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Research Article

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Effect of Paclobutrazol on Canopy Size Control and Flowering of Mango Cvs Dashehari, Langra, Chausa and Fazri

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Abstract

Paclobutrazol (2 RS, 3RS)-1-4-Chloropheny)-4, 4-dimethyl-2- (I, 2, 4 trizol-1-yl)] pentan -3-ethanol, enhanced fruit bud differentiation and increased fruit set, fruit yield and reduced fruit size in Mango Cvs. Dashehri, Langra, Chausa and Fazri. Three weeks later, as the new slushes expanded, paclobutrazol at the rate of 1.5 g/m2 was applied to soil by spraying the basin. The paclobutrazol effect on growth lasted for only one year after which normal growth resumed. The treated trees flowered more profusely and considerably earlier than the controls. Significantly quadrate relationships were observed between the rate of Paclobutrazol and fruit set, fruit yield and the fruit size. Paclobutrazol at 1.0 g applied on 15 October also resulted in higher edible portion, lower stone pulp ratio and peel pulp ratio, longer shelf life, higher TSS, increased vitamin C, lower titratable acidity, higher dry matter, reducing, non-reducing and total sugar contents as compared to lower doses 0.5 g and control plants. The present results suggest that the application of paclobutrazol at 1.0g in October enhances yield and quality in mango.

Key words: *Paclobutrazol (PBZ); Auxin (lAA); Gibberellins; Cytokinin and plant growth regulator.*

Introduction

India is the world's largest producer of Mango. The production scenario of different fruits in India indicates that all the fruits occupied 6480 thousand ha area with 92846 thousand MT production and 14.3 MT/ha productivity during 2016-17. The total allocation to the fruits in the country has been increased from 6235 to 6480 thousand ha over the previous year, while the total production of fruits has also been increased from 89512 to 92846 thousand MT. The area under mango cultivation was 1077.6 thousand ha during 1991-92 which reaches up to 2516 thousand ha in 2013-14 and recorded 2262.8 thousand ha in 2016-17. However, the production has been fluctuating drastically. During 1991-92, the total production was 8715.6 thousand MT which was increased up to 13997 thousand MT in 2007-08. During 2008-09 the production was declined from 13997 thousand MT to 12750 thousand MT. From 2009-10 there is continuous increase in the mango production (15026.7 thousand MT) to 2016-17 (19686.9 thousand MT). A total 109.99% increase in area under mango cultivation has been recorded from 1991-92 to 2014-15 while, 125.88% increase in production was recorded during the same period. However, productivity has been fluctuating drastically from 1991-92 to 2014-15. The productivity of 8.1 MT/ha was recorded during 1991-12 whereas, it was declined up to 5.5 MT/ha in 2008-09 and again increased up to 8.5 MT/ha in 2014-15 and reached up to maximum productivity of 8.7 MT/ha in 2016-17.

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There was overall increase of 7.41% in productivity of mango from 1991-92 to 2014-15. Production of Mango orchard is low, there is ample opportunity to increase the productivity. Gibberellins most likely GAs, is necessary for normal shoot elongation. Inhabitation of bud breaks and shoots elongation in response to application of growth retardants triazole (kulkarni, 1988 a, Burandkar and Gunjat, 1991, 1993, tongumpai et al., 1991a; Kurian et al, 1992, Winston, 1992, Kurian and lyer 1993a, b, Nuneg-Eligea et al., 1993; Winner, 1993) has been reported. Elongation of inflorescence is also inhibited, especially by high level of triazoles (Kulkarni, 1988 b; Winston, 1992; Soloman and Reuvini, 1994) reinforcing is the essential role of Gibberellins in normal panicle elongation.

