Indian J. Hort. 68(2), June 2011: 180-183

Influence of triacontanol and paclobutrazol on growth and leaf nutrient status of Non-Pareil almond under different soil moisture regimes

M.K. Sharma* and N.K. Joolka
Department of Pomology, Dr Y.S. Parmar University of Horticulture & Forestry, Solan 173 230

ABSTRACT

Non Pareil almond plants in containers were subjected to four levels of moisture stress, *viz.*, -0.5, -2.5, -5.0 and -10.0 bar after treating foliarly with 5 and 10 ppm triacontanol (TRIA), 50 and 100 ppm paclobutrazol (PP_{333}) and distilled water (control) and observations were recorded on growth and leaf nutrient status. Plants treated with 10 ppm TRIA attained the highest vegetative growth, volume, scion and stock girth and total length and biomass of roots at all the stress levels in comparison to other growth regulator treatments. The leaf macronutrient contents were also higher in the plants treated with 10 ppm TRIA. Macronutrient contents decreased with increase in moisture stress. Plants treated with 10 ppm TRIA performed better under stress conditions and thus can be recommended for better growth of NonPareil almond plants in the drought prone areas.

Key words: Triacontanol, paclobutrazol, almond, soil moisture.

INTRODUCTION

Almond (*Prunus amygdalus* Batsch.), one of the most important nut fruit in the world, is mainly grown under rainfed conditions in India with very low productivity. Most of the almond plantations are on the sloppy land and are rainfed. Due to frequent drought prevailing during the growing season, most of the young plants die. Hence, it was thought desirable to test the efficacy of some bioregulators in improving the drought tolerance. As triacontanol (TRIA), a primary alcohol, is reported to cause increased uptake of water and nutrients and results in the increased growth of the plants, increased CO_2 exchange (Mishra and Srivastava, 9) and paclobutrazol (PP_{333}), a growth retardant inhibits gibberellin biosynthesis and prevents stem elongation, increase transpiration and stomatal conductance and decrease the size of stomata (Abo-Rawash *et al.*, 2) may improve plant's performance under drought. However, such information is lacking in fruit trees in general and in almond in particular. Therefore, present studies were undertaken to test TRIA and PP_{333} for their influence on growth and mineral composition under different levels of soil moisture stress.

MATERIALS AND METHODS

The investigations were carried out on one-year-old NonPareil almond plants grown in 100 l capacity containers (50 cm dia.) filled with 70 kg mixture of soil:sand:FYM (3:1:1 v/v/v). The experiment was laid out in a randomized block design with three replications. Soil used for preparing potting mixture was sandy loam with pH 6.81, EC 0.41 dSm^{-1}, OC 2.25%, available N,P,K 116.0, 40.0 and 203.0 ppm, respectively. The field capacity of the experimental soil was 21.09 per cent, wilting point 4.12 per cent, bulk density 1.36 mg m^3 and porosity 40.09 per cent. The containers were placed in a polyhouse to protect these from rains. Initially the containers' soil was maintained at field capacity and then subjected to -0.5, -2.5, -5.0 and -10.0 bar soil moisture tensions. After reaching the desired tension, the soil in the containers was brought to field capacity by applying a measured quantity of water. These stress cycles were imposed from March to November. Before the commencement of the experiment, soil moisture in all the containers was brought to field capacity and 100 ml growth regulator solution of TRIA @ 5 and 10 ppm and PP_{333} @ 50 and 100 ppm was sprayed with a mini hand sprayer in the second fortnight of March. Plants sprayed with distilled water were treated as control.

