International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 1133-1137

Received: 18-05-2020
Accepted: 19-06-2020

VJ Gimhavanekar
Ph. D. Scholars, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

AV Mane
Dy. Director of Research (Seed), Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

MM Burondkar
Head, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

BS Thorat
Ph. D. Scholars, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

SG Mahadik
Assistant Professor, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

PJ Bonde
Ph. D. Scholars, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

SS Chavan
Assistant Professor, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Corresponding Author:
VJ Gimhavanekar
Ph. D. Scholars, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra, India

Studies on influence of paclobutrazol on physiological aspect of pigeon pea (*Cajanus cajan* (L.) Millsp) under Konkan condition

VJ Gimhavanekar, AV Mane, MM Burondkar, BS Thorat, SG Mahadik, PJ Bonde and SS Chavan

DOI: https://doi.org/10.22271/chemi.2020.v8.i4i.9757

Abstract
A field experiment was conducted to study the influence of paclobutrazol on physiological aspects of pigeon pea (*Cajanus cajan* (L.) Millsp) under konkan conditions during *Kharif,* 2015 season. Plant growth regulators at different concentration were applied through foliar spray at 30, 40 and 60 DAS. The experiment consisted of thirteen treatment laid out in randomized block design with three replications comprising paclobutrazol (50, 75, 100, 125, 150 ppm) treatment imposed at 30, 40 and 60 DAS. Among the treatments soil application of paclobutrazol @ 50 ppm at 40 DAS recorded significant difference on morphological parameters as compared to other treatments. The plant height decreased significantly due to application of paclobutrazol and extent of reduction was more in the treatment soil application of paclobutrazol @ 50 ppm at 40 DAS. Growth period of the crop significantly reduced with the application of paclobutrazol. The number of days required for flower initiation, pod initiation and days to 50% flowering significantly reduced with the application of paclobutrazol. The maximum chlorophyll stability index was recorded in soil application of paclobutrazol @ 50 ppm at 40 DAS.The significantly highest relative water content was found infoliar application paclobutrazol @ 100 ppm at 30 and 60 DAS.

Keywords: Morphological parameters, physiological parameters, paclobutrazol

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millsp) is an important pulse crop of India which is originated in Africa. It is primarily cultivated in semi-arid tropics of Andhra Pradesh and Maharashtra states. It is a versatile crop and is ideally suited for drought prone areas. India is largest producer of pigeonpea constituting 75 per cent of world production. The production of tur in India is approximately 2.76 million tonnes (Anonymous 2013-14) [1]. Among the several constraints attributed for low yield in pulses; vegetative biomass uncertain with growth habit is considered as one of the major constraints in improving yield. Besides this, there are various constraints in pulses production as indeterminate growth habit, instability in performance, poor response to inputs etc. Particularly in recent year PGR (growth retardants) *viz.* paclobutrazol is widely tried in improving HI and yield through manipulating the vegetative growth also.Hence the present investigation was carried out with the objective to study the effect of paclobutrazol on vegetative growth in pigeonpea.

Material and methods

The experiment was conducted at the research farm of Department of Agricultural Botany, College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra State, during *Kharif,* 2015 season. The selection of the site was considered on the basis of suitability of the land for cultivation of pigeonpea. The soil of the experimental site was lateritic type. The experimental material for the study consisted of one variety of Pigeonpea *i.e.* Konkan Tur-1. The seeds of this variety were collected from Research farm, Department of Agril. Botany, College of Agriculture, Dapoli. The experiment comprised of single variety of pigeonpea laid out in randomized block design with three replications, provided with thirteen treatments of single growth retardant i.e. paclobutrazol, at different concentrations. The plot size was 3 × 2.70 m. Seeds of pigeonpea were sown at spacing of 60 cm between rows and 45 cm between plants.

Sowing was done in June, 2015. About 2-3 seeds were dibbled at each hill. To retain only one healthy seedling per hill, thinning was done ten days after sowing. Two weeding's were done at 20 days interval after sowing. For recording the growth observations, five plants were selected randomly in each plot. These five plants were tagged with aluminum foil. The below mentioned observations were recorded at an interval of 30 days starting, from 30 days after sowing and were continued up to harvest.

