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Effect of Paclobutrazol and Partial Root Drying on Growth and Yield Attributes of Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

A pot experiment was carried out to investigate the effect of paclobutrazol (PBZ) as a growth retardant and partial root drying (PRD) as a water saving technique on excessive vegetative growth and yield of tomato (*Solanum lycopersicum* L.) at different doses of 1.0, 1.5, 2.0 and 2.5 ppm PBZ alone and in combination with PRD. The growth and yield parameters were evaluated at 50 days after transplanting (DAT), 100 DAT and at harvest (145DAT).Number of leaves, leaf area, relative growth rate, specific leaf area, dry weight of roots and shoots in tomato were decreased significantly in PBZ treated plants and PBZ + PRD@ 2.5ppm in comparison to control that clearly indicating the role of Paclobutrazol inhibiting gibberellins biosynthesis thereby reducing the growth of tomato plants. However, stem thickness increased significantly because when gibberellins biosynthesis decreases cell division still occurs, but the new cells do not elongate, resulting in stouter stem. Number of fruits/plant, dry weight of fruit, total soluble carbohydrates, fruit diameter, pericarp thickness, number of locules and fruit yield were increased significantly in PBZ treated plants and PBZ+PRD@ 2.5 ppmas compared to control. Application of PBZ @ 2.5 ppm commands a great significance in maintaining growth of plants and thereby enhancing the yield.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important fruit crops grown throughout the world. It is an important source of antioxidants in the human diet because of their relatively high content of carotenoids. It acts as an antioxidant and scavenger of free radicals, which is often associated with carcinogenesis. India has world's second rank in total production and area; however, it is 11th rank in productivity (Vanitha, 2013). Water is essential for crop production because plants require water for growth and tissue expansion. Because of the high proportion of water used for agricultural purposes and the projections that water scarcity due to unpredicted climate change will increase in the future, there is a constant need to focus on efficient use of available water resources in order to increase crop productivity per unit of used water (Mancosu *et al.,* 2015). Numerous management practices have been proposed to increase yields and improve quality attributes of tomatoes. Apart from fertilizer management, growers in recent years have attempted to develop water management strategies that maintain yields while imposing a moderate, controlled level of stress on the crops in order to improve fruit quality (Atkinson *et al.*, 2011). Therefore, great emphasis is placed in the area of crop physiology and crop management for dry conditions with the aim to make plants more efficient in water use, Partial Root Drying is applied as a physical technique and Paclobutrazol is used as a biochemical hormone to reduce the amount of water supplied and increase crop water use efficiency on tomatoes. Partial root drying (PRD) is a new irrigation and plants growing technique which improves water use efficiency without significant yield reduction. It is an irrigation technique where half of the root zone is irrigated while the other half can dry out and vice-versa. Recent comparative study indicated that alternate PRD crops have a higher yield (Dodd *et al.,* 2015).

Paclobutrazol (PBZ), a synthetic plant growth regulator, is a triazole-type inhibitor of gibberellin (GA) biosynthesis which affects plant growth and development. It inhibits the activity of ent-kaurene oxidase, which is an enzyme in the GA biosynthetic pathway that catalyzes the oxidation of ent-kaurene to ent-kaurenoic acid (Xia *et al.*, 2018). It acts by inhibiting gibberellin biosynthesis, reducing internodal growth to give stouter stems, increasing root growth, causing early fruit set and increasing seed set in plants. When gibberellin production is inhibited, cell division still occurs, but the new cells do not elongate, resulting in stouter stem and short internodes with the same number of leaves (Jungklang *et al.,* 2017). Paclobutrazol acts as stress protectant by maintaining relative water content, membrane stability index, photosynthetic activity, photosynthetic pigments and protects the photosynthetic macinery by enhancing the level of osmolytes, antioxidant activities and level of endogenous hormones and thereby enhances the yield (Soumya *et al.*, 2017).