Annual shoot extension growth (cm) was recorded in the month of December by measuring the current season's growth. Plant volume was worked out by the formula as suggested by Westwood (12). Scion girth was measured 2 inches above and stock girth 3 inches below the graft union with measuring tape. Length of primary and secondary rots (upto 2 mm dia.) was determined with the help of measuring tape. Length of tertiary roots and root hairs was recorded on Comair Root Length Scanner. Total root length was expresses in meters. Dry weight of the roots was expressed in grams. For the estimation of nutrient composition, leaf samples were collected as per the method suggested by Kenworthy (7). Total leaf N was determined by micro-Kjeldahl's method

*Corresponding author's present address: Division of Pomology, SKUAS-K, Shalimar, Srinagar 191 121 (J&K); E-mail: drsharma_mk@rediffmail.com

(AOAC, 1) and P by Vandomolybdo-phosphoric yellow colour method (Koeing and Johnson, 8). Leaf K, Ca and Mg contents were estimated on ECIL atomic absorption spectrophotometer. The contents of leaf nutrients were expressed in percentage on dry weight basis.

RESULTS AND DISCUSSION

Among the growth parameters recorded, plants irrigated at -0.5 bar soil moisture tension registered appreciably higher annual shoot growth, plant volume, scion and stock girth and length and dry weight of roots (Tables 1-3) than those maintained at other moisture levels. This might be due to the fact that soil moisture at -0.5 bar was readily available to the plants during growing season which induced better growth (Abrisqueta *et al*., 3). Growth regulators influenced the annual shoot growth, plant volume, scion and stock girth and length and dry weight of roots significantly. These parameters were significantly higher in the plants treated with 10 ppm TRIA than other growth regulator treatments. This might be due to increased uptake of water and nutrients and cell division with TRIA treatment (Gunasekaran, 6).

Plants treated with 100 ppm PP_{333} had markedly lower annual shoot growth, plant volume, scion and stock girth and length and dry weight of roots which were significantly lower than the remaining treatments which might be due to inhibition of gibberellin biosynthesis with PP_{333} application (Biasi *et al*., 5).

The roots of plants treated with PP_{333} under present study were restricted to a small volume because of inhibition of root elongation which ultimately influenced the ability of plants to make contact with nutrients or water. Similar observations were recorded by Biasi *et al.* (5) in peach. Moisture level and growth regulator interaction influenced the growth parameters significantly. Plants treated with 10 ppm TRIA and irrigated at -0.5 bar had the higher growth while it was minimum in the plants treated with 100 ppm PP_{333} and irrigated at -10.0 bar. The plants stressed at -10.0 bar had better shoot extension growth, volume, scion and stock girth and length and dry weight of roots when treated with 10 ppm TRIA in comparison to other bioregulator treatments.

Table 1. Influence of bioregulators on annual shoot growth and plant volume at various levels of soil moisture stress.

Moisture level (bar)	Annual shoot growth (cm)						Plant volume (m^3)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100			5	10	50	100		
-0.5	141.1	148.0	84.4	79.8	114.0	113.5	1.91	2.47	0.59	0.49	1.13	1.32
-2.5	111.7	126.7	71.2	62.5	96.8	93.8	1.38	1.71	0.40	0.31	0.66	0.90
-5.0	90.3	95.5	56.6	51.1	80.1	74.8	0.77	0.99	0.25	0.20	0.36	0.52
-10.0	79.7	81.9	45.8	42.7	71.3	64.3	0.36	0.55	0.16	0.11	0.22	0.28
Mean	105.7	113.1	64.5	59.1	90.6	-	1.11	1.43	0.36	0.28	0.59	-
$CD_{(0.05)}$	Moisture level					1.4					0.03	
	Bioregulator					1.5					0.05	
	Moisture level × Bioregulator					3.1					0.11	

Table 2. Influence of bioregulators on scion and stock girth at various levels of soil moisture stress.

