25.95	26.28	24.69	25.64	64.04	53.07	50.44	55.85
10	EC 686543	27.05	20.02	17.11	21.39	62.38	54.37	39.10	51.95
11	EC 608269	26.92	19.83	15.48	20.75	62.26	61.59	34.75	52.87
12	EC 686553	27.50	21.53	16.48	21.84	59.55	55.81	33.83	49.73
13	PUSA 120	29.16	25.47	21.80	25.48	60.63	54.50	58.16	57.77
Mean		41.37	36.51	31.93	36.60	57.16	51.17	42.62	50.32
Range		128.27	113.63	93.82	111.91	79.3	64.84	60.40	66.73
		24.71	19.83	15.48	20.75	13.06	12.86	13.58	13.17
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.87		2.46		1.61		4.53	
Irrigation		0.42		1.18		0.77		2.18	
G X I		1.51		4.25		2.79		7.85	

DAT = Days after transplanting

Control = Farmers practice

4.2.6.2.2 Average fruit weight (g)

In general, as the stress level increased there was significant decrease in average fruit weight was observed within the genotypes, different irrigation levels and their interaction (Table 58).

Irrespective of the irrigation levels, genotype EC 631962 had significantly greater average fruit weight (66.73) it was on par with EC 634394 (63.03) and minimum was observed in the genotype EC 638519 (13.17). Among the three irrigation levels, control had significantly more average fruit weight compared to 1.2 and 0.4 IW/CPE ratio and it varied from 13.06 to 79.3, 12.86 to 64.84 and 13.58 to 60.40 respectively. Among the interaction effects average fruit weight was found significantly the genotypes EC631962 (79.30) had significantly maximum fruit weight at control and minimum average fruit weight was observed in the genotype EC 638519 (12.86) at 1.2 IW/CPE ratio.

PCV was observed of 37.15 per cent and GCV of 35.89 per cent, the broad sense heritability (93.32%), genetic advance (35.94) and GAM (71.43) were noticed.

4.2.6.2.3 Equatorial diameter of fruit (mm)

In general equatorial diameter of fruit showed significant difference among genotypes, pan evaporation ratios and their interactions (Table 59).

Irrespective of the irrigation levels, genotype EC 634394 showed highest equatorial diameter of fruit (36.13) and Genotype EC610661 recorded least equatorial diameter of fruit (10.18). Among the pan evaporation ratios, significantly maximum equatorial diameter was observed in control (32.72) and minimum was observed at 0.4 IW/CPE ratio (23.29). Interaction had significant difference, wherein the genotype Kashi Anupam had significantly higher equatorial diameter of the fruit (42.01) under control condition and this was on par with EC 634394 (41.51) at control and significantly minimum was observed in the genotype EC 610661 (8.77) at 0.4 IW/CPE ratio.

PCV was observed of 33.21 per cent and GCV of 33.07 per cent, the broad sense heritability (99.13%), genetic advance (18.89) and GAM (67.83) were noticed.

4.2.6.2.4 Polar diameter of fruit (mm)

Polar diameter of fruit had significant difference among the genotypes, irrigation levels and for interaction effects (Table 59).

Among the irrigation levels, the genotype EC 634394 had significantly maximum polar diameter (37.46) it was on par with EC 631962 (35.93) and significantly minimum polar diameter was observed in the genotype EC 610661 (11.56). Among Irrigation schedules had significantly, higher polar diameter was observed in control, compared to 1.2 and 0.4 IW/CPE ratio and it varied from 13.82 to 44.93, 11.44 to 37.53 and 9.42 to 32.81, respectively. Interaction effect had significance difference among the genotypes and irrigation levels. Significantly highest polar diameter was observed in the genotype EC 631962 (44.93) it was on par EC 686550 (44.70) at control ratio and minimum was observed in the genotype EC 610661 (9.42) at 0.4 IW/CPE ratio.

PCV was observed of 32.71 per cent and GCV of 32.25 per cent, the broad sense heritability (97.15%), genetic advance (19.32) and GAM (65.48) were noticed.

4.2.6.2.5 Pericarp thickness (mm)

Pericarp thickness had significant difference among the genotypes, irrigation levels and their interaction (Table 60).

Genotype Arka Meghali had significantly maximum pericarp thickness (3.30) and it was on par with EC 631962 (3.18), EC 608362 (3.16), EC610652 and EC 634394 (3.14, each).while, minimum pericarp thickness was observed in the genotype EC 610661 (1.17) irrespective of the irrigation levels. Among the three irrigation levels, significantly higher pericarp thickness was observed under control condition (3.34) as against the least at 1.2 (2.55) and 0.4 IW/CPE ratio (1.86). Ranged between 1.41 to 4.30, 1.17 to 3.34 and 0.93 to 2.58, respectively. Interaction between the genotypes and irrigation levels was significant. Significantly highest pericarp thickness was observed in the genotype EC 631962 (4.30) at control on par with Arka Meghali (4.14) and EC 608362 (4.03) and the least was observed in the genotype EC 610661 (0.93) at 0.4 IW/CPE ratio.

PCV was observed of 38.13 per cent and GCV of 36.74 per cent, the broad sense heritability (92.84%), genetic advance (1.88) and GAM (72.93) were noticed.

4.2.6.2.5 Number of locules per fruit

Significant difference among the genotypes, pan evaporation ratios and their interaction was observed for number of locules per fruit (Table 60).

Among the genotypes, Arka Meghali had significantly higher number of locules per fruit (4.42) and the lower number (3.05) was found in the genotype EC 686550. Significant difference was observed for the interaction effect. Genotype Arka Meghali (5.10) had significantly higher locules per fruit at 0.4 IW/CPE ratio and significantly minimum was found in EC 686550 (2.67) at 1.2 IW/CPE ratio. As the stress level increased, number of locules were increased.

PCV was observed of 16.67 per cent and GCV of 15.45 per cent, the broad sense heritability (85.88%), genetic advance (1.06) and GAM (29.49) were noticed.

To confirm the drought tolerance of tomato genotypes through molecular markers

4.2.7 SSR Analysis

4.2.7.1 Primer selection for SSR analysis

After screening six SSR primers (Plate 3), three primers were shows that polymorphic bands were consistent and clear were selected for fingerprinting and exhibited single band the size ranged from 250 to 750 bp.

4.2.7.2 SSR profile analysis

The SSR fingerprint for 13 genotypes of tomato using six primers revealed a scorable bands that were well defined, consistent, unambiguous, readable and reproducible polymorphic bands which were used to estimate genetic diversity.

Among six primers, three primers were exhibiting polymorphic, Tom 31A-32ATA11 scored maximum polymorphic bands followed by Tom 39A-40A AATT4 and Tom 41- 42TCC6. Tom 8-9 ATT7, Tom 11-28 CTT5/CT5 and Tom 43- 44TCC6

Table 59. Equatorial and polar fruit diameter of tomato genotypes influenced by irrigation levels

Sl. No.	Genotypes	Equatorial diameter (mm)				Polar diameter (mm)			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	39.47	32.55	30.74	34.26	38.91	36.67	28.34	34.64
2	EC 608362	34.27	31.52	27.21	31.00	38.32	36.01	30.37	34.90
3	EC 610652	35.95	32.90	27.44	32.09	40.14	34.32	29.16	34.54
4	EC 634394	41.51	35.23	31.63	36.12	42.04	37.53	32.81	37.46
5	EC 638519	12.56	11.20	9.20	10.99	14.87	12.06	9.58	12.17
6	EC 610661	11.86	9.92	8.77	10.18	13.82	11.44	9.42	11.56
7	EC 631962	38.60	32.00	27.13	32.58	44.93	34.43	28.45	35.93
8	EC 686550	33.84	28.73	21.52	28.03	44.70	31.37	24.64	33.57
9	Kashi Anupam	42.01	33.69	27.17	34.29	36.26	32.00	28.91	32.39
10	EC 686543	28.48	26.27	21.48	25.41	37.35	27.23	21.38	28.65
11	EC 608269	33.56	24.77	20.95	26.42	35.19	24.22	23.26	27.56
12	EC 686553	32.74	24.52	21.39	26.22	36.21	25.79	22.46	28.15
13	PUSA 120	40.52	35.12	28.14	34.60	35.37	31.74	29.26	32.12
Mean		32.72	27.57	23.29	27.86	35.24	28.83	24.46	29.51
Range		42.01	35.23	31.63	36.12	44.9	37.53	32.81	37.46
		11.86	9.92	8.77	10.18	13.82	11.44	9.42	11.56
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.29		0.81		0.54		1.53	
Irrigation		0.14		0.39		0.26		0.73	
G X I		0.50		1.40		0.94		2.65	

DAT = Days after transplanting

Control = Farmers practice

Table 60. Pericarp thickness (mm) and number of locules per fruit in tomato genotypes as influenced by irrigation levels

Sl. No	Genotypes	Pericarp thickness				Number of locules/fruit			
		IW/CPE Ratio				IW/CPE Ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	4.14	3.18	2.57	3.30	3.79	4.36	5.10	4.42
2	EC 608362	4.03	3.06	2.39	3.16	4.15	4.30	3.78	4.08
3	EC 610652	3.69	3.34	2.40	3.14	3.77	3.89	3.59	3.75
4	EC 634394	3.75	3.10	2.58	3.14	3.55	3.69	3.37	3.54
5	EC 638519	1.46	1.20	0.98	1.22	3.31	3.14	2.72	3.06
6	EC 610661	1.41	1.17	0.93	1.17	3.12	3.07	3.33	3.17
7	EC 631962	4.30	2.88	2.35	3.18	4.08	4.00	4.25	4.11
8	EC 686550	2.85	2.57	1.59	2.34	3.44	2.67	3.04	3.05
9	Kashi Anupam	3.54	3.02	1.83	2.79	4.28	3.94	3.93	4.05
10	EC 686543	3.51	2.28	1.21	2.33	3.87	3.07	2.75	3.23
11	EC 608269	3.46	2.17	1.23	2.29	3.86	2.70	2.83	3.13
12	EC 686553	3.68	2.49	1.56	2.58	3.82	2.88	3.00	3.23
13	PUSA 120	3.59	2.75	2.54	2.96	4.37	3.84	3.95	4.05
Mean		3.34	2.55	1.86	2.58	3.80	3.51	3.51	3.61
Range		4.30	3.34	2.58	3.30	4.4	4.36	5.10	4.42
		1.41	1.17	0.93	1.17	3.12	2.67	2.72	3.05
		S.Em±		CD at 5%		S.Em±		CD at 5%	
Genotypes		0.089		0.248		0.08		0.21	
Irrigation		0.042		0.119		0.04		0.10	
G X I		0.152		0.429		0.13		0.37	

DAT = Days after transplanting

Control = Farmers practice

were showed no polymorphism. The dendrogram was constructed by UPGMA (Unweighted Pair Group Method with Arithmetical averages) method of clustering using Jaccard's Co-efficient (J). Cluster analysis based on six SSR markers revealed that the thirteen genotypes examined and all genotypes were grouped into three major clusters.

The cluster I in dendrogram is further divided into two sub clusters. Sub cluster Ia consists of genotypes Arka Meghali, EC 608362, EC 610652, EC 634394, EC 638519, EC 610661 and EC 686543 and sub cluster Ib consists of again one genotypes EC 686553, which were similar at similarity coefficient matrix. Cluster II in dendrogram is divided into two sub clusters. Sub cluster IIa consist of genotype Pusa- 120 and EC 686550. sub group IIb consists of EC 608269 genotype alone. Cluster III consist of genotype EC 631962 and Kashi Anupam alone in separate cluster.

4.2.8 Correlation and Path-coefficient analysis

4.2.8.1 Character association between yield of genotypes and its components

Selection for specific character is known to result in correlated response in certain other characters. Generally, plant breeders make selection for one or two attributes at a time. Then it becomes important to know the effect on other characters. Improvement on yield, the most important target character in many crops, it can be achieved by direct selection through other easily observable characters. But, this needs a good understanding of association of different traits with yield and their possible associations among themselves (Table 62).

At control significant positive correlation for yield was noticed with LAR at 45 DAT (0.635), SLA at 45 DAT (0.617), leaf temperature (0.613), average fruit weight (0.586), fruit polar diameter (0.579) and chlorophyll "b" at 90 DAT (0.552). NAR 45 to 90 DAT (-0.633), SLW at 45 DAT (-0.598) and transpiration (-0.570) was negatively significant correlated for yield.

At 1.2 IW/CPE ratio, leaf temperature (0.861), number of locules (0.845), plant height at 45 DAT (0.838), stomatal conductance (0.818), total chlorophyll at 45 DAT (0.805), LAI at 90 DAT (0.804), LA at 90 DAT (0.804), plant spread (EW)

Table 61. Estimates of components of variance, heritability and genetic advance for growth and earliness parameters in tomato

Sl. No.	Character	GV	PV	GCV (%)	PCV (%)	h^2	GA	GAM
Morphological charecters								
1	Days to first flowering	8.84	11.25	10.34	11.66	78.59	5.43	18.87
2	Days 50% flowering	10.68	15.04	8.70	10.32	71.02	5.67	15.10
3	Plant height 45 DAT (cm)	78.58	88.37	7.74	8.20	88.92	17.22	15.03
4	Plant height 90 DAT (cm)	186.61	190.67	20.63	20.85	97.87	27.83	42.04
5	Plant spread from north to south 45 DAT (cm)	24.4	27.27	1.36	4.56	89.48	0.96	0.84
6	Plant spread from north to south 90 DAT (cm)	161.41	163.36	21.32	21.45	98.80	26.01	43.66
7	Plant spread from east to west 45 DAT (cm)	14.27	17.43	1.14	3.64	98.52	0.84	0.74
8	Plant spread from east to west 90 DAT (cm)	139.08	141.88	19.55	19.75	98.02	24.05	39.89
9	Stem girth (cm) (45 DAT)	0.54	0.79	15.03	18.27	67.72	1.24	25.48
10	Stem girth (cm) (90 DAT)	1.07	1.46	14.17	16.55	73.30	1.82	24.99
11	Number of pubescence (abaxial)	3612.69	3770.05	64.42	65.81	95.82	121.61	129.91
12	Number of pubescence (adaxial)	22579.35	23562.87	64.42	65.81	95.82	303.01	129.91
Growth parameters								
1	Leaf area 45 DAT (cm ²)	63515.59	68429.17	31.60	32.80	92.81	500.18	62.73
2	Leaf area 90 DAT (cm ²)	314913.1	378433.4	42.79	46.90	83.21	105.45	80.41
3	Leaf area ratio 45 DAT (cm ² g ⁻¹)	25.45	50.71	17.26	24.36	50.18	7.36	25.18
4	Leaf area ratio 90 DAT (cm ² g ⁻¹)	33.29	61.71	22.97	31.27	53.94	8.73	34.75
5	Leaf area index 45 DAT (cm ²)	0.0087	0.0093	31.60	32.80	92.81	0.81	62.73
6	Leaf area index 90 DAT (cm ²)	0.043	0.051	42.79	46.90	83.21	0.39	80.41
7	Specific leaf weight 45 DAT (g.cm ⁻²)	0.09	0.13	20.48	25.45	64.74	0.49	33.94
8	Specific leaf weight 90 DAT (g.cm ⁻²)	0.45	0.62	38.72	45.19	73.41	1.19	68.34
9	Specific leaf area 45 DAT (cm ² g ⁻¹)	231.70	329.35	20.99	25.03	70.34	26.30	36.27
10	Specific leaf area 90 DAT (cm ² g ⁻¹)	398.87	644.68	29.64	37.68	61.88	32.36	48.04
11	Biomass 45 DAT (g)	46.00	60.81	24.45	28.11	75.65	12.15	43.81
12	Biomass 90 DAT (g)	238.21	284.24	30.15	32.94	83.80	29.10	56.87
13	Absolute growth rate 45-90 DAT (g.plant ⁻¹ day ⁻¹)	0.035	0.058	36.28	46.29	61.44	0.30	58.59
14	Crop growth rate 45-90 DAT (g.m ⁻² day ⁻¹)	0.063	0.098	37.15	46.20	64.67	0.41	61.55
15	Relative growth rate 45-90 DAT (g.g ⁻¹ day ⁻¹)	0.0016	0.025	7.02	27.79	6.38	0.02	3.65
16	Net assimilation rate 45-90 DAT (g.cm ⁻² day ⁻¹)	0.0013	0.0066	16.26	35.95	20.46	0.03	15.16

Contd.....