Results and Discussion

The present investigation was carried out with the central objectives to study the effect of paclobutrazol on the vegetative growth. The main constraint ascribed for low harvest index in pigeonpea are improper translocation of photo assimilate, reduced availability of photo-assimilates at the time of seed set and excessive vegetative growth, which leads to lower yield. The harvesting index of pigeon pea is estimated up to 20 per cent for Konkan region.

Plant growth regulators are known to regulate metabolism in the plant. Paclobutrazol coded as PP333, is recently introduced among other growth retardants, which counteract the gibberellin biosynthesis. The chemical was first used in England in 1978, followed by different European countries, including U.S.A. in 1982. However, in India, utility of this chemical was first reported on commercial scale for introduction of early and regular cropping in Alphonso mango by Burondkar *et al*. (1991) [2].

Paclobutrazol, a prime growth retardant, significantly influence the morphological characters. The various morphological characters such as plant height, days to flower initiation, days to pod initiation, days to 50 per cent flowering, leaf area and chlorophyll stability index significantly influenced by paclobutrazol. However, among the various treatments tried, T11 (soil application of paclobutrazol @ 50ppm at 40 DAS) performed significantly better for reducing plant height (196.10 cm), followed by treatment T12 and T13. Although, plant height is a genetically controlled character but several studies have indicated that the plant height can be either increased or decreased by the application of synthetic plant growth regulators.

In the present study, the treatments differ significantly for plant height at 30, 60, 90, 120, and at harvest in comparison with control. Significant decrease in plant height was observed as compared to control. The mechanism of reduction in plant height due to application of growth retardants appears to be due to slowing down of cell division and reduction in cell expansion (Kashid, 2008) [9]. Thus growth retardants slow down stem elongation in plants by inhibiting the activity of the sub apical meristems. Paclobutrazol is the compounds with an N-containing heterocyclic blocks the Cytochrome P-450 dependent mono-oxygenases, thereby inhibiting oxidation of ent-kaurene into ent-kaurenoic acid. Thus, reduction in plant height is due to retardation of transverse cell division particularly in cambium which is the zone of meristematic activity at the base of the internode (Grossman, 1990) [4]. Similar results were reported by large number of researchers in variety of crops viz., mango (Burondkar *et al*. 1993) [3], Brassica carinata (cv. PC 5) (Setia *et al*. 1995) [14] and rice (Jayachandran *et al*. 2000) [7], using Paclobutrazol Whipker *et al*. (2000) [17] in sunflower by application of PBZ. In cotton (Kumar *et al*. 2005) [11], in tomato (Rai *et al*. 2006) [13], while some researchers found the similar effects with other growth retardants like cycocel and mepiquat chloride (Thakur *et al*. 2008) [16], in ground nut, in rice by (Koli, 2008) [10], in sunflower by (Kashid, 2008) [9]. In pigeonpea, plant height decreased significantly due to application of growth retardants and the extent of reduction was more in the treatment foliar application paclobutrazol @ 100 ppm by Sul (2012) [15].

Leaf is the physiological platform for the process of photosynthesis which is the main input of yield. The leaf area is significantly differed in all treatments over the control. The total leaf area per plant found more in all treatments was move over control. The leaf area was (36.80 dm2 plant-1) in treatment T11 (soil application of paclobutrazol @ 50 ppm at 40 DAS), followed by T12. Similar results were obtained by the foliar application of cycocel (500 ppm) in as compared to control (Saisankar, 2000). Foliar application of mepiquat chloride (1000 ppm) and lihocin (1000 ppm) also increased the number of leaves and leaf area in cluster bean (Hanchinmath, 2005) [5], in rice (Koli, 2008) [10] and in pigeonpea (Sul, 2012) [15].