Moisture level (bar)	Scion girth (cm)						Stock girth (cm)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100			5	10	50	100		
-0.5	8.05	8.80	5.28	4.69	6.39	6.64	7.88	8.63	5.12	4.54	6.26	6.48
-2.5	7.05	7.76	4.89	4.21	6.08	6.00	7.06	7.58	4.72	4.09	5.91	5.87
-5.0	6.20	6.84	4.20	3.75	5.63	5.33	6.04	6.70	4.06	3.60	5.42	5.16
-10.0	5.49	6.33	3.72	3.50	4.94	4.80	5.35	6.16	3.58	3.34	4.47	4.64
Mean	6.70	7.43	4.52	4.04	5.76	-	6.58	7.27	4.37	3.89	5.59	-
$CD_{(0.05)}$	Moisture level					0.05					0.03	
	Bioregulator					0.06					0.03	
	Moisture level × Bioregulator					0.11					0.06	

Table 3. Influence of bioregulators on total root length and dry weight of roots at various levels of soil moisture stress.

Moisture level (bar)	Total root length (m)						Root dry weight (g)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100			5	10	50	100		
-0.5	29.38	31.36	16.18	13.72	23.46	22.82	106.50	148.20	57.66	50.06	76.38	87.75
-2.5	19.39	24.00	13.44	10.19	15.68	16.55	71.05	86.81	48.52	36.79	58.72	60.38
-5.0	15.76	21.46	11.23	8.70	13.16	14.07	56.86	73.94	38.42	30.69	47.73	49.53
-10.0	12.37	14.23	7.64	5.33	10.70	10.06	45.63	54.35	29.27	20.67	38.82	37.76
Mean	19.23	22.77	12.13	9.49	15.76	-	70.01	90.83	43.47	34.55	55.41	-
$CD_{(0.05)}$	Moisture level				0.97						2.28	
	Bioregulator				1.09						2.55	
	Moisture level × Bioregulator				2.17						5.09	

Table 4. Influence of bioregulators on leaf N and P contents at various levels of soil moisture stress.

Moisture level (bar)	N (%)						P (%)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100			5	10	50	100		
-0.5	2.75	2.81	2.20	2.14	2.63	2.51	0.173	0.178	0.121	0.118	0.161	0.150
-2.5	2.64	2.70	2.03	1.99	2.44	2.36	0.154	0.159	0.117	0.113	0.138	0.136
-5.0	2.55	2.60	1.86	1.82	2.29	2.22	0.134	0.142	0.111	0.109	0.121	0.124
-10.0	2.39	2.42	1.74	1.67	2.18	2.08	0.124	0.130	0.106	0.103	0.117	0.116
Mean	2.58	2.63	1.96	1.91	2.39	-	0.146	0.152	0.114	0.111	0.134	-
$CD_{(0.05)}$	Moisture level				0.02						0.002	
	Bioregulator				0.02						0.002	
	Moisture level × Bioregulator				0.05						0.005	

Table 5. Influence of bioregulators on leaf K and Ca contents at various levels of soil moisture stress.

Moisture level (bar)	K (%)						Ca (%)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100			5	10	50	100		
-0.5	1.30	1.36	1.06	0.92	1.20	1.17	2.03	2.08	1.80	1.82	1.62	1.87
-2.5	1.24	1.29	1.01	0.88	1.14	1.12	1.91	1.94	1.74	1.77	1.53	1.78
-5.0	1.19	1.22	0.91	0.85	1.10	1.06	1.82	1.88	1.63	1.68	1.50	1.70
-10.0	1.16	1.18	0.90	0.84	1.06	1.03	1.72	1.84	1.58	1.64	1.47	1.65
Mean	1.22	1.26	0.97	0.87	1.13	-	1.87	1.94	1.69	1.73	1.53	-
$CD_{(0.05)}$	Moisture level				0.02						0.02	
	Bioregulator				0.02						0.02	
	Moisture level × Bioregulator				NS						0.04	

Highest concentration of macronutrients (N,P,K, Ca & Mg) was estimated in the plants irrigated at -0.5 bar and their contents decreased with the increase in stress level (Table 4 to 6). This might be due to frequent irrigations at this moisture level that might have created conditions for better uptake of these nutrients.

Bioregulators had variable influence on leaf mineral composition. Plants treated with higher dose of TRIA accumulated highest leaf nutrients in comparison to the remaining treatments. This might be due to higher metabolic activity and increased dry matter production resulting in increased water and nutrient uptake from

Table 6. Influence of bioregulators on leaf Mg content at various levels of soil moisture stress.