Sl. No.	Character	GV	PV	GCV (%)	PCV (%)	h^2	GA	GAM
Biophysical parameters								
1	Photo synthetically active radiation (lux)	11294.95	20171.15	92.81	124.02	55.99	163.82	143.06
2	Leaf temperature ($^{\circ}\text{C}$)	9.67	10.79	2.71	2.86	89.65	6.06	5.29
3	Intercellular CO_2 level (ppm)	1431.87	1634.70	33.04	35.30	85.59	72.95	63.71
4	Transpiration rate ($\text{mmol. H}_2\text{O.m}^{-2}.\text{S}^{-1}$)	4.37	5.12	1.82	1.97	89.35	3.98	3.47
5	Stomatal conductance ($\text{mmol.m}^{-2}.\text{S}^{-1}$)	0.049	0.057	0.19	0.21	84.74	0.41	0.36
6	Photo synthetic rate ($\text{mmol. CO}_2.\text{m}^{-2}.\text{S}^{-1}$)	27.16	28.16	4.55	4.63	96.43	10.54	9.20
Biochemical parameters								
1	Chlorophyll "a" 45 DAT (mg.g^{-1})	0.16	0.19	27.45	29.88	84.40	0.76	51.96
2	Chlorophyll "a" 90 DAT (mg.g^{-1})	0.19	0.23	40.00	44.29	81.54	0.18	74.41
3	Chlorophyll "b" 45 DAT (mg.g^{-1})	0.034	0.038	42.24	44.27	91.03	0.36	83.03
4	Chlorophyll "b" 90 DAT (mg.g^{-1})	0.033	0.034	43.70	44.55	96.22	0.36	88.31
5	Total Chlorophyll 45 DAT (mg.g^{-1})	0.33	0.36	30.22	31.73	90.72	1.13	59.29
6	Total Chlorophyll 90 DAT (mg.g^{-1})	0.35	0.40	39.82	42.23	88.81	1.16	77.27
7	Carotenoid 45 DAT (mg.g^{-1})	1.40	1.51	42.45	44.18	92.33	2.34	84.04
8	Carotenoid 90 DAT (mg.g^{-1})	1.21	1.28	45.06	46.34	94.56	2.21	90.26
9	Proline 45 DAT ($\mu\text{g.g}^{-1}$)	9258.99	9420.00	45.44	45.83	98.29	196.51	92.81
10	Proline 90 DAT ($\mu\text{g.g}^{-1}$)	14546.65	14739.86	49.16	49.48	98.68	246.82	100.61
11	Ascorbic acid (mg.100-1g fr wt)	45.64	56.78	30.62	34.15	80.39	12.47	56.55
12	Lycopene (mg.100-1g fr wt)	0.54	0.69	35.82	40.49	78.24	1.34	65.27
13	TSS ($^{\circ}\text{Brix}$)	1.30	1.91	17.33	21.00	68.13	1.94	29.47
Fruit and yield parameters								
1	Polar diameter (mm)	90.58	93.23	32.25	32.71	97.15	19.32	65.48
2	Equatorial diameter (mm)	84.90	85.64	33.07	33.21	99.13	18.89	67.83
3	Pericarp thickness (mm)	0.90	0.97	36.74	38.13	92.84	1.88	72.93
4	Number of locules	0.31	0.36	15.45	16.67	85.88	1.06	29.49
5	Average fruit weight (g)	326.26	349.58	35.89	37.15	93.32	35.94	71.43
6	Number of fruits per plant	908.37	915.21	82.33	82.64	99.25	61.85	168.98
7	Yield per plant (kg)	0.089	0.10	21.12	22.37	89.12	0.58	41.08
8	Yield per hectare	122.93	137.93	26.79	28.38	89.12	21.56	52.11

(0.801), chlorophyll “a” at 45 DAT (0.802), total chlorophyll at 90 DAT (0.798), chlorophyll “a” at 90 DAT (0.780), proline at 90 DAT (0.789), photosynthesis (0.773), SLA at 90 DAT (0.773), LAR at 90 DAT (0.775), proline at 45 DAT (0.758), plant spread (NS) at 90 DAT (0.755), stem girth 90 DAT (0.750), plant height at 90 DAT (0.736), stem girth 45 DAT (0.739), number of pubescence (0.738), ascorbic acid (0.733), days to first flowering (0.724), chlorophyll “b” at 45 DAT (0.712), chlorophyll “b” at 90 DAT (0.658), RGR (0.720), AGR (0.702), CRG (0.702) at 45 to 90 DAT, LAI at 45 DAT (0.683), LA at 45 DAT (0.683), intercellular CO₂ (0.674), days to 50 % flowering (0.671), had positive and highly significantly association for yield and RLWC (-0.575), SLW at 90 DAT (-0.872) had negatively significant association for yield.

At 0.4 IW/CPE ratio, highly significant positive correlation for yield, was noticed with stem girth 90 DAT (0.949), plant spread (NS) at 90 DAT (0.947), plant spread (EW) at 90 DAT (0.940), stem girth 45 DAT (0.924), chlorophyll “a” at 45 DAT (0.923), plant height at 90 DAT (0.921), total chlorophyll at 90 DAT (0.928), leaf temperature (0.919), total chlorophyll at 45 DAT (0.909), LAI at 90 DAT (0.906), LA at 90 DAT (0.906), days to 50 % flowering (0.906), LAI at 45 DAT (0.901), LA at 45 DAT (0.901), biomass at 45 DAT (0.901), ascorbic acid (0.892), carotenoid at 45 DAT (0.898), plant height at 45 DAT (0.883), biomass at 90 DAT (0.838), stomatal conductance (0.818), chlorophyll “a” at 90 DAT (0.900), proline at 90 DAT (0.872), proline at 45 DAT (0.872), number of pubescence (0.866), photosynthesis (0.869), SLA at 90 DAT (0.856), days to first flowering (0.833), LAR at 90 DAT (0.807), chlorophyll “b” at 45 DAT (0.659), chlorophyll “b” at 90 DAT (0.841), RGR (0.720), AGR (0.693), CRG (0.693) at 45 to 90 DAT and SLW 45 DAT (-0.830) and SLW 90 DAT (-0.869) had negatively highly significant association for yield.

4.2.8.2 Path coefficient analysis

The correlation coefficients only indicate the relationship of independent variables with the dependent variable without specifying cause and effect relationship. Using path coefficient analysis, it is possible to resolve the correlations, which will provide direct and indirect contribution of different qualitative and quantitative traits.

The analysis was done for yield (kg/plant) which is dependent variable. Both genotypic and phenotypic paths for the dependent variable were computed.

4.2.8.3 Genotypic path coefficient analysis for yield per plant

The path analysis of yield (kg/plant) was done with 14 independent character involving growth, biophysical and yield parameters. The matrix of direct and indirect effects were presented in the (Table 63).

4.2.8.4 Genotypic path coefficient analysis

Genotypic path coefficient analysis was carried out by considering fruit yield (kg/plant) as dependent variable and others as independent variables.

absolute growth rate 45-90 DAT (1.013), transpiration rate (0.419), total chlorophyll (0.359), photosynthetic rate (0.078), and stomatal conductance (0.044) which had a positively direct effect on the yield per plant and plant height 90 DAT (-0.127), proline 90DAT (-0.286), leaf area 90 DAT (-0.161), crop growth rate (-1.004), specific leaf weight (-0.587) and number of fruits per plant (-0.196) had negatively direct effect on the yield per plant.

Table 62. Correlation of yield with physiological, morphological and biochemical, biophysical parameters at three irrigation levels

SI N0.	Parameters	Correlation co-efficient (r) At different ratio/CPE ratio		
		Control	IW/CPE ratio	
			1.2	0.4
1	Days to 1 st flowering	0.282	0.724**	0.833**
2	Days to 50% flowering	-0.266	0.671**	0.906**
3	Plant height at 45 DAT	0.114	0.838**	0.883**
4	Plant height at 90 DAT	-0.218	0.736**	0.912**
5	Plant spread (EW) at 45 DAT	0.523	0.168	0.067
6	Plant spread (EW) at 90 DAT	0.196	0.801**	0.940**
7	Plant spread (NS) at 45 DAT	-0.215	0.066	0.132
8	Plant spread (NS) at 90 DAT	-0.300	0.755**	0.947**
9	Stem girth at 45 DAT	-0.194	0.739**	0.924**
10	Stem Girth at 90 DAT	0.203	0.750**	0.949**
11	Number of pubescence (abxial)	-0.054	0.738**	0.866**
12	Number of pubescence (adaxial)	-0.054	0.738**	0.866**
13	Chlorophyll “A” at 45 DAT	0.091	0.802**	0.923**
14	Chlorophyll “A” at 90 DAT	0.230	0.780**	0.900**
15	Chlorophyll “B” at 45 DAT	-0.129	0.712**	0.695**
16	Chlorophyll “B” at 90 DAT	0.552*	0.658*	0.841**
17	Total chlorophyll at 45 DAT	0.056	0.805**	0.909**
18	Total chlorophyll at 90 DAT	0.372	0.798**	0.928**
19	Carotenoids at 45 DAT	-0.007	0.593*	0.898**
20	Carotenoids at 90 DAT	0.148	0.650*	0.911**
21	Proline at 45 DAT	0.123	0.758**	0.872**
22	Proline at 90 DAT	0.110	0.789**	0.872**
23	Lycopene	-0.403	0.621*	0.938**
24	Ascorbic acid	-0.357	0.733**	0.892**
25	RWC	-0.023	-0.575	0.330

Contd.....

SI N0.	Parameters	Correlation co-efficient (r) At different ratio/CPE ratio		
		Control	IW/CPE ratio	
			1.2	0.4
1	NAR 45-90 DAT	-0.633	-0.093	-0.628
2	RGR 45-90 DAT	-0.206	0.720**	0.162
3	AGR 45-90 DAT	-0.339	0.702**	0.693**
4	CGR 45-90 DAT	-0.339	0.702**	0.693**
5	SLA at 45 DAT	0.617*	0.459	0.724**
6	SLA at 90 DAT	0.286	0.773**	0.856**
7	SLW at 45 DAT	-0.598	-0.473	-0.830
8	SLW at 90 DAT	-0.382	-0.872	-0.869
9	LAR at 45 DAT	0.635*	0.508	0.672*
10	LAR at 90 DAT	0.491	0.775**	0.807**
11	LAI at 45 DAT	0.517	0.683**	0.901**
12	LAI at 90 DAT	0.257	0.804**	0.906**
13	Biomass at 45 DAT	-0.288	0.501	0.901**
14	Biomass at 90 DAT	-0.371	0.640*	0.838**
15	LA at 45 DAT	0.517	0.683**	0.901**
16	LA at 90 DAT	0.257	0.804**	0.906**
17	Biomass duration	-0.013	0.425	0.569*
18	Photosynthesis	0.212	0.773**	0.869**
19	Stomatal conductance	0.100	0.818**	0.845**
20	Transpiration	-0.570	0.542	0.784**
21	Leaf temperature	0.613*	0.861**	0.919**
22	PAR	0.268	-0.155	0.492
23	Intercellular CO ₂	-0.032	0.674*	0.716**
24	Fruit polar diameter	0.579	0.438	0.218
25	Fruit equatorial diameter	0.514	0.347	0.263
26	Pericarp thickness	0.551	0.420	0.567*
27	Number of locules	0.299	0.845**	0.646*
28	TSS	-0.013	0.425	0.569*
29	Number of fruits per plant	-0.386	0.064	0.321
30	Average fruit weight	0.586*	0.113	0.359

* indicates correlation co-efficient (r) significant at 5 % (0.552) and

** indicates correlation co-efficient (r) significant at % (0.683), Sample size = 13

Table 63. Genotypic path coefficient analysis for yield and its components:

	1	2	3	4	5	6	7	8	9	10	11	rG
1	-0.127	0.314	-0.108	-0.140	-0.933	0.999	0.469	0.069	0.369	0.041	-0.106	0.846**
2	-0.111	0.359	-0.025	-0.144	-0.920	0.977	0.412	0.071	0.356	0.039	-0.053	0.961**
3	-0.048	0.031	-0.286	-0.051	-0.204	0.219	0.415	0.006	0.048	0.017	-0.066	0.081
4	-0.110	0.321	-0.091	-0.161	-0.832	0.897	0.494	0.063	0.297	0.038	-0.079	0.836**
5	-0.118	0.328	-0.058	-0.134	-1.004	0.994	0.367	0.065	0.366	0.037	-0.103	0.740**
6	-0.125	0.346	-0.062	-0.143	-0.985	1.013	0.386	0.070	0.369	0.041	-0.100	0.811**
7	0.101	-0.252	0.202	0.136	0.628	-0.666	-0.587	-0.050	-0.227	-0.031	0.067	-0.678
8	-0.113	0.330	-0.023	-0.132	-0.834	0.918	0.378	0.078	0.355	0.038	-0.062	0.933**
9	-0.112	0.305	-0.033	-0.114	-0.877	0.894	0.318	0.066	0.419	0.038	-0.109	0.794**
10	-0.116	0.315	-0.109	-0.138	-0.841	0.933	0.405	0.067	0.360	0.044	-0.101	0.819**
11	-0.069	0.097	-0.096	-0.065	-0.531	0.518	0.201	0.025	0.234	0.023	-0.196	0.140

Diagonal indicates direct effect

Residual = 0.17

*significant at 5%

**significant at 1%

rG – genotypic correlation with yield per plant

- 1 Plant height (90 DAT)
- 2 Total chlorophyll 90 DAT
- 3 Proline at 90 DAT
- 4 Leaf area 90 DAT(cm²)

- 5 Crop growth rate 45-90 growth stage
- 6 Absolute growth rate 45-90 growth stage
- 7 Specific leaf weight
- 8 Photo synthetic rate

- 9 Transpiration rate
- 10 Stomatal conductance
- 11 Number of fruits per plant
- 12 Yield per plant (kg)

5. DISCUSSION

Tomato is one of the most popular and widely grown vegetables in the world which ranks next to potato. The pulp and juice of tomato fruit is digestible, promoter of gastric secretion and blood purification. It has antiseptic properties against intestinal infections and mouth cancers. Karnataka is one of the major tomato growing states. The major tomato producing districts in Karnataka are Bidar, Kolar, Belgaum, Bijapur, Dharwad, Haveri, Davangere and Bangalore Rural. These districts either come under transitional tract, dry tract or facilitated with supplemental well irrigation. But considering the potentiality of this crop, there is plenty of scope for its improvement. Though some work has been done to improve tomato yields, the yield potential of tomato, however, has not been exploited under rainfed or drought situation (Chavan, 2007).