Materials and Methods

The experiment was conducted from October 2017 to April, 2018 under screen house condition while the laboratory work was carried out in the Division of Plant Physiology, Faculty of Basic Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Main Campus Chatha, Jammu-180009, J&K. Tomato (*Solanum lycopersicum*L.) variety Pusa Ruby were raised to study the growth and yield attributes by implying the physical technique known as PRD and by the use of a plant growth retardant known as Paclobutrazol. Tomato seeds were germinated in commercial compost and established in a vegetable farm until the appearance of the fifth leaf. Two type of transplantation were done in soil with compost filled plastic pots i.e., one is normal transplantation and other as per the partial root drying methods. In PRD method tomato plants were transplanted, with the root system of each plant divided equally between two plastic bags in plastic pots containing the same commercial compost. Pots were watered daily for one week to allow establishment of the root systems. After five days of transplanting, as per the treatments, Paclobutrazol was applied at different doses of 1.0 ppm, 1.5 ppm, 2.0 ppm and 2.5 ppm. Data were recorded at 50 days after transplanting, 100 days after transplanting and at the time of harvest (145 DAT).

Observations

The following observations were recorded on three competitive plants randomly selected and tagged from each treatment in each replication after giving paclobutrazol treatment and PRD treatment to crop at 50DAT, 100DAT and at the time of harvest.

Growth characters

Number of leaves: Number of leaves was recorded from selected plants from each treatment.

Stem thickness (cm): Stem thickness was measured with the help of Vernier Caliper in centimetre at all the three stages.

Leaf Area (cm^2): The leaf surface area one side was calculated manually and recorded throughout the period of crop development at 50DAT, 100DAT and at harvest (Blanco and Folegatti, 2003).

Root dry weight (g): Total root dry weight in grams was recorded from selected plants from each treatments.

Shoot dry weight (g): Total shoot dry weight in grams was recorded from selected plants from each treatments.

Specific leaf area: The specific leaf area was calculated as the one sided leaf surface area divided by its dry oven mass at harvest. It was expressed in $cm^2\ g^{-1}$ (Cornelissen *et al.*, 2003)

Relative growth rate: The RGR was measured at harvest. It was expressed in $g\ d^{-1}$. It was calculated by using following formula (Hunt, 1982)

$$RGR = W_2 - W_1 / T_2 - T_1$$

Where, W_2 and W_1 is the final and initial plant dry weight at time T_1 and T_2.

Fruit characters, yield and yield attributing traits

Number of fruits/plant: Number of fruits/plant was taken from three plants and means were worked out of each treatment and control.

Number of locules in fruit: Tomato fruits of each treatment were cut transversely and locules were counted.

Fruit diameter (cm): Diameter of fruit was measured in (cm) with the help of a Vernier caliper at the center (equatorial length) of the fruit.

Pericarp thickness (cm): Pericarp thickness was measured in (cm) with the help of a Vernier caliper.

Dry weight of fruit (g): Dry weight of fruit was taken at harvest from three plants and mean were worked out of each treatment and control.It was expressed in grams.

Total soluble carbohydrates (mg/g): Total soluble carbohydrates was determined by using anthrone reagent (Yemm and Willis, 1954).

Fruit yield/plant (Kg): Fruit yield was recorded from all the three tagged plants by adding up weight of fruits obtained from all the previous pickings.

Experimental Design and statistical analysis

The experiment was laid out in randomized block design with three replicates of each treatment. Treatments were compared using critical difference (CD) at 5% level of significance. Data were subjected to analysis of variance (ANOVA) using Online Statistical Analysis Package (OPSTAT, Computer

Section, CCS Haryana Agricultural University, Hisar 125004, Haryana, India).

Results and Discussion

Number of leaves

A marked decrease in number of leaves was noticed when the plants treated with PBZ @ 2.5 ppm (28.00, 36.00 and 46.66) followed by PBZ @ 2.0 ppm (30.66, 39.00 and 50.66) in comparison to control (55.66, 105.00 and 118.66) at 50 DAT, 100 DAT and at harvest respectively (Table 1). When the plants were subjected to PRD technique, there was a slight, but significant reduction in number of leaves (48.33, 88.66 and 101.30) at 50, 100 DAT and at harvest respectively. Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Leaf area (cm^2)

Data presented in Table 1 showed a significant reduction in leaf area in PBZ treated plants @ 2.5 ppm (45.44, 75.35 and 139.55 cm^2) followed by PBZ @ 2.0ppm, 1.5 ppm and 1.0 ppm as compared to control plants (365.80, 759.53 and 991.60) at 50, 100 DAT and at harvest respectively (Table1). When the plants were subjected to PRD technique, there was a slight, but significant reduction in leaf area at 50, 100 DAT and at harvest (247.26, 510.88 and 755.53) in comparison to control. Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Stem thickness (cm)

