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Studies on the effect of different chemicals and paclobutrazol on flowering physiology, biochemical characters and yield of mango (*Mangifera indica* L.) cv. Imam Pasand

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Abstract
A field experiment was conducted to assess the effect of different chemicals, soil application of paclobutrazol and combined application of paclobutrazol with chemicals as foliar spray on flowering physiology and yield in mango cv. Imam Pasand at Department of Fruit Crops, Horticultural College and Research Institute, Periyakulam during the period between 2011 and 2012. The experiment was laid out with sixteen treatments and two replication in a Randomized Block Design. The soil application of paclobutrazol @ 0.75.a.i. m^{-2} of tree canopy diameter during September month along with foliar spray of KNO_3 @ 1 per cent twice during October and November at 20 days interval was very effective in physiological parameters, soil application of paclobutrazol along with KNO_3 foliar spray increased leaf nitrogen (1.75 %), phosphorus (0.16 %) and potassium (0.86 %). The same treatment registered the lowest gibberellic acid (1.39 µg g^{-1}). In both the treatments *viz*., foliar spray of KNO_3 combined with soil application of paclobutrazol @ 0.75.a.i. m^{-2} of tree canopy diameter and application of paclobutrazol alone were recorded the highest yield characters *viz.,* panicle length (34 cm & 33.63 cm), hermaphrodite flowers (12.62 % and 12.58 %) and fruit yield (33.50 kg $tree^{-1}$ and 31.40 kg $tree^{-1}$) respectively are on par and statistically significant.

Keywords: Flowering, hermaphrodite, maturity, paclobutrazol, panicle, yield

Introduction
Mango (*Mangifera indica* L.) is one of the most luscious fruits of the world which occupies a prime position in the international fruit trade. Among the varieties, "Imam Pasand" is one with its origin to a Nawab of Masulipatnam in the Krishna district of Andhra Pradesh. It is one of the best choice varieties, ideally suited for dessert purposes. This variety is also known as "Himayuddin", "Himayat" and "Himayath". Owing to its excellent flavour and delicious taste it has potential demand among the domestic consumers and fetches premium price in the market. However, the overall income generated in Imam Pasand orchard is low compare to other commercial mango varieties because of its poor productivity due to the erratic bearing behaviour of the variety. The present research was made for enhancing the productivity of this variety to the farmers with the following objectives to induce regular flowering and bearing through chemical manipulation.

Materials and Methods
The investigation on the effect of different chemicals and paclobutrazol on flowering and fruiting in mango (*Mangifera indica* L.) cv. Imampasand was undertaken at the Department of Fruit Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam during the year 2011-2012. The experimental field was located at NSKP Farms, Gudalur, Theni District which is about 60 km away from Horticultural College and Research Institute, Periyakulam. The experiment was laid out in a Randomized Block Design (RBD) with sixteen treatments in two replications. Ten year old uniform sized trees of mango cv. Imampasand spaced at 10 x 5 m were selected for this experiment. The detailed treatments are T_1 (Control), T_2 (Potassium nitrate (KNO_3 @ 1%) T_3 **(**Potassium sulphate (K_2SO_4 @ 1%), T_4 (Thiourea @ 1%), T_5 (Potassium dihydrogen phosphate (KH_2PO_4 @ 1 %), T_6 (Potassium humate @ 2 %), T_7 (IIHR Mango special mixture (B + Zn + Mg) @ 0.5 per cent), T_8 (Calcium Ammonium Nitrate (CAN) @ 1 %), T_9 (Soil application of paclobutrazol (Cultar)

@ 0.75 g a.i / m^{-2} canopy diameter), T_{10} ($T_9 + T_2$), T_{11} ($T_9 + T_3$), T_{12} ($T_9 + T_4$),T_{13} ($T_9 + T_5$), T_{14} ($T_9 + T_6$), T_{15} ($T_9 + T_7$), T_{16} ($T_9 + T_8$). The different chemicals were applied as foliar sprays twice first during the month of October (15.10.2011) and second during the month of November (05.11.2011) at 20 days interval. The soil application of paclobutrazol (Cultar 23 % W/W and 25 % W / V of Syngenta Crop Science Ltd.,) @ 0.75 g a.i m^{-2} of canopy diameter was given during the month of September, 2011. The required quantity of paclobutrazol was dissolved in water @ 1 ml $litre^{-1}$ and poured in small holes (10 - 15 cm depth) around the collar region of the fertilizer ring as suggested by Burondkar and Gunjate (1993) [6]. All the other crop management practices including pruning were done as recommended in the crop production techniques of horticultural crops for Tamil Nadu.