Drought is an important abiotic stress affecting the productivity of all crops, to date the progress achieved in improving drought resistance is very minimal. Among the specific reasons listed for slow progress are the multiplicity of drought patterns and the plant responses are foremost.

There are several physiological, genetical and biochemical traits contributing to the drought tolerance nature of agricultural/ horticultural crops. Large number of tomato genotypes have not been screened for drought tolerance or exploited for their cultivation under drought situation. Hence, the present investigation was carried out to screen the tomato genotypes for yield potential and drought tolerance related traits during 2014-2015 by adopting simple field technique, using irrigation water to the cumulative pan evaporation ratio (IW/CPE ratio) along with control as a control.

In this chapter, the results of screening of 50 tomato genotypes against the drought and further eight genotypes which were selected as drought tolerant are discussed. Genetical and molecular aspects pertaining to drought tolerance have also been discussed.

5.1 Morphological characters

Plant height and stem girth are important characters of growth and development of the crop canopy. The tomato genotypes differed significantly for plant height and stem girth (Table 4 & 7) at all the growth phases under different irrigation levels of control, 0.4 and 1.2 IW/CPE ratios. Both parameters decreased in 0.4 IW/CPE ratio compared to control, indicating the effect of moisture stress on the tomato genotypes. However, among the genotypes EC 638519 (58.00 cm), EC 638519 (77.33 cm) showed significantly maximum height at 45 and 90 DAT respectively, whereas, genotype HUB T-07 (5.42 mm) and EC 630512 (8.88 mm) showed significantly maximum stem girth at 45 and 90 DAT, respectively.

The data of selected genotypes from the first experiment indicated that, the genotypes differed significantly for plant height and stem girth (Table 33 & 36). During 45 and 90 DAT, at 0.4 IW/CPE ratio, significantly maximum plant height was noticed in the genotype EC 638519 and EC 610661. Minimum plant height was noticed in the genotype EC 608269 during 45 and 90 DAT.

Among the genotypes, Kashi Anupam recorded significantly maximum stem girth at 0.4 IW/CPE ratio, on par with EC 610661 and minimum stem girth was recorded in the genotype EC 608269 at 45 DAT. During 90 DAT, significantly maximum stem girth was recorded in the genotype EC 608362, on par with the EC 610652, EC 631962 and minimum was recorded in the genotype EC 686543. The results indicate that EC 686543, EC 608269 and EC 686543 show higher drought susceptibility. Thus, main stem had active role in translocating plant assimilates and help in increasing the sink capacity under drought (Mukesh, 2010) in tomato. The decrease in plant height and stem girth at 0.4 IW/CPE ratio was due to the development of water deficit in leaves during drought resulting in decline in leaf water potential, as well as reduction in both cell volume and cell turgor and was attributed to maintenance of higher cell volume. These results are in conformity with finding of earlier workers who also reported that, the cell elongation of plants can be inhibited by interruption of water flow from the xylem to the surrounding elongating cells (Nonami, 1998). Drought caused impaired mitosis, cell elongation and expansion resulted in reduced growth and yield traits (Hussain *et al.*, 2008) in sunflower. Bhatt and Rao (2005) reported that, the reduction in plant height was

associated with a decline in the cell enlargement and more leaf senescence in *A. esculentus* under water stress. Water deficit in the early stages of tomato showed a greater effect on reduction in plant height as observed by Gladden *et al.* (2012) in tomato.

Number of days taken for first flowering and 50 per cent flowering reduced significantly among genotypes as a stress level increased and early flowering was noticed at 0.4 IW/CPE ratio compared to control (Table 35). The genotype EC 638519 took maximum days for first flowering (29.93 days) followed by EC 610652 (28.97 days) and EC 610661 (28.87 days) and minimum days was noticed in the genotype EC 686553 (20.87 days) at 0.4 IW/CPE ratio. In case of control, the genotype EC 610661 took maximum number of days to first flowering (32.07 days) and minimum days were taken in the genotype EC 686543 (30.33 days).

Among the genotypes, EC 638591 had taken significantly maximum days for 50 per cent flowering (38 days) followed by EC 610661 (37.33 days), EC 634394 (36.33 days) (Table 35) and minimum days to flowering was noticed in the genotype EC 608261 (28.67 days) at 0.4 IW/CPE ratio. In case of control the genotype EC 610661 took maximum number of days to first flowering (42.33 days) and minimum days were taken in the genotype EC 608269 (39.67 days). Present study is in conformity with the work conducted by Inga *et al.* Who reported that, early flowering in arabidopsis, a common drought strategy that ensure plant survival under sever water deficit was associated strongly inferred plant fitness.

Pubescence is another important character which can reduce the radiant heat load of leaves by increasing the reflection of the leaf surface. Increased pubescence was observed under stress in some species and cultivars. In the present investigation also, there was significant difference for the density of pubescence among genotypes and irrigation levels at both adaxial and abaxial surface (Table 37). Pubescence increase significantly at 0.4 IW/CPE ratio both on abaxial and adaxial surface indicating adaptive mechanism in tomato to water stress conditions.

On abaxial surface of the leaf, maximum number of pubescence was noticed in the genotype EC 634 394 (237.06) at 0.4 IW/CPE ratio followed by EC 610652 (231.15) and local check Arka Meghali (205.64).

Maximum per cent increase in number of pubescence in 0.4 IW/CPE ratio over the control was noticed in the Arka Meghali (78.22 %) followed by Pusa 120 (76.78%), EC 634394 (76.31) and EC 610652 (76.23%). but in case of selected as susceptible genotypes the per cent increase in number of pubescence was minimum in the genotype EC 686543 (21.18%), EC 686553 (24.28 %) and EC 686550 (38.45%).

On adaxial surface of the leaf, genotype EC 634394 recorded significantly maximum number of pubescence (592.64), followed by EC 610652 (577.88). While, higher per cent increase at 0.4 IW/CPE ratio over control on adaxial leaf surface was noticed in the Arka Meghali followed by Pusa 120, EC 634394 and minimum per cent increase was seen in EC 686543, EC 68553 (table, 33)

Pubescence count was more than eight times greater on the abaxial than adaxial leaf surface under the drought condition as reported by Ratnayak and Kincaid (2005) in *Tinnevelly senna* and *Cassia agnustifolia*.

The drought tolerance is attributed to reduced water loss through cuticular and stomatal transpiration, because hairs on the stems and leaves protect the stomata and cuticle to the direct contact of wind. These preclude water loss through transpiration.

5.2 Growth parameters

Growth parameters have been extensively employed in crop sciences for better understanding of physiological basis of yield variation in crop plants. Genotypic difference in growth parameters viz., LAI, CGR, NAR and LAD were found to be influenced by various environmental factors. Further, it is well established that the extent of difference in growth parameters determine the variation in total dry matter among the genotypes.

Biomass is one of the important characters which influence the growth and development of the plant. Tomato genotypes differed significantly for biomass during both the years (Table 13 and 43).

As the moisture stress increased from control to 0.4 IW/CPE ratio biomass decreased. It was found significantly maximum under control at all the growth stages compared to 1.2 IW/CPE ratio and 0.4 IW/CPE ratio. Among the selected genotypes

EC 610661 recorded significantly maximum biomass during 45 DAT at 0.4 IW/CPE ratio, followed by EC 638519 and EC 610661 while, at 90 DAT recorded significantly higher biomass and minimum was in L-40-3.

These results are in conformity with results of Kirnak *et al.* (2001) who noticed 57 per cent reduction in total dry weight, when plants were irrigated with 40 per cent of pot capacity and minimum reduction was observed under irrigation with 80 per cent of pot capacity (95 per cent) compared to control in egg plant.

Mukesh *et al.* (2007), evaluated 50 tomato genotypes were screened for drought tolerance based on the per cent reduction in 0.4 over 1.2 IW/CPE. Results of pooled analysis indicated that, under the severe moisture stress of 0.4 IW/CPE ratio, was noticed Biomass production was significantly higher in the genotypes L-10 (P), S-22 and L-30 at all the growth stages as compared to local check Arka Meghali and other susceptible genotypes.

Patel *et al.* (2012) showed that, total dry weight of the plant was decreased significantly by drought stress in chickpea. Greater plant fresh and dry weights under water limited conditions are desirable characters. A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production (Farooq *et al.*, 2009). Plant productivity under drought stress is strongly related to the processes of dry matter partitioning and temporal biomass distribution (Kage *et al.*, 2004) in cauliflower. Diminished biomass due to water stress was observed in almost all genotypes of sunflower (Tahir and Mehid, 2001). However, some genotypes showed better stress tolerance than the others.

A reduction in LAI, NAR, CGR and RGR was noticed at all the growth stage as the stress increased from 1.2 to 0.4 IW/CPE ratio, in tomato (Chavan *et al.*, 2010). Similar findings can be observed from the present investigation (Table 9, 10, 15 and 16) wherein 1.2 IW/CPE ratio had significantly higher leaf area, LAR, LAI, AGR, CGR, NAR, RGR and biomass duration. It is well known fact that the persistence of assimilatory surface is a prerequisite for prolonged photosynthetic activity and ultimate crop productivity. Leaf area being the photosynthetic surface area plays an important role in determining total biomass accumulation and quantity of photosynthates available for yield production.

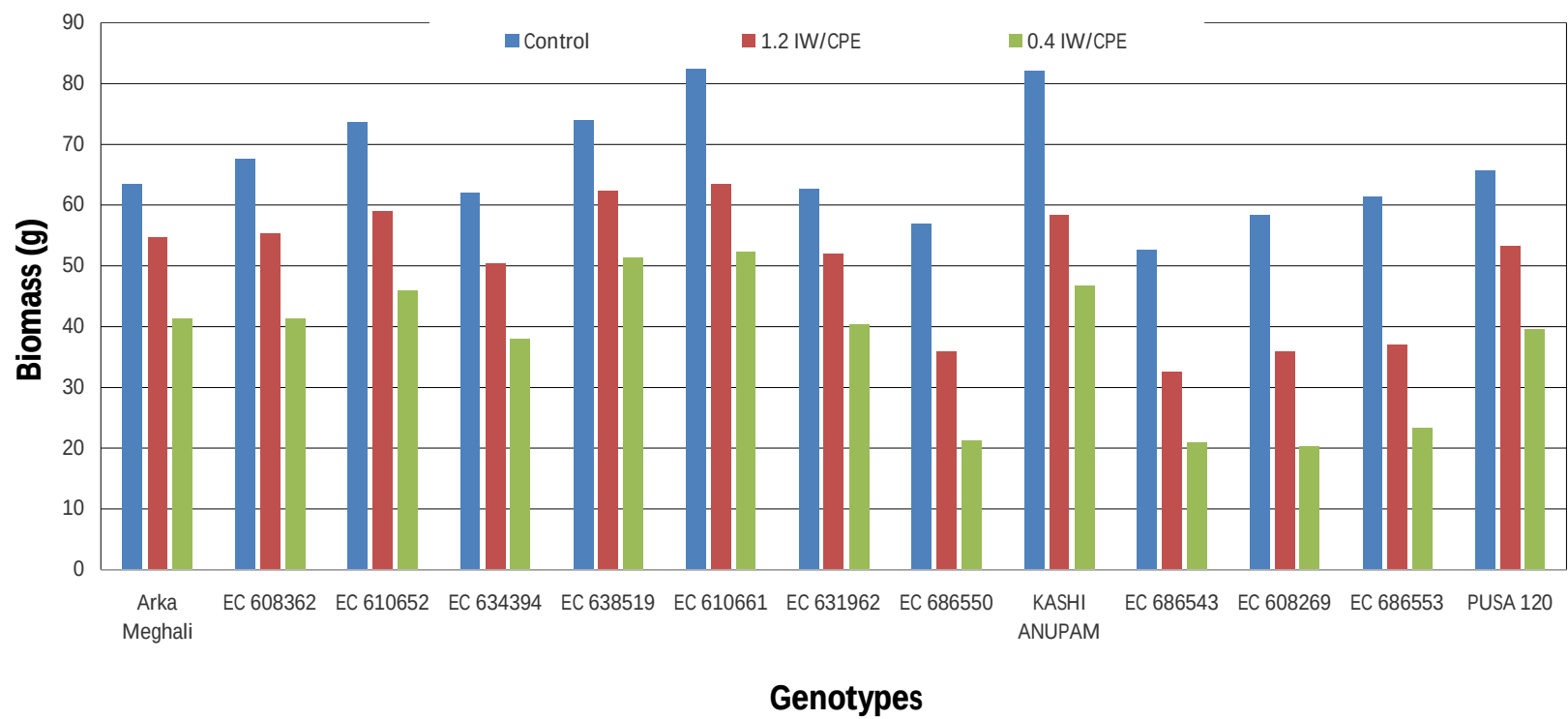


Fig. 1. Influence of irrigation levels on biomass of tomato genotypes

There was significant difference for crop growth rate (CGR) among irrigation levels and genotypes during all the growth phases (Table 15 and 45). As the stress increased from control to 0.4 IW/CPE ratio, there was significant decrease in the CGR during 45 to 90 DAT growth stage. Among the selected genotypes, at 0.4 IW/CPE ratio, genotype EC 610661 recorded maximum CGR during 45 to 90 DAT. The genotype EC 638519, EC 631962, Arka Meghali and EC 610652 exhibited minimum per cent reduction in CGR at 0.4 IW/CPE ratio over control at 45 to 90 DAT growth stage. These results are in confirmity with Chowdhury and Varma (1998) in sweet potato and Panda *et al.* (2004) in mustard.