Sansavini et al (1986) reported soil treatment of Paclobutrazol enhanced fruit bus differentiation in apple. As a result of enhanced fruit bud initiation, fruit set increased in Johagold Apple trees sprayed with PBZ (Wanichkul and Lenz, 1988). Increased fruit set were reported in apple by several other workers (Steffens and Zimmerman, 1987; Wanichkul and lenz, 1988, Jones et al, 1991; Hao et al., 1991). Similar results are reported in Avacodo (Wolstenholme et al., 1988), Apricot (Clanet and Salles, 1986), Cherry (Jacyna et al., 1989; Stan et al., 1989), Mango (Goguey, 1990, Kurian and lyer, 1993). In Conference Pear, fruit yields increased 2-3 t/ha. By spraying of 300-3000 mg Paclobutrazol (Dheim and Browning, 1988). In Gola Pear 250 mg/tree Paclobutrazol treatment (TSLP method) effectively increased fruit yield (Rai, 1991), Soil drench of 200 gm of Paclobutrazol/tree (Gaash, 1986) to increased fruit yields to a significant level in Golden Delicious Apple (William, 1984).

It is a trizol derivative with the empirical formula [(2RS, 3Rs) -1 - (4-chlorophenyl) - 4.4-dimethyl-2- (1H-1, 2, 4-triazole-1-yl) pentan-3-ol] being capable to inhibit the biosynthesis of gibberellins potentially (Sinde et al., 2000) and has been effectively used in reducing canopy volume and increasing flower intensity in mango (Nartvaranant et al., 2000). Cultar is effective not only in flower induction but also in early and off season flower induction in mango (Protacio et al., 2000, Blaikie et al., 2004, Yeshitela et al., 2004, Nafees et al., 2010, Burondkar et al., 2013). However, the Mode of action of plant growth regulators such as cultar, is highly specific to cultivar, rate of application, cultivar, developmental stages and climatic condition (Hoffmann1992). Thus, cultar holds considerable promise in manipulation of flowering, yield and vigour in fruit crops. However, its high potency for harmful to nature, slow mobility in the orchard soil, persistence in soil and fruit over its long term use (USEPA 2007). Hence, an effort was made to review the research work on the use of cultar in mango production.

Mango flowering is a key reproductive event for the production of fruit. Initiation is the first event that takes place for mangoes to flower (Davenport, 2000, 2003, 2009). The period between floral initiation and anthesis can be as little as 4 weeks under tropical conditions (Scholefield et al., 1986). The flowering of mango in India takes place as early as November - December in Rayalasema area of Andhra Pradesh (Gandhi, 1955), February – March in northern India (Singh, 1960) and slightly earlier (January - February) in eastern part of the country. In Fiji, flowering starts in July and extends through September /October (Iqbal, 19982), in Egypt during November to January (Nakhla, 1980). In northern India, mango flowers from February to March and the period of full bloom may sometimes be during the second fortnight of March. Thus, under the milder climatic conditions of southern and western India, flowering may starts from December, whereas under the climatic conditions of the north, it is late (February to March).

In northern India the duration of flowering in mango is for about 20-25 days (Singh, 1960). It takes about a fortnight for the tiny bud to develop and open into a flower (Singh, 1990). The bloom period in eastern India is earlier than in north (Singh, 1978). Increase fruit set and yield Bagel et al., (2004) were recorded maximum yield per tree (68.12 kg), yield per hectare (106.25 q/ha), and yield increase over the control (29.85%) of 10 year old mango cv. Langra trees applied with Cultar at 5.00 g/ha in combination with 20 ppm NAA. Soil application of paclobutrazol at 5 g/tree was most effective to improve the fruit set and Int.J.Curr.Microbiol.App.Sci (2018) 7(2): 1552-1562 1558 fruit retention during the off year. The highest yields of 70.50 and 68.70 kg per tree during the off year were recorded under soil application of paclobutrazol at 5 and 10 g/tree, respectively (Singh and Singh, 2006). Increase in fruit set per panicle is due to retardation of plant vigour by growth retardant. Benjawan (2005) reported that PBZ had no significant effect in extending number of days from flower initiation up to full bloom. PBZ also had no significant effect in delaying fruit maturity age but fruit sets were significantly increased with PBZ rates applied. PBZ had a highly significant effect on fruit length but significantly decreased fruit thickness. Fruit yields were significantly increased with PBZ application. The best application rate of PBZ was found with T< sub>7 (1000 ppm/plant) with an extended flower raceme length of 5 cm. This treatment gave the highest mango edible fruit yield of