Result and Discussion

Leaf nutrient status

It is quite probable that accumulation of nutrients may create favorable condition for synthesis and action of the substances responsible for flowering. The earlier studies in mango revealed the existence of floral stimulus, which was continuously synthesized in mango leaves during the conducive climate conditions. Mango leaves appeared to be the only site where the putative floral stimulus was produced. Consequently, in the current observation, all the treatments had a significant effect on the leaf nutrient content *viz*., Nitrogen, Phosphorus, Potassium, Carbohydrate and Carbohydrate - Nitrogen ratio at bud break stage (Table 1). With regard to leaf phosphorus content at bud break stage, except the foliar spray of Thiourea and IIHR mango special mixture, all the other treatments enhanced the phosphorus content with the highest value observed in paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent Next to paclobutrazol @ 0.75.a.i m^{-2} was observed to be better than other treatments.

The potassium content in leaves at bud break stage was higher in all the treatments than the control that demonstrated the efficiency of the chemicals in improving the potassium status of the leaves. Similar to phosphorus content, potassium, carbohydrate and carbohydrate - nitrogen ratio were observed to be the highest in paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent followed by paclobutrazol @ 0.75.a.i m^{-2}. The results of the current observation with regard to the effect of paclobutrazol @ 0.75.a.i m^{-2} on phosphorus, potassium, carbohydrate and carbohydrate - nitrogen ratio were in agreement with those of Sen and Guda (1965), Singh (1958) [10]. The above results indicated that the paclobutrazol @0.75.a.i m^{-2} + KNO_3 @ 1 per cent and paclobutrazol @0.75.a.i m^{-2} provided the congenial condition for the mobilization of assimilates which was possible due to the increased chlorophyll content.

Table 1: Effect of different chemicals and paclobutrazol on leaf nutrient status of mango cv. Imam Pasand

Treatments	Leaf nutrient status		
	Nitrogen (%)	Phosphorus (%)	Potassium (%)
T_1 - Control	1.56	0.06	0.60
T_2 - KNO_3 @ 1 %	1.63	0.09	0.73
T_3 - K_2SO_4 @1 %	1.61	0.08	0.71
T_4 - Thiourea @ 1 %	1.60	0.10	0.76
T_5 - KH_2PO_4 @ 1 %	1.59	0.11	0.74
T_6 - Potassium humate @ 2%	1.64	0.07	0.75
T_7 - IIHR mango special mixture @ 0.5 %	1.59	0.08	0.77
T_8 - Calcium Ammonium Nitrate @ 1%	1.58	0.08	0.65
T_9 - Paclobutrazol @ 0.75 g a.i.	1.71	0.14	0.85
T_{10} - $T_9 + T_2$	1.75	0.16	0.86
T_{11} - $T_9 + T_3$	1.62	0.11	0.78
T_{12} - $T_9 + T_4$	1.64	0.12	0.80
T_{13} - $T_9 + T_5$	1.63	0.10	0.81
T_{14} - $T_9 + T_6$	1.65	0.09	0.84
T_{15} - $T_9 + T_7$	1.61	0.12	0.83
T_{16} - $T_9 + T_8$	1.66	0.13	0.76
SE (d)	0.0292	0.0051	0.0075
CD (P = 0.05)	0.0701	0.0302	0.0240

Physiological parameters

The state of physiological parameters directly indicates the efficiency of a tree in terms of yield. The improvement in crop productivity in modern agricultural systems is increasingly dependent on physiological manipulation of the crop by chemical means. The first report about the use of paclobutrazol on mango came from India where Kulkarni (1988) tested concentrations of 1.25 to 10 a.i m^{-2} of canopy diameter in the cultivars Dashehari and Banganapalli. The results obtained on the physiological parameters of this study revealed that all the treatments had a profound effect over control. There was a significant reduction in specific leaf area and increase in specific leaf weight by all the treatments over control. With regard to specific leaf area, the soil application of paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent significantly reduced the specific leaf area when compared to control. This is in contrary to the findings of Vijayalakshmi and Srinivasan (1999) [19] as well as Kurian and Iyer (1992) who reported that paclobutrazol increased the leaf area.