Significantly maximum RGR was recorded at control compared to 0.4 IW/CPE ratio (Table 16 and 46). The selected genotypes on RGR indicated that, irrespective of irrigation levels and at 0.4 IW/CPE ratio, maximum RGR was recorded in the genotype EC 610661 and EC 638519 followed by Arka Meghali, EC 610652 and EC 686553 at 45 to 90 DAT growth stage. The results confirm the earlier findings of Haloi and Baldev (1986) in chickpea and Singh and Singh (1994) in sugarcane.

The maximum NAR was noticed at the irrigation schedule of control at 45 to 90 DAT growth stages during both the years compared to 1.2 and 0.4 IW/CPE ratio (Table 16 and 46). The selected genotypes indicated that, NAR was significantly maximum at control and it varied from 0.17 to 0.47 whereas, at 0.4 IW/CPE ratio it ranged from 0.12 to 0.37 $\text{g cm}^{-2} \text{ day}^{-1} \times 10^3$ during 45 to 90 DAT growth stage.

The results of selected genotypes data indicated that, during 45 to 90 DAT genotype EC 686553 recorded higher NAR at 0.4 IW/CPE ratio. These genotypes maintained significantly optimum photosynthetic rate and also maintained more leaf area with optimum transpiration rate.

The results of present investigation confirm the earlier findings of Haloi and Baldev (1986) in chickpea and Singh and Singh (1994) in sugarcane and they found that, interception of maximum solar radiation by upper leaves showed higher rate of photosynthesis than the lower leaves. This may account for higher NAR under stress condition as observed in these genotypes and may be regarded as a characteristic feature of drought tolerant. Similarly, in accordance with Mukesh (2007) in tomato.

Leaf area is a function of cell expansion and is again depends upon turgidity of cell. Development of optimal leaf area is important for effective light interception and CO₂ fixation. Water deficit stress mostly reduced leaf growth and in turn the leaf areas in many species of plants like *Populus* (Wullschleger *et al.*, 2005), soybean and many other species (Farooq *et al.*, 2009).

Selected genotypes indicated that, leaf area (Table 38) was significantly differed among genotypes and irrigation levels at 45 to 90 growth stage. When the plants subjected to deficit water condition there was decrease in the leaf area.

Leaf area was found significantly maximum at control when compared to 0.4 IW/CPE ratio. The selected genotypes from first experiment, data indicated that, at 0.4 IW/CPE ratio maximum leaf area was maintained by EC 631962 followed by EC 610661, EC 634394 and Kashi Anupam and least was maintained by EC 686553 at 45 DAT whereas, at 75 DAT, significantly maximum leaf area was noticed in the genotype EC 638519 followed by EC 634394 and EC 608362. These genotypes also maintained optimum photosynthetic rate with lower transpiration rate. The present study was found to be on par with earlier workers, Upreti *et al.* (2000) opined that, water stress treatments lead to significant reduction in leaf area in all the cultivars of pea and the decline was greater with stress at flowering than at vegetative stage. Similarly, Kumar and Elston (1993) observed significant reduction in leaf area in *Brassica sp.* due to water stress. The possible reason for reduced vegetative growth of most of the tomato genotypes under stress might be due to decreased relative turgidity to below 90 per cent which caused dehydration of the protoplasm and associated with loss of turgor.

These results are in confirmity with earlier findings, total leaf area in stress imposed plants of tomato was lower than well-watered plants. Water deficit diminishes leaf size, longevity, and number of leaves per plant as observed by Tahi *et al.* (2008) and (Shao *et al.*, 2008) in tomato.

Leaf area index (LAI) is the most important variable and it can be widely changed by manipulation. LAI indicated significant difference among the irrigation levels and genotypes at all the growth stages (Table 10 and 39). Significantly maximum LAI was noticed under control compared to 0.4 IW/CPE ratio.

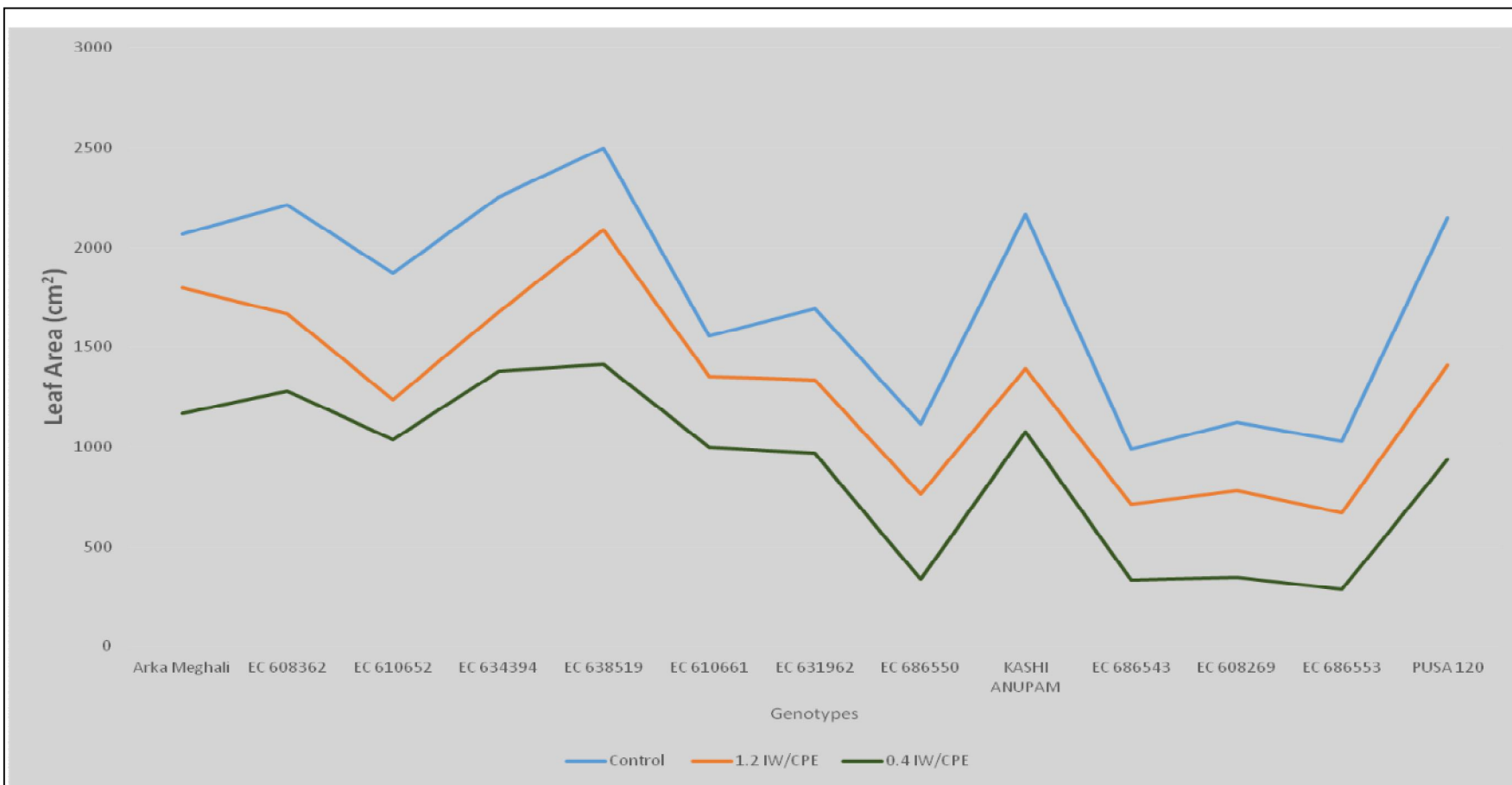


Fig. 2. Influence of irrigation levels on leaf area of tomato genotypes

The selected genotypes indicated that, EC 631962 exhibited maximum LAI at 0.4 IW/CPE ratio followed by EC 610661, EC 634394 and Kashi Anupam at 45 DAT whereas, at 90 DAT, EC 638591 recorded maximum LAI and it was followed by EC 634394 and EC 608362 and minimum was recorded in the genotype EC 686553 at both stages.

Similarly Haloi and Baldev (1986) showed that good supply of moisture was the basis for the maximum LAI. Present investigation is in confirmity with earlier findings of Chavan *et al.*, 2010 in tomato, Panda *et al.* (2004) in mustard.

Leaf area ratio (LAR) indicated significant difference among the genotypes and irrigation levels at all the growth stages (Table 6). In case of selected genotypes LAR significantly varied only among genotypes. However, Maximum LAR was noticed at control compared to 1.2 IW/CPE ratio and 0.4 IW/CPE ratio. The genotype EC 631962 exhibited highest LAR in 0.4 IW/CPE ratio and lower LAR in the EC 686553 at 45 DAT. The genotype EC 634394 exhibited highest LAR in 0.4 IW/CPE ratio and lowest LAR in the EC 686553 at 90 DAT.

Specific leaf weight (SLW) indicates the leaf thickness. There were significant differences among genotypes but the irrigation levels found non significant in both experiments (Table 11 and 41), except in the 2nd experiment at 90 DAT, Whereas, among selected genotypes there was significance only for irrigation levels at 90 DAT (Table 36). Significantly higher SLW was noticed at 0.4 IW/CPE ratio compared to 1.2 IW/CPE ratio and control. The genotype EC 686550 exhibited highest SLW and lowest in the EC 634394. Milton *et al.* (1992), reported that, tomato responded to a reducing water frequency by growing smaller leaves, in contrast increased leaf thickness which adapts to water stress. Increase in the specific leaf area of tomato as the frequency of watering decreased. Present investigation is in confirmity with earlier findings of Mukesh (2007) in tomato.

Biomass duration (BMD) depends on the biomass production over the period. There were significant differences among the genotypes and irrigation levels and their interaction (Table 14 and 44). Significantly maximum BMD was noticed at control during the both the experimental periods. Decrease in the BMD was noticed as the stress increased which indicates that it may be due to variation in water supply and genetic composition.

The selected genotypes data indicated that, among the genotypes, significantly maximum BMD at 0.4 IW/CPE ratio was noticed in EC 610661 followed by EC 638519 at 45 to 90 DAT. In general maintenance of higher growth at early stages helped the plant to escape drought in tolerant genotypes and could produce more yield.

Relative water content of leaf (RWC) indicates, the actual water content to its maximum turgidity. In general RWC was higher in control IW/CPE ratio. However, it varied among the genotypes, irrigation levels and their interaction (Table 22).

The data indicated, significantly maximum RWC at control and it ranged from 32.18 to 104.78, 32.85 to 80.47 and 21.75 to 85.28 per cent at control, 1.2 and 0.4 IW/CPE ratio, respectively. Among the genotypes, significantly higher RWC was noticed in Hisar Arun at 75 DAT and minimum was noticed in the genotype HUB T-10 at 75 DAT. These genotypes showed better maintenance of higher RWC ensuring better hydration and more favorable internal water relations of tissue with a possibly higher pressure potential and showed better drought tolerance capacity. Similar results were reported earlier by Sivakumar (2014). The drought condition was created at 15 days after transplanting based on field capacity of soil. As the stress increased from 100 per cent field capacity to 50 per cent field capacity, leaf water potential, relative water content (RWC) were noticed at all the growth stages. They stated that, tomato plant water potential decreased with the onset of drought, however, some species which maintained higher RWC were found to be drought resistant than those with low RWC. Almeselmani *et al.* (2012) showed that the relative water content was reduced significantly under drought condition in susceptible varieties than tolerant varieties in durum wheat. Choudhury *et al.* (2010) stated that the relative water content significantly affected by the water stress in french bean. In brinjal, leaf relative water content was decreased at water stress condition compared to control as shown by Kirnak *et al.* (2001). Galmes *et al.* (2011) reported that the leaf relative water content significantly decreased in all accessions of tomato under water stress conditions. Kumar *et al.* (2011) also noticed a significant reduction in RWC under water stress condition in pigeon pea. Present investigation is also in accordance with earlier findings of the three tomato genotypes studied, the growth of the leaf was limited by reduction of relative water content of the leaves as reported by Jurekova *et al.* (2011) and said above investigators.

It may also be due to accumulation of polyamines which has association for the better maintenance of turgidity and cell membrane stability by increased levels of spermine as evident from lesser change in RWC under stress. Spermine has been shown to counter the stress induced change in RWC in plant, since spermine enhances ABA levels in stressed plants (Mukesh, 2007).

5.3 Biophysical characters

The photosynthetic rate of tomato leaves under a given environmental condition is a function of various biophysical and biochemical processes involved during diffusion of CO₂ from atmosphere into chloroplast and the subsequent enzyme reactions. In the present investigation, PAR, photosynthesis, intercellular CO₂ level, transpiration, stomatal conductance and leaf temperature, difference (Table 17 to 19 and 47 to 49) observed at 75 DAT differed significantly among the irrigation levels and genotypes.

Maximum photosynthetic rate, intercellular CO₂ level, transpiration rate, PAR and stomatal conductance were observed under control compared to 0.4 IW/CPE ratio. These biophysical characters were significantly reduced as the stress level increased from 1.2 IW/CPE ratio to 0.4 IW/CPE ratio. Among the genotypes, photosynthetic rate, intercellular CO₂ level, transpiration rate and stomatal conductance varied from 10.55 to 19.92 mmol CO₂.m⁻². S⁻¹, 192.5 to 242.5 ppm, 5.88 to 10.45 mmol H₂O.m⁻². S⁻¹ and 0.32 to 0.78 mmol.m⁻². S⁻¹, respectively at 1.2 IW/CPE ratio, while at 0.4 IW/CPE ratio it ranged from 6.00 to 15.48 mmol CO₂.m⁻². S⁻¹, 166.5 to 237.00 ppm, 4.13 to 7.92 mmol H₂O.m⁻². S⁻¹ and 0.23 to 0.71 mmol.m⁻². S⁻¹ respectively.