Moisture level (bar)	Mg (%)					
	TRIA (ppm)		PP_{333} (ppm)		Control	Mean
	5	10	50	100		
-0.5	0.75	0.77	0.70	0.71	0.66	0.72
-2.5	0.67	0.70	0.58	0.60	0.50	0.61
-5.0	0.57	0.61	0.51	0.55	0.44	0.54
-10.0	0.50	0.51	0.46	0.50	0.33	0.46
Mean	0.62	0.65	0.56	0.59	0.48	-

$CD_{(0.05)}$	Moisture level	0.02
	Bioregulator	0.02
	Moisture level × Bioregulator	0.06

the soil (Barua, 4). PP_{333} treated plants had the lowest accumulation of N, P and K which might be due to poor root system and impaired vegetative growth (Rieger, 10). The effect was more pronounced on leaf N with increase in moisture stress. However PP_{333} increased Ca and Mg accumulation over control. The increased leaf Ca might be due to reduced K uptake since Mg ions generally compete with K for their uptake (Tisdale *et al.*, 11). Plants irrigated at -0.5 bar and treated with 10 ppm TRIA had the highest accumulation of N, P, K, Ca and Mg in their leaves. Plants stressed at -10.0 bar and treated with 10 ppm TRIA had the higher accumulation of all the macronutrients under study.

REFERENCES

1. A.O.A.C. 1990. *Official Methods of Analysis. Association of Official Agricultural Chemists*. Benjamin Franklin Station, Washington, D.C.
2. Abo-Rawash, M., Behairy, Z., Maximos, S., Migahed, H. and Bashear, R. 1991. Studies on the effect of irrigation and some growth retardants on fig transplants. 3-leaf anatomy. *Ann. Agric. Sci.* **36**: 193-201.
3. Abrisqueta, J.M., Hernansaez, A. and Franco, J.A. 1994. Root dynamics of young almond trees under different drip irrigation rates. *J. Hort. Sci.* **69**: 237-42.
4. Barua, S.S. 1990. Effect of triacontanol on growth and fruiting of plum cv. Santa Rosa. Ph.D. thesis, Dr Y.S. Parmar University of Horticulture and Forestry, Solan (H.P.).
5. Biasi, R., Costa, G. and Succi, F. 1989. Paclobutrazol and root zone water content influence peach seedling behaviour. *J. American Soc. Hort. Sci.* **114**: 923-26.
6. Gunasekaran, N. 1982. Studies on the effect of triacontanol on tomato Co3 Maruthani. M.Sc. thesis, TNAU, India.
7. Kenworthy, A.L. 1964. *Fruit, Nut and Plantation Crops, Deciduous and Evergreen. A Guide for Collecting Foliar Samples for Nutrient Element Analysis.* Memo. Dept. Hortic. Michigan State University, Michigan.
8. Koeing, R.A. and Johnson, R.C.R. 1942. Colorimetric determination of phosphorous in biological products. *Indust. Engg. Chem. Anal.* (14 Edn.): 155-64.
9. Mishra, A. and Srivastava, N.K. 1991. Effect of triacontanol formulation Miraculan on photosynthesis, growth, nutrient uptake and essential oil yield of lemon grass (*Cymbopogan flexuosus*) Stevol, Watts (Steva)Wats). *Pl. Growth Reg.* **10** : 57-63.
10. Rieger, M. 1990. Paclobutrazol, root growth, hydraulic conductivity and nutrient uptake of 'Nemaguard' peach. *HortSci.* **25**: 95-98.
11. Tisdale, S.L., Nelson, W.L. and Beatch, J.D. 1985. *Soil Fertility and Fertilizers*. MacMillan, New York.
12. Westwood, M.N. 1993. *Temperate Zone Pomology*. W.H. Freeman and Co., San Francisco, USA.

Received: November, 2009; Revised: March, 2010; Accepted : January, 2011