48 281.25 kg ha-1. Paclobutrazol was applied in mango cvs. Chausa, Dashehari and Langra as soil drench @ 2, 4, 6 and 8 g/tree and recorded maximum fruits set per panicle, fruit number and fruit yield per tree in 4 g/tree treated Dashehari tree whereas 6 g/tree of PP333 was found more effective in cvs. Chausa and Langra (Singh and Singh, 2003).

Soil drenching of PP333, 5 or 10 ml at 120, 90 and 60 days before bud break on mango cv. Neelum and recorded the maximum number of fruits (380) and fruit yield per tree (91.65 kg) both in off season and main season (302 fruits and 72.85 kg per tree) with 5 ml of PP333, 90 days before bud break (Anbu et al., 2001). Applying 10 ml paclobutrazol had the greatest effect increasing all the parameters (ascorbic acid, total sugar, reducing sugar and TSS, except for acidity) in harvested fruits from 10 year-old trees of Alphonso mangoes at Coimbatore, India (Vijayalakshmi and Srinivasan, 2000). Compared with the control, trees treated with paclobutrazol had higher results for number of panicles produced, yield as well as quality of the fruit (Yeshitela et al., 2004).

Materials and Methods

Treatment and layout: The treatment cost of different doses of PBZ namely 1.0 g and 0.5 g/m canopy diameter along with control in the uniform trees of Cvs. Dashehari, Langra, Chausa and Fazri. This experiment is carried out in the Horticultural Research Center, GB Pant Univ. of Agriculture & Technology, Pant Nagar.

Fruit set and yield: During this experiment the number of fruit set measured t measured at mustard stages, pea stage, mature fruit/ pencils, total number of fruits/trees and yield were recorded at the time of harvest. The observation of fruit in term of fruits size, fruits weight volume, specific gravity etc. were recorded soon after harvest and after ripening of the fruits, skin weight and stone size were measured separately at the time of fruits harvest

Statically Design: Two factors randomized block design used in the case of fruit experiments and CRD for lab experiments. Valid conclusions were drawn only significant differences between treatments mean at 5% level probability.

Result and Discussion

The data were recorded on the effect of PBZ on fruit set, fruit growth and yield of mango Caves. Dushehara, Langrage, Hausa and Fare was conducted in 1997, 1999 using difterent doses of PBZ application in 15 October and 15 September besides control with used the doses 1.0 g and 0.5 g/m canopy diameter spared.

Response in the fruit set: Soil application of Paclobutrazol significantly promote fruit setting in bearing Mango Cvs. Dahehari, Langra, Chausa and Fazri. Pre-bloom application of PBZ at 15 October to increase fruit setting compare with control. The fruit setting data's of the both years experiments on Mango Cvs. Dahehari, langra, Chausa and Fazri are presented in Table 1A and 1B in the first year of applicable. The interaction of cultivars and treatment are non significant but in the second years the interaction of cultivars and treatment are significant.

Response in fruit Growth: These investigation have shown that first year of application of PBZ were directly affected the fruit weight (gm), fruit volume, length of fruit (cm) and width of fruits, data further shows that fruit weight volume, length of fruit and width of fruits decrease compare to lower doses and with control in all the cvs. Of Mango named Dashehari, Langra, Chausa and Fazri. The interaction of treatment and cvs. Are non- significant in the both year experiment, width of fruit (cm) in second year.

Response in fruit yield: Soil application of Paclobutrazol significantly promoted fruit yield in mango cvs. Dashehari, Langra, Chausa and Fazri in the first year of application compare to second years with control. The interaction between the treatment and cultivars were non-significant in both years. (Table 1 A & 1 B).