Significantly higher photosynthetic rate was observed in the genotype Hisar arun (19.92 mmol CO₂.m⁻². S⁻¹) and minimum was noticed in the genotype EC 686550 (10.55 mmol CO₂.m⁻². S⁻¹) at 1.2 IW/CPE ratio. While, at 0.4 IW/CPE ratio EC 610661 recorded maximum photosynthetic rate of 15.48 mmol CO₂.m⁻². S⁻¹ and minimum was in EC 686550 of 6 mmol CO₂.m⁻². S⁻¹.

These results are in conformity with findings of Sivakumar (2015). The photosynthetic rate in 100 per cent FC plants was significantly higher than 50 per cent FC plants and it was increased up to 60 DAT and reduced at 90 DAT. Highest

photosynthetic rate (39.76) under 100 per cent FC was observed in tomato genotype TNAU, THCO 3 at 60 DAT. His report indicated that, water deficit stress inhibited photosynthetic rate in tomato genotypes. Abdellah *et al.* (2011) reported that, the highest reduction in the photosynthetic rate was observed in susceptible wheat cultivar by water stress of 30 per cent FC (Shah *et al.* 2010) showed that, the moisture stress reduced the net photosynthetic rate from 25.42 to 19.44 mmol CO₂ m⁻² S⁻¹ in *Withania somnifera*. Chavan *et al.* (2010) reported that the stomatal conductance, transpiration rate and photosynthetic rate were significantly decreased under stress condition compared to control in tomato. Sanadhya *et al.* (2012) reported that the water stress reduced the photosynthetic rate with increased levels of stress in mung bean. Choudhury *et al.* (2010) showed that the transpiration rate significantly affected by the water stress in french bean.

In the present investigation, significantly maximum stomatal conductance was recorded in the genotype Arka Meghali and EC 608362 (0.78 mmol m⁻²s⁻¹) and minimum was in EC 686553 (0.32 mmol m⁻²s⁻¹) at 1.2 IW/CPE ratio. While at 0.4 IW/CPE ratio maximum conductance was noticed in the genotype EC 608362 (0.71 mmole m⁻²s⁻¹) and minimum was in EC 686553 (0.23 mmole m⁻²s⁻¹) at 0.4 IW/CPE ratio. A fundamental response to drought by plants is to conserve water through stomatal regulation. Stomata are pores found in the epidermis of the leaf that allow for an influx of CO₂ for photosynthesis and consequently water loss through transpiration. These pores are flanked by specialized cells, known as guard cells. Within these guard cells, the plant hormone abscisic acid (ABA) is one of the most important chemical signals that triggers a signaling cascade leading to stomatal closure under abiotic conditions such as drought. Guard cell control of transpiration and water loss is strongly associated with drought tolerance (Tuberosa, 2012).

Chavan *et al.* (2010) reported that, the stomatal conductance, transpiration rate and photosynthetic rate were significantly decreased under stress condition compared to control in tomato. Hopper *et al.* (2014) reported that grapevine can bring some changes in stomatal response to cop up with drought stress. Stomata of drought resistant species and varieties of grapevine are very sensitive and close immediately on water shortage. Stomatal density of the resistant cultivars found to be lower compared to the susceptible ones. Reduced stomatal conductance and photosynthetic rate were observed under 50 per cent and 100 per cent water stress over control in

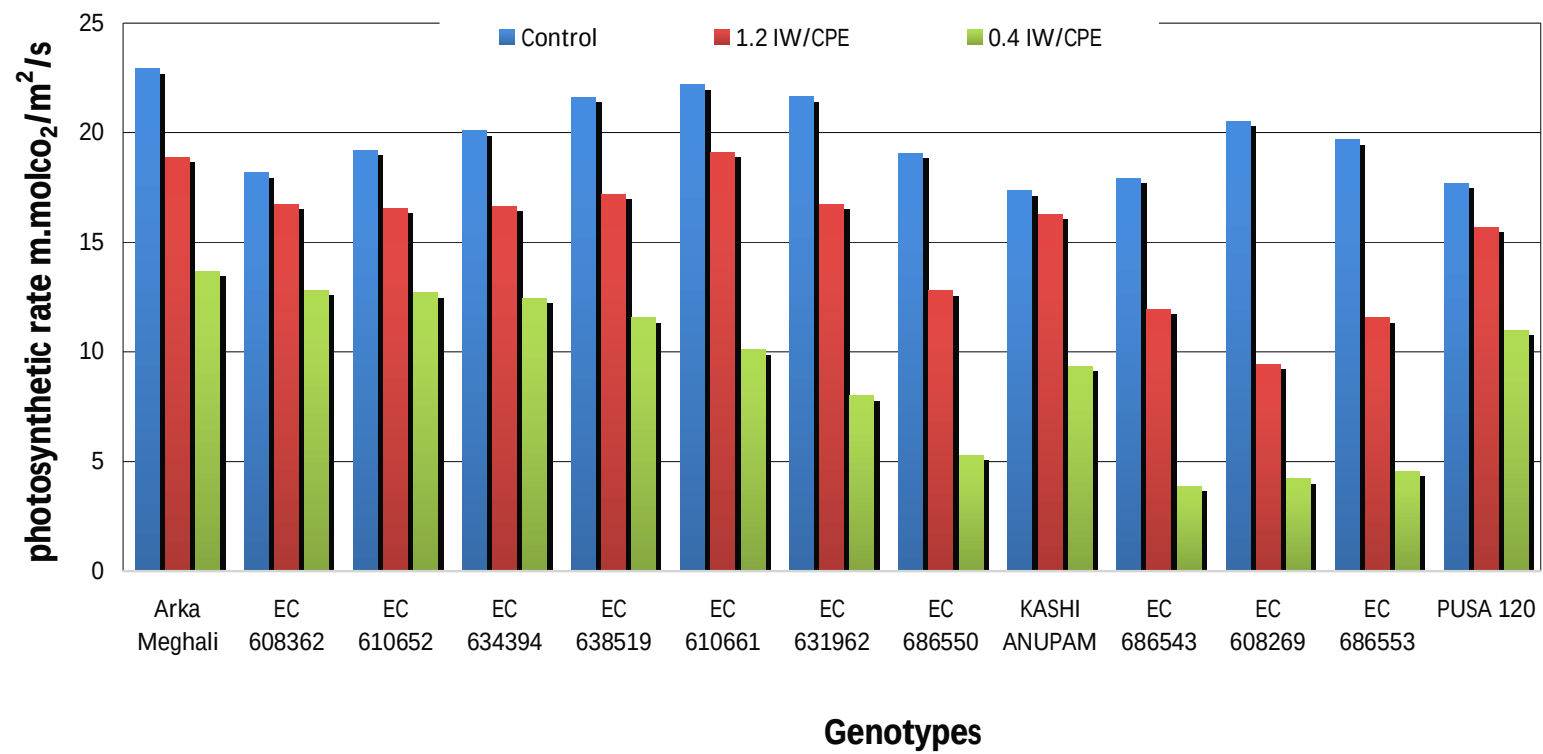


Fig. 3. Influence of irrigation levels on photosynthetic rate of tomato genotypes

tomato (Bhatt *et al.*, 2002). Photosynthetic and transpiration rate were reduced, whereas leaf temperature and stomatal resistance were increased by water stress in all cultivars of tomato (Hnilickova and Duffek, 2004).

In present study maximum transpiration was observed 1.2 IW/CPE ratio (8.09 mmol H₂O.m⁻². s⁻¹) and minimum was noticed at 0.4 IW/CPE ratio (6.36 mmol H₂O.m⁻². s⁻¹). Among the genotypes maximum transpiration was noticed in the genotype HUB -18 (10.45 mmol H₂O.m⁻². S⁻¹) and minimum was recorded in EC 686550 (5.88 mmol H₂O.m⁻². S⁻¹) at 1.2 IW/CPE ratio. While, at 0.4 IW/CPE ratio higher transpiration was exhibited by the genotype Kashi Anupam (7.92 mmol H₂O.m⁻². s⁻¹) and least was in the genotype EC 686550 (4.13 mmol H₂O.m⁻². s⁻¹). Leaf temperature was significantaly less at 1.2 IW/CPE ratio 31.71°C and highest was noticed at 0.4 IW/CPE ratio (33.67 °C).

Transpiration is important trait for assessment of drought tolerance, and is widely affected by environmental stress conditions. Higher transpiration rate were observed in control plants (100% FC) at all the stages compared to water deficit stress condition (50% FC) in tomato all the genotypes (Sivakumar, 2014). Mingchi *et al.* (2010) reported that, the stomatal conductance, transpiration rate and photosynthetic rate were reduced under simulated drought stress in tomato. Kudoyarova *et al.* (2007) showed that the partial root zone drying decreased the whole plant transpiration rate by 22 per cent in tomato plants. Anjum *et al.* (2011a) indicated that drought stress in maize led to considerable decline in net photosynthesis (33.22%), transpiration rate (37.84%), stomatal conductance (25.54%), water use efficiency (50.87%), intrinsic water use efficiency (11.58%) and intercellular CO₂ (5.86%) as compared to well water control.

Among the selected genotypes from first experiment, similar results were observed for photosynthesis, stomatal conductance, transpiration, leaf temperature, intercellular CO₂ at higher level of water stress (0.4 IW/CPE ratio). Thus based on the studies of biophysical characters like maintenance of higher photosynthetic rate, stomatal conductance, lower transpiration and growth parameters like LA, NAR, CGR, RGR, BMD, LAR, LAI, *etc.*, the genotypes EC 608362, EC 610 652, EC 634394, EC 638519, EC 610661, EC 631962 Kashi Anupam and Pusa 120 could be categorised as drought tolerant and EC 686550, EC 686543, EC 608269 and EC 686553 as drought susceptible genotypes.

5.4 Biochemical parameter

In the present study, chlorophyll content and proline content were studied in the tomato genotypes. Chlorophyll are photosynthetic pigments which absorb light energy for synthesis of carbohydrates and are an important factor for plant productivity.

Total chlorophyll content indicated significant difference among irrigation schedules during the first year and among the genotypes, irrigation levels and their interactions for the selected genotypes data during second experiment (Table 21 and 52). As the stress increased from control to 0.4 IW/CPE ratio, there was reduction in chlorophyll “a”, “b” and total chlorophyll content during 45 DAT.

The selected genotypes data on chlorophyll content indicated that, irrespective of the irrigation levels, EC 638519 and EC 608362 showed higher chlorophyll “a”, EC 638519 and EC 631962 recorded significantly higher chlorophyll “b” and EC 638519 and EC 631962 total chlorophyll content compared to other genotypes including the check Arka Meghali during 45 and 90 DAT, respectively.

At 0.4 IW/CPE ratio, EC 686 553, recorded significantly maximum chlorophyll ‘a’ and minimum was noticed in EC 686553, while Pusa 120 and EC 610661 recorded significantly maximum chlorophyll ‘b’ and minimum was in EC 686550 and EC 686553 whereas, Kashi Anupam and Pusa 120 recorded significantly maximum total chlorophyll content and minimum was noticed in the genotype EC 686553 during 45 and 90 DAT, respectively.

Present investigation is in conformity with Gladden *et al.* (2012) who showed that water deficit earlier in the growth of tomato caused a significant reduction in leaf chlorophyll content. Abdellah *et al.* (2011) recorded the highest reduction in the chlorophyll content in susceptible wheat cultivar under water stress of 30 per cent FC. Water stress reduced the total chlorophyll content significantly in different genotypes of moth bean and reduction was more pronounced in late flowering genotypes (Garg *et al.*, 2004). Salami and Saadat (2013) reported that, drought stress damaged chloroplast and reduced chlorophyll content in maize cultivars. The resistant cultivars were potential yielders and had higher amount of chlorophyll. Decline in concentration of chlorophyll a, b and total chlorophyll was reported in rice also by Chaum *et al.* (2013).

The results on proline (Table 23) indicated significant differences in irrigation levels only and in second experiment (Table 54) indicated significant differences among genotypes, irrigation levels and their interactions.

During the first year of experiment, among the irrigation levels proline production increased to the extent of 58.09 per cent as the stress level increased from control to 0.4 IW/CPE ratio, whereas, in the selected genotypes proline showed increase to the extent of 38.02 and 38.84 per cent during 45 and 90 DAT, respectively. The selected genotypes data indicated that, at 0.4 IW/CPE ratio maximum proline content was noticed in the genotype EC 638519 followed by EC 610652 during 45 and 90 DAT.

The present findings are accordance with the earlier findings of Shah *et al.* (2010) who showed that the moisture stress increased the proline content 2.75 and 3.60 times that of control by moderate and severe stress respectively in *Withania somnifera*. The highest average proline content found in the tomato cultivar Denar, displayed the most evident adaptation to stress conditions through osmotic adjustment (Jurekova *et al.*, 2011). Patel *et al.* (2012) showed that the proline content was increased significantly by drought stress in chickpea. Beena *et al.* (2012) reported that, high proline content was recorded in tolerant inbred lines of rice than susceptible lines under water stress condition.

Thus, from the above biochemical studies, it could be inferred that chlorophyll and proline content could be taken as one of the parameters while screening for drought tolerance.

5.5 Yield and yield components

The final yield and yield attributing characters are basically governed by vegetative growth and its distribution. Yield is the function of many yield contributing character like number of fruits per plant, fruit weight, *etc.*

For number of fruits per plant, during experimental period, significant differences were found among irrigation levels, genotypes and their interaction (Table 25 and 58) and number of fruits per plant decreased as the frequency of irrigation decreased. Per cent reduction in number of fruits per plant was to extent of 23.38 and

22.82 per cent during the first year and second year selected genotypes data, respectively.

Among the selected genotype data indicated, significantly higher number of fruits per plant was recorded in the genotype EC 638519 (93.82) at 0.4 IW/CPE ratio and followed by EC 610661 (89.01) and minimum was noticed in EC 608269 (15.48).

Therefore, number of fruits per plant contributes much for plant yield both under control and stress. Thus, the genotypes which showed minimum per cent reduction in number of fruits per plant at 0.4 IW/CPE ratio over control such as EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 are found to be drought tolerant. These results are in confirmity with earlier findings of Chavan *et al.* (2011) in tomato, Yadav *et al.* (2003) in potato.