Amongst all the treatments, T11 (114.67 days) i.e. soil application of paclobutrazol @ 50 ppm at 40 DAS, T12 (116.67 days) i.e. soil application of with paclobutrazol @ 50 ppm at 60 DAS and T4 (116.33 days) i.e. foliar application of 30 paclobutrazol @ 125 ppm at 30 DAS caused significantly early flowering by near about 9-10 days than control and also, pod initiation by 8-9 days.

Paclobutrazol might have created a favourable condition for early flowering by early blocking of conversion of kaurene to kaurenoic acid, a precursor of gibberellins. Earliness in flowering by paclobutrazol was reviewed in various crops, like mango (Burondkar *et al*. 1993) [3], mustard (Setia *et al.* 1995) [14], sunflower (Whipker and McCal 2000) [17] rice (Koli, 2008) [10] and in pigeonpea, (Sul, 2012) [15].

In the present study, it was observed that, growth retardant paclobutrazol had profound influence on chlorophyll stability index of leaf. Significant differences were observed among the treatments with respect to chlorophyll stability index. The maximum chlorophyll stability index was recorded in treatment T_{11} (soil application of paclobutrazol @ 50 ppm at 40 DAS). This is in accordance with the earlier report of Setia *et al*. (1995) [14], who also reported increased chlorophyll content treated with paclobutrazol. Jeyakumar and Thangaraj (1996) [8] explained that, the application of cycocel to groundnut resulted in higher chlorophyll content without the modification of leaf anatomy and decreased chlorophyll degradation. Zaky *et al*. (1999) [18] reported that application of mepiquat chloride (pix) significantly increased chlorophyll a, chlorophyll b and total chlorophyll content in leaves of *faba*. The variation in chlorophyll content due to growth retardants may be attributed to decreased chlorophyll degradation rate and increased chlorophyll biosynthesis in growth retardant (Setia *et al*. 1995) [14].

The relative water content is probably the most appropriate measure of plant water status in terms of physiological consequences of cellular water deficit. T_8 (foliar application of paclobutrazol @ 100 ppm at 30 and 60 DAS) recorded significantly the highest relative water content. Similar result also reported earlier by Mathur and Priti *et al*. (2005) [12], Sul (2012) [15] and Jagadhane (2014) [6].

Table 1: Effect of paclobutrazol on mean plant height (cm) at different growth stages in Pigeon pea

Treatments	Mean plant height (cm)				
	30 (DAS)	60 (DAS)	90 (DAS)	120 (DAS)	At Harvest
T_1 FA of PBZ @ 50 ppm at 30 DAS	21.15	84.22	95.07	140.14	200.64
T_2 FA of PBZ @ 75 ppm at 30 DAS	21.66	85.22	95.12	132.87	200.57
T_3 FA of PBZ @ 100 ppm at 30 DAS	20.00	82.42	96.16	130.79	199.90
T_4 FA of PBZ @ 125 ppm at 30 DAS	18.84	72.20	97.23	136.15	200.93
T_5 FA of PBZ @ 150 ppm at 30 DAS	20.60	73.72	96.27	134.26	201.35
T_6 FA of PBZ @ 50ppm at 30+60 DAS	20.58	84.88	95.88	133.37	202.55
T_7 FA of PBZ @ 75 ppm at 30+60 DAS	20.46	92.37	98.29	135.04	201.49
T_8 FA of PBZ @ 100 ppm at 30+60 DAS	20.28	91.75	98.26	135.94	201.58
T_9 FA of PBZ @ 125 ppm at 30+60 DAS	19.60	84.74	97.99	135.47	200.56
T_{10} FA of PBZ @ 150 ppm at 30+60 DAS	19.83	82.34	97.68	133.79	200.60
T_{11} SA of PBZ @ 50 ppm at 40 DAS	20.01	65.31	92.22	130.34	198.10
T_{12} SA of PBZ @ 50 ppm at 60 DAS	19.14	70.40	92.71	131.72	199.43
T_{13} (Control)	20.39	83.49	99.56	142.93	204.24
Mean	20.19	81.00	96.34	134.83	200.91
S.E±	2.07	1.34	0.16	0.83	0.31
CD at 5%	NS	3.93	0.48	2.43	0.93