Stem thickness was significantly increased in plants treated with PBZ @ 2.5 ppm (1.201, 1.533 and 1.601 cm) followed by PBZ @ 2.0 ppm (1.067, 1.467 and 1.533) at 50, 100 DAT and at harvest respectively (Figure 1). When the plants were subjected to PRD technique, stem thickness was slightly but significantly increased at 50, 100 DAT and at harvest (0.433, 0.633 and 0.801) in comparison to control. Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Total soluble carbohydrates (TSC) (mg/g DW)

A marked increased in TSC was observed when PBZ applied @ 2.5 ppm (3.903 mg/g drywt.) followed by PBZ @ 2.0 ppm (3.853) at harvest. As evident from Table 2, PBZ when applied @ 1.5 ppm and 1.0 ppm alone, also greatly increased soluble sugar (3.823) and (3.767) respectively at harvest as compared to control plants (2.930).

When the plants were subjected to PRD technique, there was a significant increase in soluble sugar (3.617) in comparison to control. Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Specific leaf area (cm^2)

Specific leaf area in PBZ treatment was significantly decreased @ 1.0, 1.5, 2.0 and 2.5 ppm (43.53, 39.90, 33.19 and 32.86) respectively at harvest in comparison to control (157.70).As evident from Table 2, when plants were subjected to PRD technique, specific leaf area was also noticed significant (124.70) as compared to control (157.70). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Relative growth rate (g/day)

Relative growth rate in PBZ treatment was significantly decreased @ 1.0, 1.5, 2.0 and 2.5 ppm (0.154, 0.150, 0.144 and 0.138) respectively at harvest in comparison to control (0.173). As evident from Table 2, when plants were subjected to PRD technique, relative growth rate was noticed significant (0.167) as compared to control (0.173). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Dry wt. of root (g)

Dry weight of root in Paclobutrazol (PBZ) treatment was significantly decreased @ 1.0, 1.5, 2.0 and 2.5 ppm (3.84, 3.77, 3.73 and 3.68 g) respectively at harvest in comparison to control (4.06). As evident from Fig. 4, when plants were subjected to PRD technique, dry weight of root was noticed non-significant (4.10) as compared to control (4.06). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Dry wt. of shoot (g)

Dry weight of shoot (Fig. 4) was significantly decreased when plants treated with PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm (22.91, 22.89, 22.86 and 22.84 g) respectively at harvest in comparison to control (28.97).

In PRD technique, dry weight of shoot was found non-significant (28.92) as compared to control (28.97). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Dry wt. of fruit (g)

Dry wt. of fruit was significantly increased in PBZ treated plants @ 1.0, 1.5, 2.0 and 2.5 ppm (7.95, 8.13, 8.24 and 8.33) respectively at harvest in comparison to control (7.24). As evident from Fig. 4, When the plants were subjected to PRD technique, dry wt. of fruit was found non-significant (7.22) as compared to control (7.24). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Pericarp thickness (cm)

Pericarp thickness of tomato fruit was slightly increased in PBZ treated plants @ 1.0, 1.5, 2.0 and 2.5 ppm (0.63, 0.66, 0.70 and 0.73 cm) respectively at harvest in comparison to control (0.56) but they are statistically non-significant (Table 3).

When the plants were subjected to PRD technique, pericarp thickness was found non-significant (0.56) as compared to control (0.56). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm (Fig. 2 and 3).

Fruit diameter (cm)

Fruit diameter (Table 3) was significantly decreased in PBZ treated plants @ 2.5 ppm (3.82 cm) in comparison to control (4.43). PBZ when applied @ 1.0, 1.5 and 2.0 ppm alone, fruit diameter was found non-significant.

When the plants were subjected to PRD technique, fruit diameter was found non-significant (4.73) as compared to control (4.43). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Yield per plant (Kg)

Tomato yield per plant was significantly increased in Paclobutrazol (PBZ) treated plants @ 1.0, 1.5, 2.0 and 2.5 ppm (2.44, 2.51, 2.62 and 2.67) respectively at harvest in comparison to control (1.63).

As evident from Table 3, When the plants were subjected to PRD technique, the yield per plant was found non-significant (1.57) as compared to control (1.63). Same trend was observed in plants treated with PRD + PBZ @ 1.0, 1.5, 2.0 and 2.5 ppm.