Increase in the yield is a function of many yield contributing characters like fruit weight. During both the years fruit weight (Table 25 and 58) was decreased as the stress level increased. Fruit weight decreased to the extent of 13.70 per cent, respectively during first year, while, during the second year it was 25.44 per cent,

Irrespective of the irrigation levels, second experiment data also indicated that among the genotypes, EC 631962 (66.73g) recorded maximum fruit weight. However, at 0.4 IW/CPE ratio higher fruit weight was recorded in the genotype EC 634394 followed by Pusa 120 and EC 631962. Further, these genotypes also showed minimum per cent reduction in the fruit weight at 0.4 IW/CPE ratio over control.

This investigation is in confirmity with the earlier study of Mukesh (2007) in tomato and Bhagavanthagoudra (2000) in cabbage.

Significant difference for yield per plant and yield per hectare were noticed among the irrigation levels, genotypes and their interaction during both experimentation (Table 24 and 557). Significant yield reduction was noticed as irrigation frequency reduced and reduction was to the extent of 21.92 and 22.95 per cent, respectively. Data on yield per plant of selected genotypes for experimental trail during second phase at 0.4 IW/CPE ratio showed significantly maximum yield in the genotype EC 631962 (1.37 kg/plant) followed by Arka meghali and EC 634394 (1.33

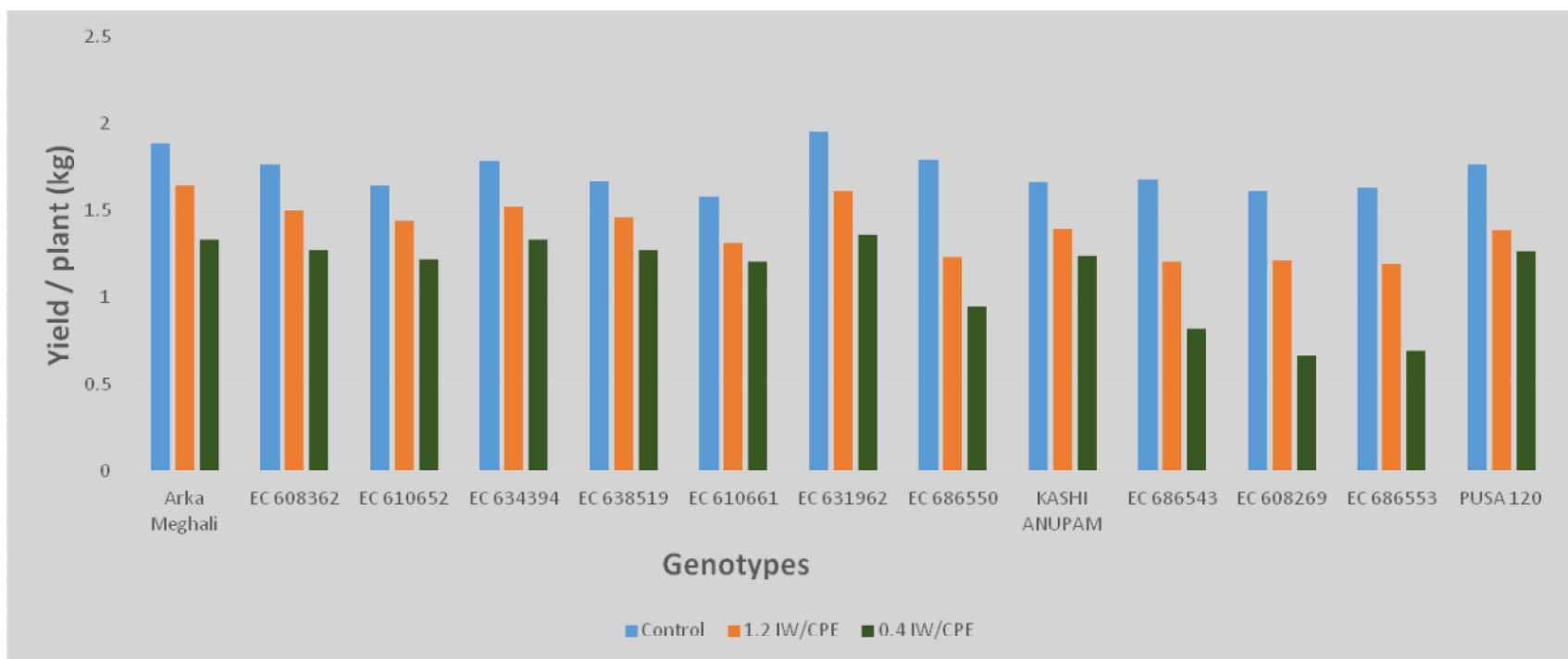


Fig. 4. Influence of irrigation levels on yield per plant

kg/plant), EC 608362 (1.28 kg/plant) and minimum was recorded in the genotype EC 608269 (0.66 kg/plant).

These results are in conformity with findings of Sivakumar (2014c), Fruit yield showed significant differences among the genotypes and treatments. Decrease in fruit yield was observed at 50 per cent FC level compared to 100 per cent FC. LE 114 recorded higher fruit yield (1,372.64) followed by LE 118 (1,112.88), LE 57 (1,071.20) and LE 27 (948.96). The percentage yield reduction under drought over control has been suggested as the most important parameter for assessing drought tolerance than fruit yield. Renquist and Reid (2001) reported that, 38 per cent reduction of fruit yield due to the fall of the fruit size by 35 per cent appeared at the water deficit in the period of fruit formation.

Water stress decreased yield, flower number, fruit set percentage and dry matter production in all cultivars, but the reduction was greater in drought sensitive cultivars than in tolerant ones in tomato (Rahman *et al.*, 1999a). Almeselmani *et al.* (2012) opined that, the yield and yield parameters were reduced significantly under drought condition in susceptible varieties than tolerant varieties in durum wheat. Rahman *et al.* (1999b) reported that, water stress significantly decreased yield, yield components and dry matter production in both tolerant and sensitive tomato cultivars, but the reductions were more pronounced in the drought sensitive cultivar compared to the tolerant cultivar. Reduced fruit weight was observed under 50 per cent and 100 per cent water stress over control in tomato (Bhatt *et al.*, 2002).

Based on the above discussion on biophysical parameters, yield and yield attributing characters it could be inferred that, EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 genotypes were found to be drought tolerant compared to EC 686550, EC 686543, EC 608269 and EC 686553 and local check Arka Meghali.

5.6 Quality parameters

Ascorbic acid, TSS and lycopene content enhance the quality of fruits which are regulates the potential characters. Tomato is a rich source of ascorbic acid (Vit - C), which is a potent antioxidant protecting plants against oxidative damages imposed by environmental stress such as drought and ozone.

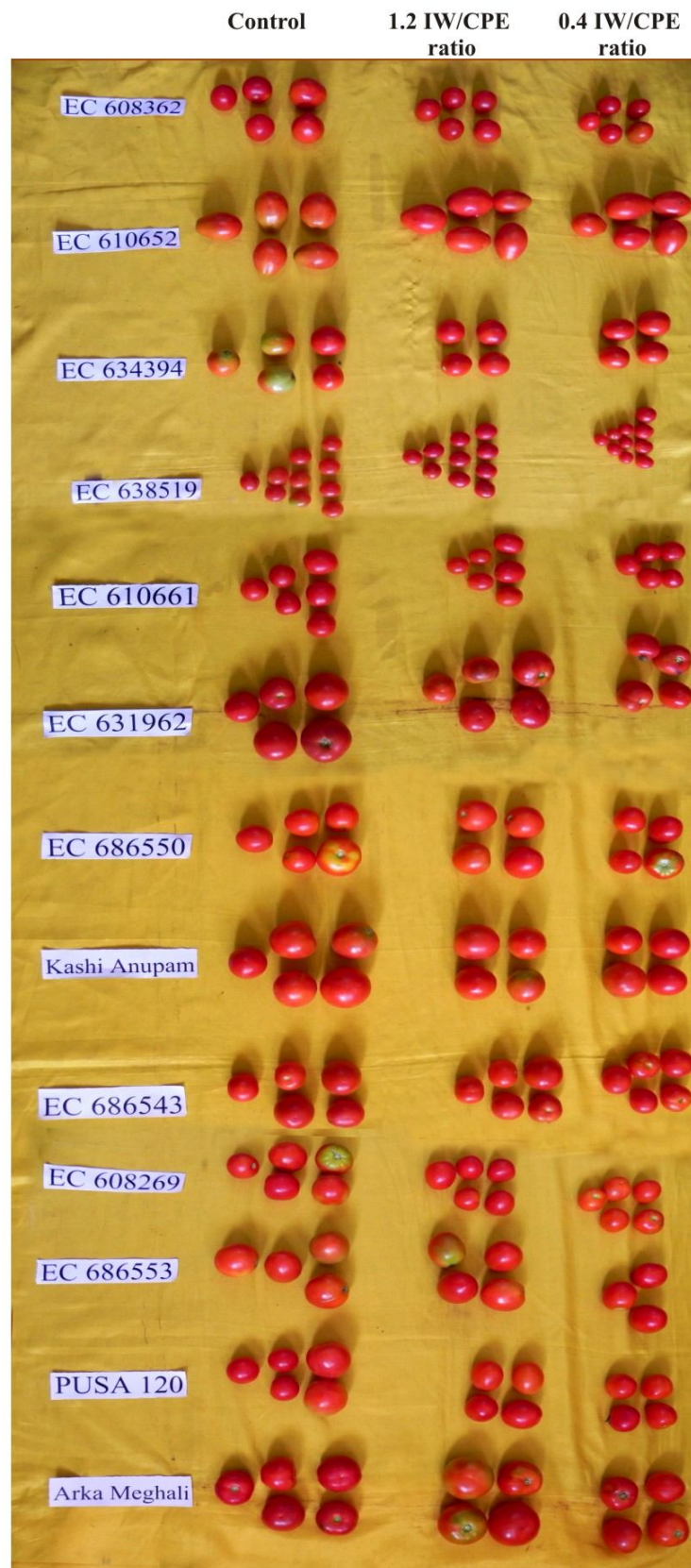


Plate 2. Fruits of selected genotypes at different irrigation levels

The data on selected genotypes which were tolerant, susceptible and local check (second experiment) indicated that, as the irrigation frequency decreased there was increase in ascorbic acid, lycopene and TSS content. It increased to the extent of 46.88, 50.39 and 28.74 per cent, respectively. Among the genotypes at 0.4 IW/CPE ratio higher ascorbic acid, lycopene and TSS content were recorded in Pusa 120, EC 638519 and EC 638519 and whereas, EC 686553, EC 608269 and EC 686550 recorded minimum, respectively. Increasing the ascorbic acid content of leaves might be the effective strategy to protect the thylakoid membrane from oxidative damages in water stressed leaves and resulting in enhanced net photosynthesis and tolerance to drought as evidenced by Tambussi *et al.* (2000) in wheat. The results of Amor and Amor (2007) showed that, when irrigation was reduced by 50 per cent increased the pH by 13.2 per cent and TSS by 18.9 per cent and reduced acidity by 30 per cent in tomato fruits compared to full irrigation. The fruit quality improvement was observed under water deficit condition in tomato as a result of the synthesis of ascorbic acid, citric acid and malic acid (Nahar *et al.*, 2011). Martino *et al.* (2006) also reported on tomato plants adaptation to environmental stress and reported that lycopene content in tomato fruits increased to 32 per cent under osmotic stress. Similarly Bang *et al.* (2004) studied the irrigation impact on lycopene on watermelon and reported that fruit lycopene content increased with maturity (7 and 22 days after ripening) at all the irrigation levels.

Based on the forgoing discussion of quality parameters, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, and Pusa 120 genotypes performed better under stress condition and were found to be drought tolerant compared to EC 686550, EC 686543, EC 608269 and EC 686553 and local check Arka Meghali.

Thus, considering the above discussion on morphological, growth, biochemical, biophysical, yield and yield attributes and quality studies it can be inferred that genotypes that EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 performed better under drought conditions and could be catagorised as drought tolerant genotypes compared to genotypes to EC 686550, EC 686543, EC 608269 and EC 686553 which can be categorized as drought susceptible.