Biochemical constituents

Mango flowering is predominantly influenced by the biochemical constituents for the floral stimuli at bud break stage. The state of biochemical constituents determine the synchronization of flower stimuli and earliness to flowering. The results of this experiment have clearly indicated that the biochemical constituents in shoots at bud break stage were significantly influenced by the chemical treatments. In respect of leaf phenol content, soil application of paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent recorded maximum leaf phenol content over control. The soluble protein content was also influenced by the application of different chemicals. The most striking influence of chemicals on IAA oxidase activity and gibberellin due to the different treatments had necessarily

to be elaborated as these two factors exert a definite influence on flowering in the cv. Imam Pasand. A distinctly high IAA oxidase activity was recorded by paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent (Table 2) while a moderate activity was registered in treatments *viz*., paclobutrazol @ 0.75.a.i m^{-2} + KH_2PO_4, CAN, thiourea, and potassium humate and the lowest activity in control. The higher IAA oxidase activity might be due to restriction of vegetative growth through the auxin degradation process or it can also be explained that a steady increase in the IAA oxidase observed in paclobutrazol application might be positively correlated with the anti - gibberellin activity, since the gibberellin had synergistic role on cell growth. This present finding agreed with the results of Kurian and Iyer (1992). With respect to gibberellic acid content, the soil application of paclobutrazol @ 0.75 a.i m^{-2} + KNO_3 @ 1 per cent drastically reduced the gibberellin content of the leaves. These results are in consistence with the well documented effects of the paclobutrazol on inhibition of gibberellin bio-synthesis (Vazquez and Santos, 1982; Gnasekaran, 2007; Rahim *et al*., 2008 and Jayavalli *et al*., 2009) [17].

Table 2: Effect of different chemicals and paclobutrazol on biochemical characters of mango cv. Imam Pasand

Treatments	Total carbohydrate content (%)	Carbohydrate Nitrogen ratio	Total phenol content (mg 100 g^{-1})	Soluble protein content (mg g^{-1})	IAA oxidase activity (µg unoxidized auxin g^{-1} h^{-1})	Gibberellic acid content (µg g^{-1})
T_1 - Control	20.11	12.37	1.71	8.05	3.85	2.83
T_2 - KNO_3 @ 1 %	25.70	15.68	1.79	10.47	2.86	1.91
T_3 - K_2SO_4 @1 %	24.10	14.89	1.93	11.17	2.52	1.81
T_4 - Thiourea @ 1 %	25.35	14.74	1.94	10.20	3.12	1.80
T_5 - KH_2PO_4 @ 1 %	24.78	15.47	1.84	9.37	2.40	1.80
T_6 - Potassium humate @ 2%	23.96	14.94	1.77	9.25	2.65	1.71
T_7 - IIHR mango special mixture @ 0.5 %	23.63	14.80	1.93	9.37	3.17	1.78
T_8 - Calcium Ammonium Nitrate @ 1%	22.91	15.50	1.91	11.30	2.55	1.68
T_9 - Paclobutrazol @ 0.75 g a.i.	26.69	16.38	2.17	12.22	2.15	1.40
T_{10} - T_9 + T_2	26.88	16.68	2.37	12.41	2.07	1.39
T_{11} - T_9 + T_3	23.83	14.48	1.90	11.12	2.21	1.43
T_{12} - T_9 + T_4	20.69	11.81	1.91	10.15	2.44	1.50
T_{13} - T_9 + T_5	22.88	14.23	1.87	10.14	2.32	1.52
T_{14} - T_9 + T_6	21.49	13.40	1.94	11.09	2.65	1.42
T_{15} - T_9 + T_7	21.89	13.53	2.12	12.20	3.12	1.48
T_{16} - T_9 + T_8	23.52	14.91	1.96	11.16	2.75	1.46
SE (d)	0.1102	0.2437	0.0374	0.1945	0.2175	0.0844
CD (P = 0.05)	0.2348	0.5195	0.0797	0.4146	0.4636	0.1799