Table 2: Effect of paclobutrazol on flowering behaviour in Pigeon pea

Treatments	Flower initiation (days)	50% flowering (days)	Pod initiation (days)
T_1 FA of PBZ @ 50 ppm at 30 DAS	117.67	125.67	126.67
T_2 FA of PBZ @ 75 ppm at 30 DAS	116.67	124.33	125.67
T_3 FA of PBZ @ 100 ppm at 30 DAS	117.33	124.33	126.33
T_4 FA of PBZ @ 125 ppm at 30 DAS	116.33	124.00	125.33
T_5 FA of PBZ @ 150 ppm at 30 DAS	119.33	126.33	128.33
T_6 FA of PBZ @ 50ppm at 30+60 DAS	117.33	124.33	126.33
T_7 FA of PBZ @ 75 ppm at 30+60 DAS	119.33	126.00	128.67
T_8 FA of PBZ @ 100 ppm at 30+60 DAS	118.67	125.67	126.67
T_9 FA of PBZ @ 125 ppm at 30+60 DAS	117.67	125.00	125.33
T_{10} FA of PBZ @ 150 ppm at 30+60 DAS	116.67	123.67	124.67
T_{11} SA of PBZ @ 50 ppm at 40 DAS	114.67	121.67	122.67
T_{12} SA of PBZ @ 50 ppm at 60 DAS	115.67	122.67	123.67
T_{13} (Control)	123.67	130.67	131.67
Mean	117.76	124.94	126.30
S.E±	0.474	0.478	0.478
CD at 5%	1.384	1.395	1.397

Table 3: Effect of paclobutrazol on mean leaf area (dm^2 $plant^{-1}$) at different growth stages in Pigeon pea

Treatments	Mean leaf area (dm^2 $plant^{-1}$)				
	30 (DAS)	60 (DAS)	90 (DAS)	120 (DAS)	At Harvest
T_1 FA of PBZ @ 50 ppm at 30 DAS	9.984	16.556	32.914	50.592	32.073
T_2 FA of PBZ @ 75 ppm at 30 DAS	9.987	16.284	34.542	50.264	33.326
T_3 FA of PBZ @ 100 ppm at 30 DAS	9.719	17.345	37.437	50.959	33.989
T_4 FA of PBZ @ 125 ppm at 30 DAS	9.504	17.736	34.567	50.173	27.574
T_5 FA of PBZ @ 150 ppm at 30 DAS	9.914	17.350	31.444	47.286	28.293
T_6 FA of PBZ @ 50ppm at 30+60 DAS	9.906	17.884	33.142	52.324	24.356
T_7 FA of PBZ @ 75 ppm at 30+60 DAS	9.860	18.643	33.501	52.977	22.793
T_8 FA of PBZ @ 100 ppm at 30+60 DAS	9.831	17.827	34.287	49.519	32.380
T_9 FA of PBZ @ 125 ppm at 30+60 DAS	9.648	18.909	34.579	49.957	32.618
T_{10} FA of PBZ @ 150 ppm at 30+60 DAS	9.713	18.579	37.457	51.226	26.134
T_{11} SA of PBZ @ 50 ppm at 40 DAS	9.774	19.936	38.724	53.882	36.800
T_{12} SA of PBZ @ 50 ppm at 60 DAS	9.549	18.984	35.712	52.792	35.217
T_{13} (Control)	9.858	11.190	27.056	36.580	21.984
Mean	9.778	17.478	34.258	49.88	29.810
S.E±	0.777	0.429	0.461	0.483	0.564
CD at 5%	NS	1.254	1.345	1.412	1.648

Table 4: Effect of paclobutrazol on mean chlorophyll stability index at different growth stages in Pigeon pea