These investigations have shows that soil application of Paclobutrazol effectively controls the fnuit weight, fruit length and width of the fruit in the both year. Pre- bloom application of PBZ in 15 October with highest doses increase the fruit sitting compare in 15 September with lower doses of Paclobutrazol. Data's further shown that Paclobutrazol significantly increase the fruit set at mustard stage, fruit set at pea stage, no of fruit/tree, compare to control in both years. Soil applications of PBZ more effective and increased the fruit yield/ tree compare to control. In mango, soil drench of (1.0 g/m first year) Paclobutrazol is reported to increase 16% fruit yield (Kulkarni, 1988) and similar increase in yield were also reported by (Kurian and Iyer, 1993), significant increase in yield with PBZ is also reported in other fruit trees.

Soil application of PBZ increase fruit set were reported in apple by several other workers (Wanichkul and Lenz, 1988, Steffens and Zimmerman, 1989; Jones et al, 1991) However, higher doses of PBZ with post bloom (15 October and 15 September) resulted increased fruit yield, on fruits/tree but occasionally decreased the fruit weight (gm), fruit length and fruit width due to the inhibitor of

Gibberellins Biosynthesis. Paclobutrazol appears to be remarkably persistent (Stinchcombe et al., 1989 Webster and Quinlan, 1989; William, 1989). In the present studied also, single soil application increased the yield for up to two years. The leg time appears to be some what longer and post harvest application may be ideal for bearing trees. Finally proves that PBZ undoubtedly increased the fruit set and yield during experiment but not fruit growth.

Treatment	Length of shoots(cm)			Diameter of shoots(cm)			No of leaves /shoots		
	15 Sept. 1998	15 June 1999	% increase	15 Sept. 1998	15 June 1999	% increase	15 Sept. 1998	15 June 1999	% increase
Dashehari Control	11.69	11.92	2.13	0.68	0.70	2.94	9.42	9.54	1.81
1.0g PBZ m tree canopy diam.	12.39	12.52	1.04	0.64	0.69	7.81	11.56	11.68	1.03
Langra Control	10.40	10.67	2.59	0.63	0.64	1.58	8.06	8.26	2.48
1.0g PBZ m tree canopy diam.	11.49	11.64	1.30	0.63	0.67	6.34	9.15	9.32	1.85
Chausa Control	9.33	9.68	3.75	0.65	0.66	1.53	9.16	9.32	1.74
1.0g PBZ m tree canopy diam.	9.56	9.65	2.00	0.56	0.58	3.57	8.34	8.47	1.55
Fazri Control 1.0g	9.95	10.15	2.01	0.65	66	1.53	7.71	7.88	2.20
PBZ m tree canopy diam.	9.59	9.76	1.77	0.65	0.67	3.07	8.58	8.75	1.98
CD at 5% Cultivar	0.64	0.62	0.96	0.20	0.19	0.41	0.67	0.64	0.41
Treatment Interc-tion	NS	NS	NS	0.29	0.27	NS	0.95	0.91	NS
	NS	NS	0.13	NS	NS	0.59	1.34	1.29	0.59

(Means followed by different letters within columns significantly differ by Fisher's LSD at p = 0.05)

Table 1A: *Effect of Paclobutrazol treatments on vegetatative growth on mango cvs. Dashehari, Langra, Chusa and Fazli (1997-99).*