Table.1 Effect of physical and biochemical approaches on number of leaves, leaf area (cm^2) and at various growth stages in tomato (Pusa Ruby)

Treatments	Number of leaves			Leaf Area (cm^2)		
	Days after transplanting			Days after transplanting		
	50DAT	100DAT	At harvest	50DAT	100DAT	At harvest
T1-Control	37.33	79.00	88.33	365.80	759.53	991.60
T2-PBZ (1.0ppm)	20.00	25.00	30.66	94.87	143.22	247.33
T3-PBZ (1.5ppm)	17.66	22.33	26.00	80.44	124.11	220.66
T4-PBZ (2.0ppm)	14.33	19.66	23.66	65.33	102.33	175.00
T5-PBZ (2.5 ppm)	12.00	18.00	20.00	45.44	75.35	139.55
T6-PRD	29.00	66.66	80.66	247.26	510.88	755.53
T7-PRD+PBZ (1.0ppm)	24.66	28.66	33.66	125.20	179.10	353.05
T8-PRD+PBZ (1.5ppm)	19.66	25.33	30.66	104.60	157.07	306.44
T9-PRD+PBZ (2.0ppm)	15.33	22.33	27.66	82.94	130.05	262.22
T10-PRD+PBZ (2.5ppm)	14.00	19.33	26.00	55.88	99.72	199.33
CD at 5%	5.34	5.09	3.97	46.25	46.62	59.05
±SE (m)	1.79	1.71	1.33	15.56	15.69	19.87

PBZ=Paclobutrazol, PRD= Partial Root Drying, PBZ+PRD=Paclobutrazol in combination with Partial Root Drying, CD at 5%= Critical Difference, ±SE (m) = Standard error mean

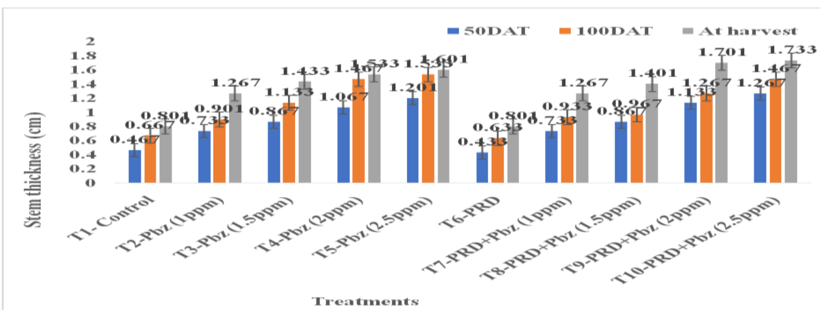
Table.2 Effect of physical and biochemical approaches on specific leaf area (cm^2/g), relative growth rate (g/day) and total soluble carbohydrates (mg/g) at harvest on tomato variety (Pusa Ruby)

Treatments	Specific leaf area(cm^2/g)	Relative growth rate (g/day)	Total soluble carbohydrates (mg/g)
T1-Control	157.70	0.173	2.930
T2-Pbz (1.0ppm)	43.53	0.154	3.767
T3-Pbz (1.5ppm)	39.90	0.150	3.823
T4-Pbz (2.0ppm)	33.19	0.144	3.853
T5-Pbz (2.5ppm)	32.86	0.138	3.903
T6-PRD	124.70	0.167	3.617
T7-PRD+Pbz(1.0ppm)	60.16	0.149	3.883
T8-PRD+Pbz(1.5ppm)	56.48	0.142	3.923
T9-PRD+Pbz(2.0ppm)	54.81	0.136	3.960
T10-PRD+Pbz(2.5ppm)	52.73	0.131	4.080
CD at 5%	*17.39*	*0.007*	*0.111*
±SE (m)	*5.85*	*0.002*	*0.037*

Table.3 Effect of physical and biochemical approaches on yield/plant (Kg), pericarp thickness (cm), fruit diameter (cm) and number of fruits/plant at harvest on tomato variety (Pusa Ruby)