5.7 To confirm the drought tolerance of tomato genotypes through molecular markers

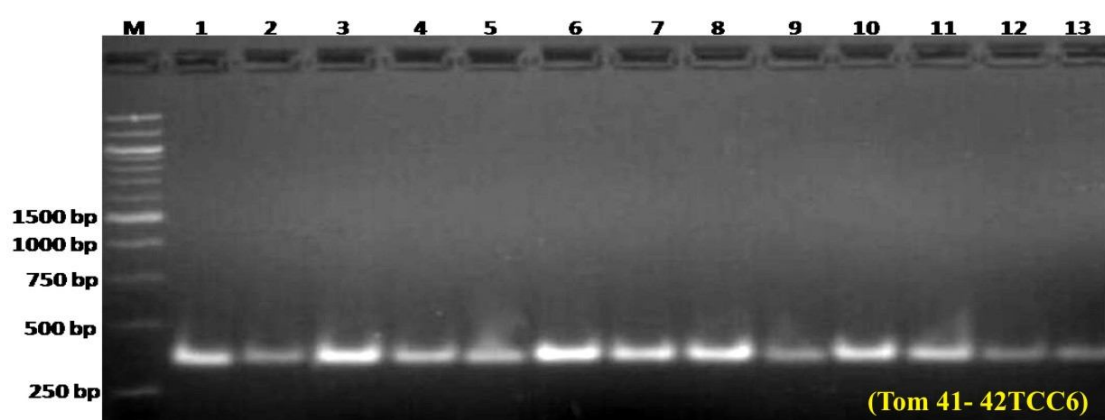
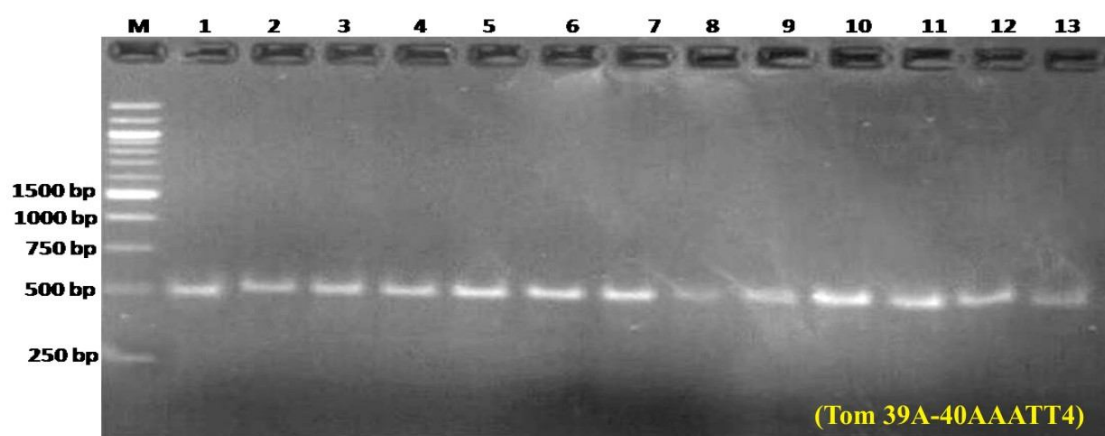
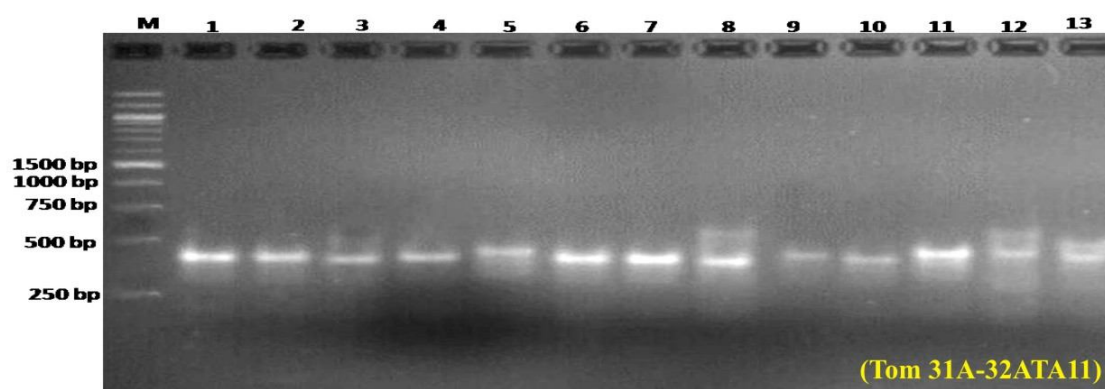
The important link between the conservation and utilization of plant genetic resources is germplasm characterization. Molecular techniques allow researchers to identify accessions with the most accuracy and certainty, assess the relative diversity within and among species and locate diverse accessions for breeding purposes. Assessing the diversity or characterization of germplasm based on morphological or taxonomical descriptors is the common method which results in overlapping complex results. These morphological methods depend on the environmental conditions hence there is a chance for occurrence of variation at phenotypic expression level. Some genotypes diverse at morphological level may not be at molecular level and vice-versa. Therefore, there is a need to support morphological variability with molecular variability studies in selecting better performing genotypes.

5.7.1 SSR analysis

In the study, SSR analysis (Plate 3), the similarity matrix coefficient ranged from 50 to 98 per cent, suggesting a moderate genetic variation within genotypes. The dendrogram based on UPGMA clustering resulted in the identification of three major clusters. Majority of the genotypes fall under the cluster-I with eight genotypes among these EC 686550 and EC 686553 are susceptible and Arka Meghali, EC 608362, EC 610652, EC 634394, EC 638519, EC 610661 are tolerance genotypes and cluster-II with Pusa- 120 as tolerance where EC 686550 and EC 608269 are susceptible and EC 631962 and Kashi Anupam are tolerance genotypes in cluster III. The results were compatible with Syamkumar and Sasikumar (2007) and Korir *et al.* (2014) in tomato.

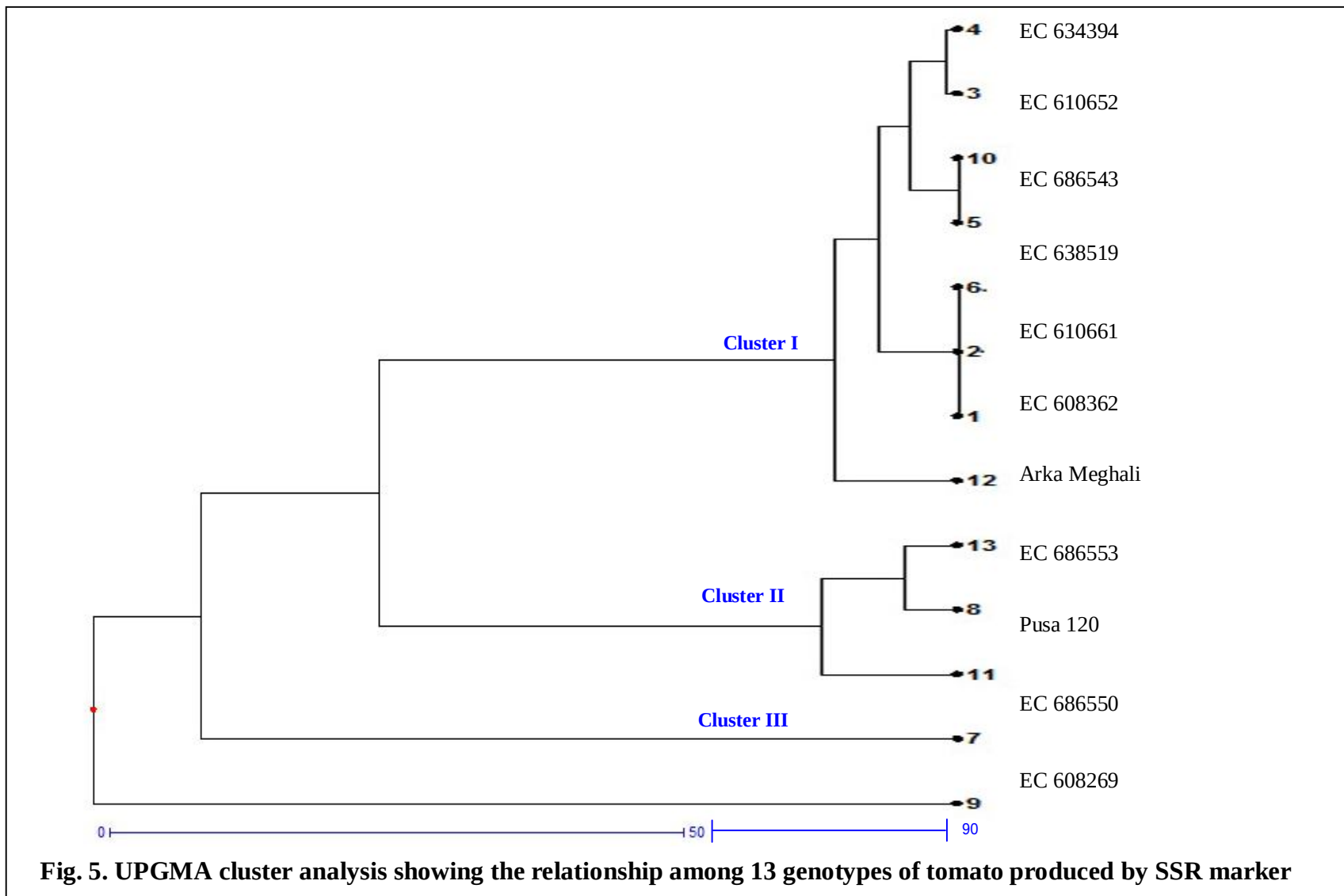
5.8 Character association

Variability studies provide information on the extent of improvement in different characters, but they do not throw light on the extent and nature of relationship existing between various characters may be on physiology and genetics. Therefore, for rational approach towards the improvement of yield, selection has to be made for the components of yield, since there may not be involvement genes for yield



Gel photograph showing PCR amplification of Lane M: marker-1 kb ladder; lane 1-13 showing different genotypes of tomato

Plate 3. SSR gel profile of 13 tomato genotypes generated by different primers



perse, but only for various yield components (Grafius, 1959). Genetic correlations between two characters arise because of linkage, pleiotrophy or development induced functional relationship (Harland, 1939). Hence, correlation study has greater significance and could be effectively utilized in formulating an effective selection scheme.

Many of these yield contributing characters which are may be desirable or undesirable for the interaction in any direction. Therefore, knowledge of association between the traits can greatly help in avoiding inversely related compensation effects during selection. A narrow difference between the genotypic and phenotypic correlation coefficients was observed (Table 4) for various traits in the present finding indicates the lesser influence of environment in the expression of these traits and presence of strong inherent association among the traits. Therefore, in the present study, though the correlation coefficients were worked out for growth, yield and biochemical components in tomato under different drought stress, among these traits only the heritable genotypic and phenotypic associations has been discussed.

In the present investigation, genotypic correlation is higher than phenotypic correlation for all the characters, indicating little influence of environment and the presence of inherent association between various characters. Yield is a complex character determined by several other characters. Hence, the association of these characters with yield and among themselves is of paramount importance in framing effective selection.

At control among the growth, biochemical and biophysical parameters highly significant (both at $p = 0.01$ and $p = 0.05$) and positively correlated for yield with LAR at 45 DAT, SLA at 45 DAT, leaf temperature, average fruit weight, fruit polar diameter and chlorophyll “b” at 90 DAT.

At 1.2 IW/CPE ratio, At control among the growth, biochemical and biophysical parameters highly significant (both at $p = 0.01$ and $p = 0.05$) and positively correlated for yield with leaf temperature, plant height at 45 DAT, stomatal conductance, total chlorophyll at 45 DAT, LAI at 90 DAT, LA at 90 DAT, total chlorophyll at 90 DAT, chlorophyll “a” at 90 DAT, proline at 90 DAT, photosynthesis, SLA at 90 DAT, LAR at 90 DAT, plant spread (NS) at 90 DAT, stem

girth 90 DAT, plant height at 90 DAT, stem girth 45 DAT, number of pubescence, RGR, AGR, CRG at 45 to 90 DAT, LAI at 45 DAT, LA at 45 DAT.

At 0.4 IW/CPE ratio, highly significant positive correlation for yield, was noticed with stem girth 90 DAT, plant spread (NS) at 90 DAT, plant spread (EW) at 90 DAT, chlorophyll “a” at 45 DAT, plant height at 90 DAT, total chlorophyll at 90 DAT, leaf temperature, LAI at 90 DAT, LA at 90 DAT, LAI at 45 DAT, LA at 45 DAT, biomass at 45 DAT, plant height at 45 DAT, biomass at 90 DAT, stomatal conductance, chlorophyll “a” at 90 DAT, number of pubescence, photosynthesis, SLA at 90 DAT, LAR at 90 DAT, RGR, AGR, CRG at 45 to 90.

Satoshi *et al.* (1989) studied the varietal differences in chilling tolerance of cucumber (*Cucumis sativus* L.) chilled at 4°C or 7°C for 2 days and changes in the photosynthetic rate and increase of leaf area were investigated. There was a positive and significant correlation between the chilling-induced depression of photosynthesis and of the increase in the apparent leaf area. Both parameters were also positively correlated among various varieties.

Tazuke and Sakiyam (1986) studied the effect of fruit temperature on the growth of cucumber fruit, relative growth rate (RGR) increased as the fruit temperature was raised to 30°C and was estimated to be 0 at about 5°C. The multiple regressions of RGR on fruit temperature and fruit volume gave high multiple correlation coefficients for different seasons and cultivars. Partial correlation was positive between RGR and fruit temperature and negative between RGR and fruit volume. Haque *et al.* (2009) studied that, at 50 per cent photosynthetic active radiation (PAR) number of leaves per plant did not decrease significantly in bottle gourd. Leaf weight ratio (LWR) remained more or less similar up to 50 per cent reduction of PAR. SPAD value increased with the reduction of PAR level *i.e.*, partial shading stimulated chlorophyll synthesis in leaves. Bottle gourd produced the highest yield (41.53 t ha) at 75 per cent PAR level and it did not show significant fruit yield reduction at 25per cent PAR level compared to full sunlight. Higher AGR, CGR, RGR and NAR indicate better growth and development which in turn depends on the leaf area of cotton (Ningnur, 2012).

The results indicated that selection of these traits would simultaneously result in selection for higher fresh rhizome yield.

5.9 Path analysis

The correlation coefficient measures the relationship existing between pairs of characters. But, a dependent character is an interaction product of many mutually associated component characters and change in any one component will disturb whole network of cause and effect system. The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect relation between the variables, is unique in partitioning the association into direct and indirect effects through other independent variables. Path analysis also measures the relative importance of causal factors involved. This is simply a standardized partial regression analysis, wherein total correlation value is subdivided into causal scheme.

5.9.1 Genotypic path coefficient analysis

The path coefficient analysis for yield (kg/plant) was carried out considering 15 and 12 characters. The residual effect of the genotypic path analysis was low (0.46 and 0.17) for first and second experiment, respectively. Indicating that, the characters considered for the path analysis were appropriate for the study and yield is taken as a dependent variable.

Yield (t/ha) was directly and positively influenced by Leaf area index 90 DAT, crop growth rate 45 to 90 DAT, plant spread north-south, net assimilation rate 45 to 90 DAT, average fruit weight and number of fruits per plant, plant height 90 DAT, absolute growth rate 45 to 90 DAT, transpiration rate, total chlorophyll, photosynthetic rate, and stomatal conductance. Plant height 90 DAT, proline 90DAT, leaf area 90 DAT (-0.161), crop growth rate, specific leaf weight, number of fruits per plant, leaf area ratio 90 DAT had negative direct effect on yield.

Similar findings were reported by Kumar *et al.* (2003) yield per plant was positively and significantly associated with plant height, fruit number per plant, fruit shape index and pericarp thickness. Path coefficient analysis indicated that fruit number per plant had the highest positive direct effect on yield per plant followed by average fruit weight. Manivannan *et al.* (2005) revealed that fruit yield exhibited highly significant and positive correlation with number of leaves, weight of fruit and juice per cent at both genotypic and phenotypic level.

Makesh *et al.* (2007) reported that yield per plant was positively and significantly correlated with number of fruits per plant, plant height, number of laterals per plant and number of fruits per cluster and was negatively correlated with number of locules per fruit and flesh thickness. Path analysis indicated that the number of fruits per plant, total soluble solids and acidity had positive and direct influence on yield, while the number of laterals per plant, number of fruits per cluster and flesh thickness had negative direct effect on yield.

Singh *et al.* (2006) and Islam *et al.* (2007) reported significant positive correlations between fruit length and fruit yield per plant in tomato. Haydar *et al.* (2007) observed that fruit yield had high positive phenotypic and genotypic correlation with total number of fruits at harvesting period and number of fruits in three clusters per plant. Plant height at flowering, number of flowers in three clusters per plant, days to flowering and total number of fruits at harvesting period also contributed to yield directly.