Flowering characters

Flowering is the first of several events that set the stage for mango production each year. Flowering in mango cv. Imam Pasand is reported to be associated with the reduced vegetative growth which was often induced by lower level of gibberellin and the highest IAA oxidase activity. In general, paclobutrazol owing to its anti - gibberellin activity, could induce or intensify flowering by blocking the conversion of kaurene to kaurenoic acid. The soil applications of paclobutrazol @ 0.75.a.i m^{-2} had an impact on reduction of vegetative growth with the required physiological changes, which resulted in high intensity of flowering. Following the reduction in vegetative growth parameters, there was a high chlorophyll content, carbohydrate, carbohydrate - nitrogen ratio, phosphorus and potassium content in leaves at bud break stage which were the other causes for better flowering characters. A higher accumulation of reserves in the current year shoots before flowering was also observed by Stassen *et al*. (1997) [13]. One of the principal effects of gibberellin was to mobilize carbohydrate by stimulating their degradation to glucose.

The development of hermaphrodite flowers needed more reserves from the tree than unisexual flowers because of the additional structures required. Consequently, in the current observation, the percentage of hermaphrodite flowers was higher in soil application of paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent which had the higher reserves. This finding is in close conformity to that of Yeshitela (2004) [22]. The fruit set pattern and yield of fruits $tree^{-1}$ followed a similar trend to that of percentage of hermaphrodite flowers and length of panicle for the same reason discussed above. The impact of suppressed vegetative growth observed due to soil application of paclobutrazol @ 0.75.a.i m^{-2} + KNO_3 @ 1 per cent contributed to superior yield observed (Table 3). Research evidence in support of this finding has been observed in different cultivars of mango (Burondkar and Gunjate, 1993 and Kurian and Iyer, 1993) [6]. Other than the application of paclobutrazol @ 0.75.a.i m^{-2} and the combined application of paclobutrazol 0.75.a.i m^{-2} + KH_2PO_4, paclobutrazol 0.75.a.i m^{-2} + CAN @ 1 per cent produced early flowering, higher number of fruits and yield. This might be due to the high values in respect of specific leaf weight, chlorophyll content, soluble protein content, IAA oxidase activity and the lower level of gibberellin content recorded in these treatments. In addition, the nutrient content *viz*., nitrogen, phosphorus, potassium, carbohydrate and carbohydrate - nitrogen ratio at bud break stage were also conducive for the production of more number of hermaphrodite flowers, high fruit set and yield in these treatments.

Table 3: Effect of different chemicals and paclobutrazol on yield characters of mango cv. Imam Pasand

Treatments	Number of fruits $tree^{-1}$	Individual fruit weight (g $fruit^{-1}$)	Fruit yield (kg $tree^{-1}$)
T_1 - Control	58.28	380.00	20.25
T_2 - KNO_3 @ 1 %	56.45	372.00	21.00

T_3 - K_2SO_4 @1 %	53.98	376.00	20.30
T_4 - Thiourea @ 1 %	56.18	364.00	20.45
T_5 - KH_2PO_4 @ 1 %	64.64	362.00	23.40
T_6 - Potassium humate @ 2%	56.43	363.28	20.50
T_7 - IIHR mango special mixture @ 0.5 %	59.52	361.20	21.50
T_8 - Calcium Ammonium Nitrate @ 1%	77.43	355.15	27.50
T_9 - Paclobutrazol @ 0.75 g a.i.	92.87	338.10	31.40
T_{10} - T_9 + T_2	100.76	332.45	33.50
T_{11} - T_9 + T_3	70.81	360.11	25.50
T_{12} - T_9 + T_4	62.08	346.28	21.50
T_{13} - T_9 + T_5	78.40	376.26	29.50
T_{14} - T_9 + T_6	67.36	371.12	25.00
T_{15} - T_9 + T_7	65.55	366.10	24.00
T_{16} - T_9 + T_8	80.65	378.15	30.50
SE (d)	0.3563	18.0165	1.2045
CD (P = 0.05)	0.7265	14.4312	2.401

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