Treatments	Yield/plant (Kg)	Pericarp thickness(cm)	Fruit diameter(cm)	Number of fruits/ plant
T1-Control	1.63	0.56	4.43	128.33
T2-Pbz (1.0ppm)	2.44	0.63	4.16	206.00
T3-Pbz (1.5ppm)	2.51	0.66	4.13	210.66
T4-Pbz (2.0ppm)	2.62	0.70	3.93	215.33
T5-Pbz (2.5ppm)	2.67	0.73	3.82	219.66
T6-PRD	1.57	0.56	4.73	126.33
T7-PRD+Pbz(1.0ppm)	2.33	0.63	3.86	205.33
T8-PRD+Pbz(1.5ppm)	2.48	0.70	3.83	209.66
T9-PRD+Pbz(2.0ppm)	2.54	0.73	3.76	214.66
T10-PRD+Pbz(2.5ppm)	2.56	0.76	3.60	218.33
CD at 5%	*0.07*	*0.32*	*0.11*	*16.28*
±SE (m)	*0.02*	*0.10*	*0.03*	*5.48*

Fig.1 Effect of physical and biochemical approaches on stem thickness (cm) at various growth stages in tomato (Pusa Ruby)



CD at 5 %	*0.180*	*0.188*	*0.295*
±SE (m)	*0.061*	*0.063*	*0.099*

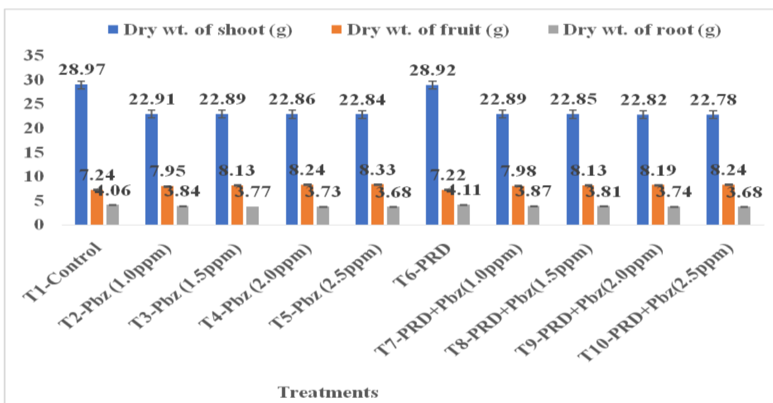
Fig.2 Effect of PBZ treatment on fruiting in Tomato

Left: Control, Right: PBZ @2.5ppm

Fig.3 Effect of PRD + PBZ on fruiting in Tomato

Left: Control, Right: PRD+PBZ @ 2.5ppm

Fig.4 Effect of physical and biochemical approaches on dry wt. of shoot (g), dry wt. of fruit (g) and dry wt. of root (g) at harvest on tomato variety (Pusa Ruby)



CD at 5%	*0.32*	*0.30*	*0.11*
±SE (m)	*0.10*	*0.10*	*0.03*

In present investigation, the number of leavesand leaf area (Table 1) was significantly reduced by PBZ treatment alone and also in combination with PRD (PRD+PBZ) @ 2.5 ppm. Maximum number of leaves and leaf area was observed in control and PRD alone. The PBZ induced reduction in leaf area may be linked to inhibition of GA biosynthesis whereas small leaves helps in minimum loss of water by the leaf surface and it also helps in improvement of water use efficiency. Our findings are in accordance with Pal *et al.*, (2016) in which they noticed that PBZ application led to decreased leaf area and root area ratio in tomato plants. PBZ application led to decreased leaf area ratio in irrigated plants (Berovaand Zlatev, 2003). Paclobutrazol treatment induced reduction in leaf area under deficit irrigation and also in both irrigated and deficit irrigated conditions in tomato plants (Parent *et al.*, 2009; Mahdieh *et al.*, 2009). Lei *et al.*, (2009) noticed that, leaf area under PRD was significantly decreased in comparison to control. Leaf growth reduction was the result of both a decrease in the number of leaves and leaf area (Stikic *et al.*, 2003).

The stem thickness was significantly increased in PBZ alone and PRD+PBZ treatment @ 2.5 ppm as compared to control and PRD alone (Fig. 1). Increased stem thickness in PBZ treated plants due to reduced GA endogenous level and hence increased stem width because cell division still occurs, but the new cells do not elongate, resulting in stouter stem and short internodes.

Our observations are in vicinity to other researchers, who observed that the plants treated with PBZ exhibit stunted growth due to reduced GA endogenous level (Mobli and Baninasab, 2008; Upreti *et al.,* 2013). PBZ application has reduced plant height and therefore improved stem diameter (Pal *et al.,* 2016). Jungklang *et al.,* (2017) also reported that gibberellins production is inhibited in PBZ treated turmeric plants whereas cell division continue, but the new cells do not elongate, resulting in stouter stem and short internodes with the same number of leaves.