Breeder's point of view, the characters with high positive correlation and high direct effects at genotypic level under the high level of drought (0.4 IW/CPE ratio) are useful for selection for hybrid seed production programme with regard to change in the climatic condition.

5.10 Practical utility

Based on the above discussion on physiological, genetical and molecular studies it may be concluded that, the genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 were identified as drought tolerant source and may be included in the future crop improvement programmes.

The drought screening methodology and the drought tolerant traits like plant height, pubescence, stem girth, per cent reduction in yield, higher RWC, higher photosynthetic rate, higher internal CO₂, low transpiration rate, lower leaf temperature, higher proline and chlorophyll content and higher physiological growth parameters may be used as a selection indices for drought tolerance in new tomato germplasm screening activities for production of superior quality of germplasm for crop improvement against change in the climatic condition.

5.11 Future line of work

1. The genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 were identified as drought tolerant can be tested under multi-location trials for further confirmation and release of varieties suitable for drought under drought condition.
2. Selected genotypes may be used as drought tolerant source in breeding tomato for change in the climatic conditions or climate adaptation.
3. Genetic and molecular analysis for drought tolerant traits may be worked out for testing the reliability of these traits against the climatic change.

6. SUMMARY AND CONCLUSIONS

Drought is an important abiotic stress affecting the productivity of all rainfed crops, however, no remarkable progress has been made in this area. It is because there is no consistent relationship between measured response and field performance. Unlike creating epiphytotic condition, it is very difficult to create drought situation in the field. Hence the moisture stress is the major constraint for yield in tomato. The performance of genotypes in terms of productivity is the net result of interaction of genotypes and environment. So far, breeders have made attempts to breed high yielding genotypes under rainfed conditions based on only morphological, yield and yield attributing characters. However, drought tolerant traits include, morphological, physiological, biophysical and biochemical parameters which have a molecular genetic base. Thus, there is a need to identify drought tolerant traits and cultivars to minimize the reduction in production and productivity of crops (Chavan, 2007).

With these points in view, field experiments were conducted in the present investigation.

Initially, 50 tomato genotypes were screened for drought tolerance by using IW/CPE ratio method of scheduling of irrigation under field conditions with an objective of identifying drought tolerant genotypes based on (1) means of IW/CPE ratio (2) per cent reduction at 0.4 over 1.2 IW/CPE ratio (3) potential yield at 0.4 IW/CPE ratio which yielded more than 1kg/plant.

In successive year, a few identified genotypes were tested in field experiment to confirm the performance of the genotypes under stress with scheduling of irrigation based on morphological, physiological, biophysical and biochemical traits associated with the drought.

The salient features of these experiments are: Field experiment- II

1. Under moisture stress condition of 1.2 IW/CPE ratio the genotype, Arka Meghali had significantly higher yield ($1.65 \text{ kg plant}^{-1}$ and 49.95 t ha^{-1}) and under the severe moisture stress of 0.4 IW/CPE ratio higher yield was noticed in the genotype EC 631962 ($1.37 \text{ kg plant}^{-1}$ and 39.48 t ha^{-1}) and least yield was noticed in the susceptible genotype EC 608269 ($0.66 \text{ kg plant}^{-1}$) at 0.4 IW/CPE ratio.

2. Biomass production was recorded higher in the genotypes EC 638519, EC 610661 and EC 610661 at control, 1.2 and 0.4 IW/CPE ratio during all the growth stages as compared to local check Arka Meghali.
3. Irrespective of the irrigation levels, genotypes EC 610661 recorded maximum fruit weight, whereas, EC 638519 had maximum number of fruits per plant.
4. Among the different biochemical traits, Irrespective of the irrigation levels, genotypes EC 638519 and EC 608362 had significantly higher chlorophyll 'a' content at 45 and 90 DAT respectively. EC 638519 had maximum chlorophyll 'b' and total chlorophyll content at 90 DAT,
5. Highest proline content in the genotype EC 610652 and least was in the EC 608269 during 90 DAT, EC610661 exhibit the higher lycopene and ascorbic acid content. The tolerant genotype EC 634394 exhibit maximum number of pubescence and least was in the susceptible genotype EC686550 at both abaxial and adaxial.
6. Irrespective of the irrigation levels, genotypes EC 638519 recorded maximum leaf area, leaf area index and specific leaf weight. The genotype EC 610661 shows higher absolute growth rate and crop growth rate and lowest was in the susceptible genotype EC 686543.
7. The photosynthetic rate and stomatal conductance exhibit maximum in the genotype Arka Meghali and minimum photosynthesis was in the EC 686543.

Hence, considering all the parameters such as morphological, growth, biochemical, biophysical, yield and yield attributes and quality it can be inferred that genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 performed better under drought conditions and could be catagorised as drought tolerant genotypes compared to genotypes EC 686550, EC 686543, EC 608269 and EC 686553 which can be catagorised as drought susceptible ones and local check Arka Meghali.

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Appendix A: Weather data of ARS, Arabhavi for the year 2015

Month	Temperature °C				RH %	Actual		Normal (15 Yrs)		Evaporation (mm)
	Min.	Min Nor	Max	Max Nor		Rainfall (mm)	No. of rainy day	Rainfall (mm)	No. of rainy day	
January	17.6	9.3	28.7	29.4	88	0	0	0.3	0	4.2
February	12.7	10.2	32.3	30.9	87.5	0	0	1.1	0	4.2
March	17.4	16.0	34.3	33.1	87.5	17.3	1	6.4	0	3.3
April	20.2	18.2	36.8	35.1	82.1	22.0	01	22.6	1	3.4
May	22.7	19.9	38.0	34.4	85.5	108.8	03	93.8	2	4.6
June	21.2	20.9	31.4	29.1	85.5	69.5	06	20.9	6	3.9
July	20.7	19.9	31.1	28.3	84.5	7.9	01	19.9	6	4.3
August	19.9	19.1	30.9	28.5	88.3	33.7	04	51.5	5	7.4
September	18.9	18.3	31.9	29.2	89.4	53.7	03	66.9	6	4.6
October	18.3	14.7	34.6	30.0	89.9	53.3	04	99.0	6	3.9
November	14.8	16.5	30.9	29.6	87.7	3.2	01	24.3	2	4.2
December	14.0	13.2	32.6	29.2	91.3	0.0	00	5.4	0	3.8
Total						369.4	24	412.1	34	51.8

Weather data of ARS, Arabhavi for the year 2016

[illegible]

**Appendix B: Physical and chemical properties of the soil of the experimental site at
K.R.C. College of Horticulture, Arabhavi (after experimentation)**

Particulars	Characterization	Methods employed
I. Physical properties		
Clay (%)	47.50	Hydrometer method (Piper, 1950)
Silt (%)	23.00	Hydrometer method (Piper, 1950)
Fine sand (%)	13.00	Hydrometer method (Piper, 1950)
Coarse sand (%)	8.00	Hydrometer method (Piper, 1950)
II. Chemical properties		
Organic carbon (%)	0.79	Modified kjeldahls method (Jackson, 1967)
Total nitrogen (%)	0.29	Modified kjeldahls method (Jackson, 1967)
Available Phosphorous (kg/ha)	36.22	Olsens method (Muhr <i>et al.</i> , 1965)
Available Potassium (kg/ha)	361.20	Flame photometer method (Muhr <i>et al.</i> , 1965)
III. pH (1:2.5) (soil: water)	7.4	pH meter (Piper, 1950)

PHYSIOLOGICAL AND GENETICAL INVESTIGATION FOR DROUGHT TOLERANCE IN TOMATO (*Solanum lycopersicum* L.) GENOTYPES

PRAKASH G.

2016

Dr. MUKESH L. CHAVAN

Major Advisor

ABSTRACT

Drought tolerance studies in tomato genotypes were undertaken at K.R.C. College of Horticulture Arabhavi during 2014-2016. Initially, 50 tomato genotypes were screened for drought tolerance based on the per cent reduction in 0.4 over 1.2 IW/CPE for physiological, biophysical, biochemical and morphological characters. Based on first experimental results 13 genotypes consisting of eight tolerant four susceptible and one local check were selected for detailed investigation under stress with above traits in addition to some parameters during second experiment.

Results of selected genotypes analysis indicated that under the sever moisture of 0.4 IW/CPE ratio, higher yield was noticed in the genotype EC 631962 as compared to susceptible genotype EC 608269. Biomass production was significantly higher in the genotypes EC 638519, EC610661 and Kashi Anupam at all growth stages as compared to local check Arka Meghali and susceptible genotypes. Among the biophysical parameters genotype EC 610661 had maximum transpiration rate, whereas in Arka Meghali had significantly higher photosynthesis. Among biochemical traits, chlorophyll 'a', 'b' and TSS content was maximum in the genotype EC 638519 whereas, ascorbic acid content were higher in the genotype PUSA 120. Lycopene content was more in the genotype EC 610661 while proline was higher in EC 610652. Number of pubescence count on adaxial and abaxial surface was significantly higher in EC 634394.

Path coefficient analysis revealed that relative growth rate and total chlorophyll had positive direct effect on yield at genotypic level. SSR profile analysis of 13 tomato genotypes by using six primers, only three primers had shows polymorphism. The dendrogram was revealed that the thirteen genotypes examined and all genotypes were grouped into three major clusters.

Hence, considering morphological, biophysical, biochemical, yield and quality parameters it can be inferred that genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 performed better under drought conditions and could be categorised as drought tolerance genotypes compared to EC 696550, EC 686543, EC 608269 and EC 686553. These tolerant genotypes can be used for further breeding programme.

mÉ^aǺmÉ SgÀ ÀµǺÉǺ+ǺjǺjPǺ^aǺǺCǺǺǺ²ǺiǺ,Ǻ+ÉǺzǺÉ

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2016

qÁ. a ÆPĖÀZÀÁÈÀ
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ÁgÁA±À

mÆ^aiÁimÆ v½U¼° Sg ,»µÄVAiÄ CzAiÄE^aEÄ 2014-15 C^aΦAiÄ° Q.gÁ.Z.vÆÄIUájP aÄ°Á«zÁ@AiÄz° PÉUÆ¼Ä¬ÄvÄ. DgA¨z° 50 mÆ^aiÁimÆ v½U¼±ájJp, fÄ^a¨Ev±Á, fÄ^ag,ÁAiÄpP aÄvÄ DPëw @PtU¼EÄ 0.4 IW/CPE aÄÄ 1.2 IW/CPE ±Ä Prv DzÁgz aÄÄ ¥jÄP aÍq¬ÁVz. aÆz@ aµðz ¥°vÁ±z DzÁgz aÄÄ 13 mÆ^aiÁimÆ v½U¼EÄ, 8 ,»µ ,°E, 4 aÄvÄ 1 ,½ÄAiÄ ZPi v½U¼EÄ DAiÄ aÍr C^aIU¼EÄ ,»µÄv Mvq CrAiÄ° «,Äv v^aS aÍq¬ÁVz.

°ϕ^aÄEgÄ v½U¼ ¥jÄPAiÄEÄ «±Ä¶, ¯ÄV (0.4 IW/CPE vÄ^aÄA±z CrAiÄ°)

EC 631962 v½AiÄÄ EC 608269 v½VAv CϕP E¼Ä^aj ¢Är z. EC 638519, EC 610661

aÄvÄ PÄ² CÄÄ¥^aÄ v½U¼Ä, CPÄð aÄUÄ° aÄvÄ MvQpI vÄvÄUÄ^a v½VAv °a£ fÄ^agÄ²

GvÄ¢¹z. fÄ^a ¨ ¨Ev±Ä, z ¢AiÄvÄAPU¼°, EC 610661 v½AiÄÄ Ujµ ¨ ¨Ä¶ÄPg t °ÄA¢zÄ

°ÄUÄ EC 610661 CPÄð aÄUÄ° v½AiÄÄ Ujµ zÄw, A±Äµu °ÄA¢z. fÄ^ag, ÄAiÄE±Ä,

¢AiÄvÄAPU¼° EC 638519 v½AiÄÄ ¥vÄejvÄ J aÄvÄ © aÄvÄ n. J, i. J, i CA±^aEÄ °a£

¥ÄiÄt z° °ÄA¢z. Dzg C, ÄjPi DÄÄ^a ¥Ä, Ä 120 v½AiÄ°, ¯iPÄÄ|Ei CA±^a

EC 6100661 v½AiÄ° °a£ ¥ÄiÄt z°^a. ¥ÄÄEÄi CA±^a EC 610652 v½AiÄ°

°ZÄVzÄ, EC 634394 v½AiÄ° J ¯AiÄ aÄÄ°£ aÄvÄ P¼V£ ¥zgU¼° Ujµ gÄÄ^a

, ÄAzæ °ÄA¢z.

v½U¼ Uät «±ÄµuAiÄ°, ASAcv ¼atUAIÄ zg aÄvÄ MIÄ ¥vÆjvÄ, EªU¼Ä
zÉÁvP °AUÉ ÉĜ ¥juÁªā ©Ājgªā CA±U¼AzÄ PAqÄSACz. 13 m/EªiÄim/E v½U¼
gÄSÁPwAiÄEÄ ga,®Ä DgÄ SSR ¥ÆÄgi G¥AiÆÄV, ÄVvÄ. ¥jÄQÄ¹z ¥ÆÄgiU¼EÄ
¥ÆÄ WIP «±Äµu avæ° 3 UÄ¥ÄU¼ÉÄV «Aur, ÄVz.

¼atU, fÄa"Ev±Á, fÄag,ÁAiäp, E¼aaj aÄvÄ Evg UÄt aÄIz
 aAiävÁAPU¼ÄÄ ¥jut¹, EC 608362, EC 610652, EC 634394, EC 638519,
 EC 610661, EC 631962, PÁ² CÄ¥aüi aÄvÄ ¥Æ,Á 120 v½U¼Ä Sg¥j¹wU¼° GvªÄ
 ¥æ±ðE vÆG\$®aÄ aÄvÄ F v½U¼Ä EC 696550, EC 686543, EC 608269 aÄvÄ
 EC 686553 U½U °Æ°¹zg Sg ,»µÄv v½U¼AZÄ aVÄðPj, S°ÄZÄ. aÄÄÄ££ ££U¼°
 Sg ¥j¹wAiÄ° C£P E¼aaj v½AiÄ C£a££ PÁAiÄðz° F v½U¼Ä S¼, S°ÄZÄ.