Treatment	Width of leaves(cm)			Length of shoots(cm)			Intermodal length(cm)		
	15 Sept. 1998	15 June 1999	% increase	15 Sept. 1998	15 June 1999	% increase	15 Sept. 1998	15 June 1999	% increase
Dashehari Control 1.0g PBZ	4.59	4.72	2.83	17.73	17.98	1.14	2.97	2.97	6.83
m tree canopy diam.	4.81	4.90	1.87	16.76	16.84	0.47	2.68	2.78	3.77
Langra Control 1.0g PBZ m	4.40	4.53	2.59	16.59	16.81	1.32	2.80	2.93	4.64
tree canopy diam.	4.61	4.66	1.08	16.76	16.82	0.35	2.70	2.81	4.07
Chausa Control 1.0g PBZ m	4.35	4.51	3.67	16.73	16.95	1.31	2.65	2.8522	7.47
tree canopy diam.	4.39	4.45	1.36	16.77	16.82	0.71	2.36	.44	3.38
Fazri Control 1.0g PBZ m	4.99	5.10	2.20	16.33	16.85	2.55	2.46	2.54	3.25
tree canopy diam.	4.51	4.35	1.77	16.67	16.80	0.77	2.57	2.65	3.11
CD at 5% Cultivar Treat-	NS	0.42	0.41	NS	3.54	0.82	NS	NS	0.38
ment Interction	NS	NS	0.29	NS	NS	NS	0.20	0.17	NS
	NS	0.64	0.59	NS	NS	0.11	0.14	0.34	0.54

(Means followed by different letters within columns significantly differ by Fisher's LSD at p = 0.05).

Table 1B: *Effect of Paclobutrazol treatments on vegetatative growth on mango cvs. Dashehari, Langra, Chusa and Fazli (1997-99).*

Treatment	Main stem diameter (cm)			Circumferences of Tree(cm)			Tree crown diameter(m)		
	15 Oct. 1997	15 July 1998	% increase	15 Oct. 1997	15 July 1998	% increase	15 Oct. 1997	15 July 1998	% increase
Dashehari Control 1.0g PBZ m tree canopy diam.	18.57	19.20	1.74	16.34	16.77	2.63	5.27	5.35	1.51
	20.75	21.12	1.78	15.03	15.16	0.93	4.78	4.82	0.83
Langra Control 1.0g PBZ m tree canopy diam.	30.12	30.49	1.22	19.12	19.38	1.36	6.01	6.16	2.49
	29.25	29.77	1.77	21.08	21.18	0.47	6.71	6.77	0.89
Chausa Control 1.0g PBZ m tree canopy diam.	30.74	31.12	1.20	21.29	21.69	1.87	6.77	6.90	1.92
	33.00	33.80	2.42	24.50	24.60	0.41	6.16	7.24	1.12
Fazri Control 1.0g PBZ m tree canopy diam.	29.50	29.83	1.11	20.01	20.31	1.49	6.40	6.54	2.18
	31.50	32.40	2.85	19.65	19.73	0.41	6.76	6.84	1.18
CD at 5% Cultivar Treatment Interactions	NS	NS	0.67	NS	NS	0.84	NS	1.07	0.75
	3.77	3.88	0.47	2.63	2.78	NS	0.76	NS	NS
	NS	NS	0.95	NS	NS	0.59	NS	NS	0.10

(Means followed by different letters within columns significantly differ by Fisher's LSD at p = 0.05)

Table 2: *Effect of Paclobutrazol treatments on vegetatative growth on mango cvs. Dashehari, Langra, Chusa and Fazli (1997-99).*

Treatment	Fruit set at mustard stage	Fruit set at pea stage	Ature Fruits/ pnicle	No. of fruits/ Tree	Fruit yield tree(kg)	Per fruit weight (gm)	Per fruit volume	Length of fruit(cm)	Width of fruit(cm)
Dashehari Control 0.5g PBZ m tree canopy diam.	47.60	13.15	3.79	375.75	98.37	245.45	241.25	10.31	6.80
	56.12	15.41	5.16	577.75	136.38	200.65	195.00	10.00	6.70
Langra Control 0.5g PBZ/ m tree canopy diam.	21.11	13.92	3.23	273.75	73.49	270.25	261.12	9.43	7.40
	21.78	17.11	4.14	405.25	107.62	265.57	235.16	9.00	4.29
Chausa Control 0.5g PBZ/ m tree canopy diam.	21.64	13.65	2.80	252.45	73.31	290.50	282.35	11.71	6.56
	21.81	15.03	3.58	392.50	112.16	285.75	265.82	11.33	6.50
Fazri Control 0.5g PBZ/ m tree canopy diam.	39.76	10.10	1.95	212.50	91.50	430.75	422.50	12.42	7.90
	47.10	12.11	2.28	390.00	166.32	426.50	426.50	12.10	7.75
CD at 5% Cultivar Treatment Interction	0.72	0.64	0.28	28.28	10.94	2.98	3.42	0.22	0.14
	0.51	0.45	0.20	40.00	7.73	2.10	2.42	0.16	0.10
	1.02	NS	0.40	NS	15.47	NS	NS	NS	1.00