Biomass

Dry weight of root, shoot and fruit of tomato was significantly decreased in PBZ alone and PRD + PBZ treated plants @ 2.5 ppmin comparison to control and PRD alone (Fig. 4). Changes in the root dry weight and shoot/dry weight have been linked to the PBZ induced inhibition of GA biosynthesis leading to reduced shoot/root growth. GA induced growth and activity of the enzyme xyloglucan transglycosylase (XET) in plant tissues. This enzyme hydrolyses xyloglucans of the cell walls internally and causes molecular rearrangement in the cell wall matrix which could promote extension of cell wall. Berovaand Zlatev (2003); Gopi *et al.,* (2007); Bayat *et al.,* (2012) supporting our findings.

They noticed that fresh weight and dry weight of roots and shoots was significantly decreased in wheat, carrot and maize plants treated with Paclobutrazol. Pal *et al.,* (2016) also observed that the application of PBZ at different concentration significantly reduced shoot dry weight and root dry weight considerably in tomato plants. In PRD treatment, there was found no significant difference in total dry biomass as compared to control (Lei *et al.,* 2009 and Perez-Perez *et al.,* 2012).

Specific leaf area

In present investigation, specific leaf area was significantly decreased in PBZ alone and in PRD+PBZ @ 2.5 ppm in comparison to control and PRD alone (Table 2). Reduction in specific leaf area in PBZ treated plant is due to the leaf structural adaptation and also helping in higher chlorophyll index and higher rate of photosynthesis. Our observations are in agreement with Pal *et al.,* (2016) in tomato and Abdul Jaleel *et al.,* (2007) in *Catharanthus roseus.* They found a significant reduction in specific leaf area in PBZ treated tomato and China rose plant.

Relative growth rate

Relative growth rate was significantly decreased in PBZ alone and in PRD+PBZ @ 2.5 ppm in comparison to control and PRD alone (Table 2). Reduction in RGR may be due to the reduction in plant height under PBZ treated plants. Our observations are in agreement with other researchers study results (Pal *et al.,* 2016). They noticed that PBZ application under irrigated conditions lowered RGR in tomato plants.

Total soluble carbohydrates

Accumulation of sugars in different parts of plants is enhanced in response to a variety of environmental stresses (Prado *et al.,* 2000). When the plants were subjected to PRD technique, there was a significant increase in soluble sugar. Our results are in agreement with other researchers (Loveys *et al.,* 2000; Stikic *et al.,* 2003; Xu *et al.,* 2009) in tomato and (Francaviglia *et al.,* 2013) in apple. They found that as compared with deficit irrigation practice, PRD leads to greater sugar and organic acid concentrations in tomato fruits. Ruan *et al.,* (2010) also found that higher accumulation of ABA due to mild stress in PRD stimulates the activity of enzyme invertase in the fruits and as a result the concentration of sugars hexose in the fruits is increased. Similarly, Subbaiah *et al.,* (2017) conducted an experiment on mango and they found that fruit quality, in terms of sugars was improved at lower water application levels over the higher water application levels. This may be due to increase in total soluble solids associated with reduced fruit water content and greater hydrolysis of starch into sugars.

In the present investigation, the total soluble sugar was significantly increased in PBZ alone and PRD + PBZ @ 2.5 ppm in comparison to control plants (Table 2). Our results was proved by the other researchers (Gopi *et al.,* 2007, Mobli and Baninasab, 2008; Pal *et al.,* 2016; Reddy *et al.,* 2013; Hua *et al.,* 2014). They found that the total soluble sugar, sucrose, and starch content in the stem, leaf and bud organs were significantly increased by paclobutrazol application in carrot, almond, tomato, mango, canola plants respectively.

The increased of total soluble sugars and sucrose content could be partially accounted by the activating effect of paclobutrazol on enzymes related to sucrose synthesis and catalysis (Hua *et al.,* 2014).

Yield attributes

Fruit yield, pericarp thickness, fruit diameter and total number of fruits per plant was significantly increased in PBZ and PRD+PBZ treatment @ 2.5 ppm as compared to control and PRD treated plants (Table 3). Similar pattern of high yield in PBZ treated plants has been observed in other studies (Xia *et al.,* 2018). They noticed that application of paclobutrazol in crop plants would increase the fruit yield.