Treatments	Mean chlorophyll stability index			
	30 (DAS)	60 (DAS)	90 (DAS)	120 (DAS)
T_1 FA of PBZ @ 50 ppm at 30 DAS	1.10	1.06	0.77	1.01
T_2 FA of PBZ @ 75 ppm at 30 DAS	1.04	1.04	0.68	0.97
T_3 FA of PBZ @ 100 ppm at 30 DAS	1.04	1.04	0.97	1.06
T_4 FA of PBZ @ 125 ppm at 30 DAS	1.08	1.08	0.87	1.04
T_5 FA of PBZ @ 150 ppm at 30 DAS	1.10	1.10	1.21	1.10

T_6 FA of PBZ @ 50ppm at 30+60 DAS	1.14	1.14	1.23	1.15
T_7 FA of PBZ @ 75 ppm at 30+60 DAS	1.08	1.08	0.76	0.96
T_8 FA of PBZ @ 100 ppm at 30+60 DAS	1.03	1.03	1.11	1.10
T_9 FA of PBZ @ 125 ppm at 30+60 DAS	1.04	1.04	1.02	1.03
T_{10} FA of PBZ @ 150 ppm at 30+60 DAS	1.05	1.05	0.91	1.04
T_{11} SA of PBZ @ 50 ppm at 40 DAS	1.26	1.26	1.51	1.14
T_{12} SA of PBZ @ 50 ppm at 60 DAS	1.16	1.10	1.28	1.10
T_{13} (Control)	0.98	0.98	0.54	0.83
Mean	1.083	1.073	0.988	1.04
S.E±	0.051	0.022	0.025	0.012
CD at 5%	0.150	0.066	0.075	0.036

Table 5: Effect of paclobutrazol on mean relative water content (%) at different growth stages in Pigeon pea

Treatments	Mean relative water content (%)				
	30 (DAS)	60 (DAS)	90 (DAS)	120 (DAS)	150 (DAS)
T_1 FA of PBZ @ 50 ppm at 30 DAS	86.61	80.85	76.85	73.52	66.52
T_2 FA of PBZ @ 75 ppm at 30 DAS	87.41	79.20	75.20	72.20	65.20
T_3 FA of PBZ @ 100 ppm at 30 DAS	88.09	80.65	76.65	73.65	66.65
T_4 FA of PBZ @ 125 ppm at 30 DAS	85.83	81.87	77.74	74.74	67.54
T_5 FA of PBZ @ 150 ppm at 30 DAS	86.76	78.97	75.04	72.04	65.04
T_6 FA of PBZ @ 50ppm at 30+60 DAS	86.71	80.53	76.53	73.53	66.53
T_7 FA of PBZ @ 75 ppm at 30+60 DAS	86.00	78.69	74.54	71.54	64.54
T_8 FA of PBZ @ 100 ppm at 30+60 DAS	87.65	81.19	77.50	74.60	69.60
T_9 FA of PBZ @ 125 ppm at 30+60 DAS	87.04	85.99	81.85	78.85	63.49
T_{10} FA of PBZ @ 150 ppm at 30+60 DAS	80.92	78.88	75.10	72.10	67.10
T_{11} SA of PBZ @ 50 ppm at 40 DAS	85.24	79.79	75.79	72.79	67.95
T_{12} SA of PBZ @ 50 ppm at 60 DAS	86.86	81.03	77.08	74.08	66.08
T_{13} (Control)	84.69	82.04	77.92	74.92	66.92
Mean	86.14	80.74	76.75	73.73	66.39
S.E±	0.377	0.321	0.362	0.378	0.396
CD at 5%	1.100	0.939	1.056	1.106	1.158

Conclusion

From the present investigations, it could be stated that pigeonpea crop plant growth retardant paclobutrazol has the ability to shorten the vegetative growth for early maturity of the crop. Amongst all paclobutrazol treatments tried, soil application of paclobutrazol @ 50 ppm at 40DAS significantly shortened the growth period of the pigeonpea crop under Konkan condition. Thus, this study encourages taking up for further research on use of paclobutrazol for boosting up yield in pulse crop like pigeonpea. Hence, this present investigations open wide scope for evaluation of paclobutrazol in pulse crop.

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