(Means followed by different letters within columns significantly differ by Fisher's LSD at p = 0.05)

Table 3: *Effect of Paclobutrazol on fruit set, fruit growth and yield of Mango Cvs. Dashehari, Langra, Causa and Fazri (1998-99).*

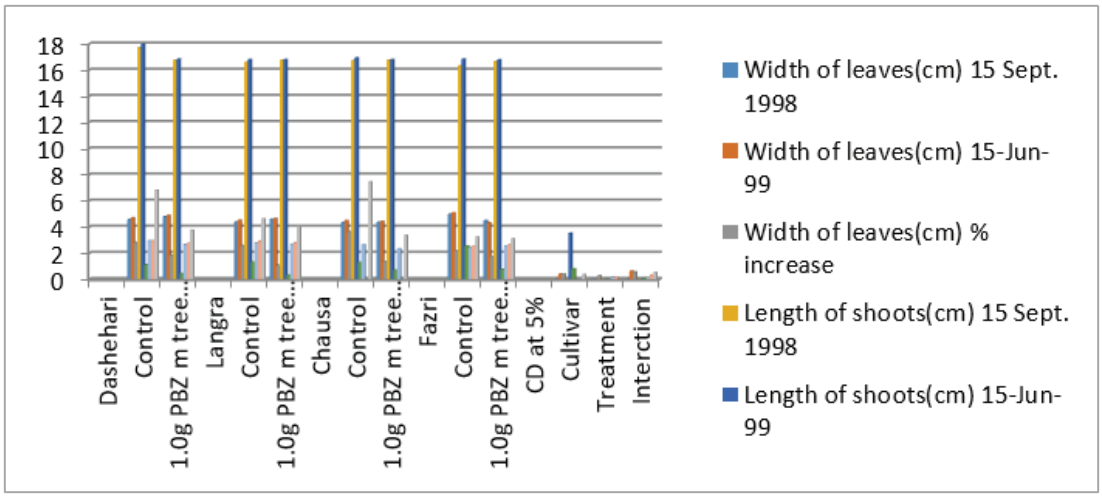

Figure 1: *Effect of Paclobutrazol treatments on vegetatative growth on mango cvs. Dashehari, Langra, Chusa and Fazli (1997-99).*