The yield of canola plant could be significantly improved by paclobutrazol application (Hua *et al.,* 2014). Paclobutrazol application increased the chlorophyll content which led to greater rate in photosynthesis and higher yield. When the plants were subjected to PRD technique, the yield per plant was found non-significant as compared to control.

Our results were in agreement with Lei *et al.,* (2009). This was proved by other researchers (Reddy *et al.,* 2013). They reported that application of PBZ increases the fruit biomass, PBZ enhanced the photosynthetic rate and thereby enhances the fruit yield which may be linked with the highest number of fruits and fruit biomass in PBZ treated plants. In PRD treatment, our results showed that PRD caused a slight but non-significant reduction in fruit numbers and fruit biomass as compared to control. Davies *et al.,* (2000) demonstrated that PRD reduces leaf growth of grapevines, but has no influence on fruit growth and development. Our results are in agreement with other researchers (Stikic *et al.,* 2003; Lei *et al.,* 2009).

In conclusion the application of 2.5 ppm PBZ by soil drenching method may be beneficial for better yield and quality production of tomato crop. This dose of PBZ could not be recommended at this stage to farmers prior to its confirmation at the field scale. Nevertheless, the positive results with reference to PBZ in tomato crop is undoubtedly encouraging for making elaborate studies at field scale with adequate concentrations of PBZ.PBZ induce several physiological and biochemical alterations that generally lead to morphological modifications with consequent effect on yield in tomato. Hence, it is suggested that the use of PBZ would effectively increase the biomass with higher yield in tomato. The effective concentrations of 2.5 ppm of PBZ were found to be the most suitable for the purpose. It helps to maintain relative growth rate, increases the soluble carbohydrates, fruit biomass and thereby enhances the yield in crop plants.

References

Abdul Jaleel, C.A., P. Manivannan, B. Sankar, A. Kishorekumar, S. Sankari and Panneerselvam, R. 2007. Paclobutrazol enhances photosynthesis and ajmalicine production in *Catharanthus roseus*. Process Biochemistry, 42: 1566-1570.

Atkinson, N. J., T. P. Dew, C. Orfila and Urwin P.E. 2011. Influence of combined biotic and abiotic stress on nutritional quality parameters in tomato (*Solanum lycopersicum* L). Journal of Agricultural and Food Chemistry, 59: 9673–9682.

Berova, M., and Zlatev, Z. 2003. Physiological response of Paclobutrazol- treated triticale plants to water stress. Biologia Plantarum, 46: 133-136.

Cornelissen, J. H. C., S. Lavorel and Garnier E. 2003. A handbook of protocols for standardized and easy measurement of plant functional traits. Australian Journal of Botany, 51: 335–380.

Dodd, I. C., J. Puertolas, K. Huber, J. G. Perez-Perez, H. R. Wright and BlackwellM. S. A. 2015. The importance of soil drying and re-wetting in crop phytohormonal and nutritional responses to deficit irrigation. Journal of Experimental Botany, 66: 2239–2252.

Francaviglia, D., V. Farina, G. Avelloneand Bianco, R. 2013. Fruit yield and quality responses of apple cultivars to partial rootzone drying under Mediterranean conditions. Journal of Agricultural Science, 151: 556–569.

Gopi, R., C. A. Jaleel, R. Sairam, R. Lakshmanan and Pannerselvam R. 2007.Differential effects of hexaconazole and paclobutrazol on biomass, electrolyte leakage, lipid peroxidation and antioxidant potential of *Daucus carota* L. Colloids and surfaces. Biointerfaces, 60: 180–186.

Hua, S., Y. Zhang, H. Yu, B. Lin, H. Ding, D. Zhang, Y. Renand Fang Z. 2014. Paclobutrazol application effects on plant height, seed yield and carbohydrate metabolism in Canola. International journal of agriculture and biology, 16: 471–479.

Hunt, R., 1982. Plant growth curves: the functional approach toplant growth analysis. London: Edward Arnold.

Jungklang, J., K. Saengnil and Uthaibutra J. 2017. Effects of water-deficit stress and Paclobutrazol on growth, relative water content, electrolyte leakage, proline content and some antioxidant changes in *Curcuma alismatifolia*. Saudi Journal of Biological Sciences,24 (7): 1505-1512.

Lei, S., Q. Yunzhou, J. Fengchao, S. Changhai, Y. Chao and Yuxin L. 2009. Physiological mechanism contributing to efficient use of water in field tomato under different irrigation. Plant Soil Environment, 55: 128–133.