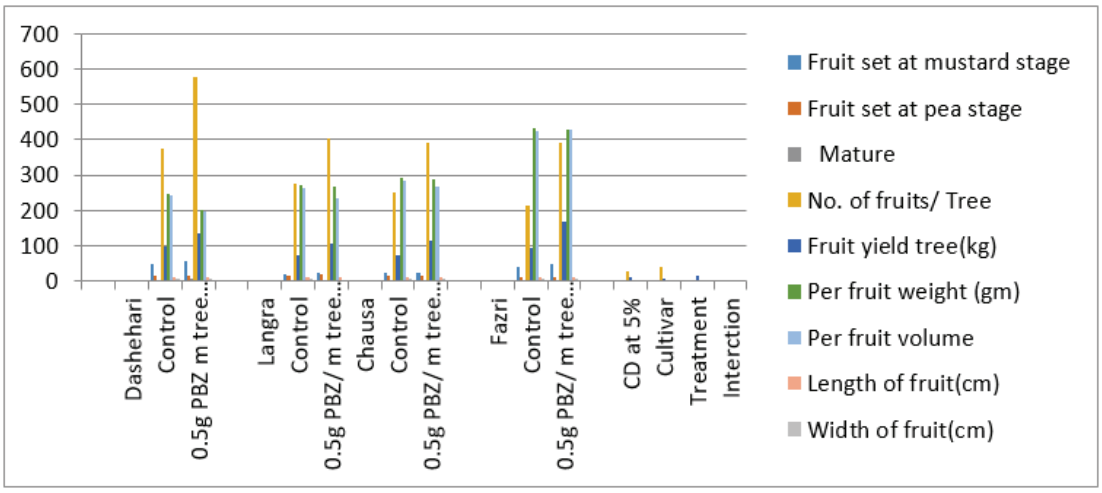

Figure 2: *Diagrametic reprensntation of effect of Paclobutrazol on fruit set, fruit growth and yield of Mango Cvs. Dashehari, Langra, Causa and Fazri (1998-99).*

Paclobutrazol is characterized by moderate potential of mobility in soil which enables it is applied in soil unlike other growth regulators (Costa et al., 2012), however its mobility varied with the soil type. Studies conducted in USA indicate that half-lives of paclobutrazol residues ranged from 450-950 days for orchard soils which indicates poor degradation rate of PBZ. Paclobutrazol showed low soil adsorption coefficient (KD= 1.3 to 23.0 ml/g), however adsorption appeared to increase with soil organic matter and a decrease in soil pH. Studies conducted in USA revealed that less than 10% of total PBZ applied were detected in soils between the depths of 60-120 cm, whereas the PBZ ketone metabolite was predominately detected in the subsurface soil layers though at insignificant levels. Sharma and Awasthi (2005) detected residues of paclobutrazol in the tree basin soil (0- 15 cm) at the end of each season followed by a slight increase in the amount of residues with the year of applications. Reddy and Kurian (2008) also observed residual influence of PBZ in soil if applied continuously for three consecutive years and suggested discontinuation of application or to taper down its dose. Sharma et al., (2008) could not detect paclobutrazol residues above quantifiable levels (0.01 ppm) either in tree basin surface soils or in the fruits even after more than five years continuous application. However, they further reported that the residues increased to 0.34

ppm with the increase of the application rate (20 g a. i./tree). Singh and Bhattacharjee (2005) also detected paclobutrazol residue below permissible limit (0.4898–1.0005 µg/g) in the rhizosphere after two years of application. Jaradrattanapaiboon et al., (2008) reported spatial difference of paclobutrazol residue in soils as they observed high concentration of PBZ residue in upper soil layer (0-5 cm) and low residue level in lower soil layer (10- 20 cm).

They further reported that PBZ persisted for about 3-5 months. On the other hand, Narvaranant et al., (2000) reported the persistence of PBZ residue up to 12 months Ochoa et al., (2009) expressed the possibility of environmental contamination with the regular application of paclobutrazol in containerized oleander production due the leaching of PBZ into the nursery soil with the irrigation water. The adsorption and leaching of the residues is dependent upon the soil physical and chemical characteristics as well as environmental factors such as rainfall. Wu et al., (2013) have reported that paclobutrazol was more persistent in greenhouse than in open field soil; leaching by rainfall being responsible for the difference in dissipation. Paclobutrazol is also known to leach in soil with high sand content.

Conclusions

The cultar is a growth inhibitor and also belong to triazol group. It is inhibit the biosynthesis of GA3 at kaurene stage. The cultar is most commonly used for the induction of flowering in off season, control tree vigour for HDP (canopy managment), increase fruit set and yield, improve fruit quality when applied to the soil but has the drawback of relatively high persistence in both soil and fruit in mango. Studies aiming to adjust the amount of application dose of cultar to each cultivar will allow the formulation of recommendations for more efficient applications, which can not only provide quality fruit production throughout the year but also reduce the risk of residues in the mango orchard soil, tree, fruit and environment.

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