Loveys, B. R., M. Stoll,P. R. Dry and McCarthy M. G. 2000. Using plant physiology to improve the water use efficiency of horticultural crops. Acta Horticulture, 537: 187–199.

Mahdieh, M., and Mostajeran, A. 2009. Abscissic acid regulates root hydraulic conductance via aquaporin expression modulation in *Nicotiana tabacum*. Journal of Plant Physiology, 166: 1993–2003.

Mancosu, N.,R. L. Snyder,G. Kyriakakis and Spano D. 2015. Water scarcity and future challenges for food production. Water, 7: 975–992.

Mobli, M., and Baninasab, B. 2008. Effects of plant growth regulators on growth and carbohydrate accumulation in shoots and roots of two almond rootstock seedlings. Resumen Espanol, 63: 363-370.

Pal, S., J. S. Zhao, A. Khan, N. S. Yadav, A. Batushansky, S. Barak, B. Rewald, A. Fait,

N. Lazarovitch and Rachmilevitch S. 2016. Paclobutrazol induces tolerance in tomato to deficit irrigation through diversified effects on plant morphology, physiology and metabolism. Scientific Reports, 6: 39321.

Parent, B., C. Hachez, E. Redondo and Tardieu F. 2009. Drought and abscissic acid effects on aquaporin content translate into changes in hydraulic conductivity and leaf growth rate: a trans-scale approach. Plant Physiology, 149: 2000–2012.

Perez-Perez, J. G., I. C. Dodd and Botia P. 2012. Partial rootzone drying increases water-use efficiency of lemon trees independently of root-to-shoot ABA signalling. Functional Plant Biology, 39: 366–378.

Prado, F.E., C. Boero, M. Gallardoand Gonzalez J.A. 2000. Effect of NaCl on germination, growth and soluble sugar content in *Chenopodium quinoa* wild seeds. Botanical Bulletin of Academia Sinica, 41: 27-34.

Reddy, Y.T.N., S. R. Shivu Prasad and Upreti K.K. 2013. Effect of paclobutrazol on fruit quality attributes in mango (*Mangifera indica* L.). Journal of Horticultural Science, 8: 236-239.

Ruan, Y., Y. Jin, Y. Yang, G. Li and Boyer J. S. 2010. Sugar input, metabolism, and signaling mediated by invertase: roles in development, yield potential, and response to drought and heat. Molecular Plant, 3: 942–955.

Soumya, P.R.,P. Kumar and Pal M. 2017. Paclobutrazol: a novel plant growth regulator and multi-stress ameliorant. Indian Journal of Plant Physiology, 22: 267–278.

Stikic, R., S. Popovic, M. Srdic, D. Savic, Z. Jovanovic, L. J. Prokic and ZdravkovicJ. 2003. Partial root drying (PRD): a new technique for growing plants that saves water and improves the quality of fruit. Journal of Plant Physiology, 164–171.

Subbaiah, K. V., N. N. Reddy, M. L. N. ReddyDorajeerao, A. V. D and Reddy, A. G. K. 2017. Effect of Different Irrigation Levels on Yield and Physiological Biochemical Characteristics of Mango cv. Banganpalli. International Journal of Pure and Applied Bioscience, 5 (6): 177-182.

Upreti, K. K., S. R. Shivu Prasad, N. Reddy and Bindu G.V. 2013. Hormonal changes in response to paclobutrazol induced early flowering in mango. Scientia Horticulturae, 150: 414–418.

Vanitha, S. M., G. Kumari and SinghR. 2013. Export competitiveness of fresh vegetables in India. International Journal of Vegetable Science, 20: 227-234.

Xia, X., Y. Tang, M. Wei and Zhao D. 2018. Effect of Paclobutrazol Application on Plant Photosynthetic Performance and Leaf Greenness of Herbaceous Peony. Journal of Horticulturae, 4: 5.

Xu, H. L., F. F. Qin, F. L. Du, Q. C. Xu, R. Wang and Shah R. P. 2009. Application of xero phyto-physiology in plant production-Partial Root Drying improves tomato crops. Journal of Food Agriculture and Environment, 7: 981–988.

Yemm, E.W., and Willis, A.J. 1954. The estimation of carbohydrates in plant extract by anthrone. Biochemistry Journal, 57: 508-514.

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