Journal of Crop and Weed, 15(1): 29-34 (2019)

Induction of flowering in mango cv. Himsagar

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Received : 20-02-2018 ; Revised : 12-02-2019 ; Accepted : 24-02-2019

ABSTRACT

An experiment was carried out to study the effect of different flower inducing treatments viz. ethephon 0.625 ml l^{-1} (T_1), KNO_3 10 g l^{-1} (T_2), ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1} (T_3), KH_2PO_4 10 g l^{-1} (T_4), pacobutrazol 4 ml m^{-1} canopy radius (T_5), decapitation in October (T_6), decapitation (June) + urea 5g l^{-1} (July) + KNO_3 10 g l^{-1} (T_7) on 10 years old mango cv. Himsagar at Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India during 2012–14. Among different treatments, paclobutrazol and ethrel 0.625 ml l^{-1} + KNO_3 10 g l^{-1} were found most effective in production of higher flowering shoots with higher content of total non-structural carbohydrate (starch and sugar) and C:N of leaves both in the 'on' and 'off' year. Yield was recorded higher with the same treatments of paclobutrazol and ethephon 0.625 ml l^{-1} + KNO_3 10g l^{-1}.

***Keywords*:** C/N ratio, flowering shoots, total non-structural carbohydrate and yield

The commercial varieties of mango are gripped with the problem of bienniality. The problem is manifested mainly due to inability of once fruited shoots to differentiate flower buds directly for the next fruiting season. Such fruited shoots have to undergo a vegetative phase to develop new shoots, which is turn mature to become the new fruiting shoots for the next flush of flowering and by this process one year of flowering is skipped off causing bienniality in cropping (Rao, 1997). Himsagar, the choicest cultivar in mango in West Bengal, similarly suffered from the problem of biennial bearing habit. Attempts have been made to manage the problem of bienniality by way of stimulating the sub apical buds of fruited shoots to develop flowers directly instead of undergoing the vegetative phase or the development of flowers on new shoots with the use of bioregulators and nutrients (Ram, 1996; Sanyal *et al*. 1996, Debnath, 2000). However, there is a necessity of further comprehensive studies for cultivars and agro-climate specific standardization of these chemicals. Present investigation was designed with an objective of induction of flowering with the chemicals and decapitation treatments for fruiting both in the 'on' and 'off' year.

MATERIALS AND METHODS

The effect of different flower inducing treatments *viz*. ethephon 0.625 ml l^{-1} (T_1), KNO_3 10 g l^{-1} (T_2), ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1} (T_3), KH_2PO_4 10 g l^{-1} (T_4), pacobutrazol 4 ml m^{-1} canopy radius (T_5), decapitation in October (T_6), decapitation (June) + urea 5 g l^{-1} (July) + KNO_3 10 g l^{-1}(T_7) and control (T_8) were studied for induction of flowering on 10 years old mango cv. Himsagar at Horticultural Research Station of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, India during 2012–14. The area is in new alluvial zone which is situated between 21.5 ^{0}North latitude and 86-89 ^{0}E longitude with an average altitude of 9.75 m above sea level. The experiment was laid out with 8 treatments and 3 replications following randomized block design. All the chemicals were applied as foliar spray except paclobutrazol which was applied in the soil. Ethephon, KNO_3 and KH_2PO_4 were applied as foliar spray in 4 consecutive months starting from September. For combined treatment of ethephon + KNO_3, ethephon was applied in September and October and KNO_3 in the month of November and December. Paclobutrazol was applied once in the soil during 2nd fortnight of September. Four branches consisting of approximately 100 shoots from each plant were selected for differentiation of shoots. Five panicles were taken for counting hermaphrodite and male flowers for each replication. Four to seven month old leaves (latest mature flush) from the middle of the shoot were sampled in December. Leaf samples were also collected before starting of experiment. Collected leaf samples were washed with distilled water to make them dust free and then chopped and dried in hot air oven at 70 ^{0}C for 72 hours. The dried samples were grinded and collected in brown paper for analysis. Nitrogen was determined by micro-Kjeldahl method as described by Black (1965). Total non-structural carbohydrate (starch and sugar) was estimated by colorimetric method using anthrone as a reagent (Hedge and Hofreiter, 1962). The data obtained were analysed statistically by the analysis of variance method as suggested by Goon *et al.* (2001) and the significance of different source of variation was tested by error mean square by Fisher's 'F' test of probability level of 0.05 per cent.

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RESULTS AND DISCUSSION

The present investigation revealed that all the treatments effectively induced flowering, advanced the flowering, increased the hermaphrodite flowers in a panicle and improved the yield in both years. The effect of chemicals was more as compared with decapitation alone (T_6) or with decapitation+chemicals (T_7). In the 'on' year, among eight different treatments, paclobutrazol resulted production of maximum flowering shoots (77.7%) followed by KH_2PO_4 10 g l^{-1} (68.2%) and ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1} (67.3%). In the following 'off' year, the flowering shoots were recorded much higher with paclobutrazol (48.4%) and ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1} (37.2%) as compared with control (13.9%). KH_2PO_4 10 g l^{-1} (T_4), ethephon 0.625 ml l^{-1} (T_1) and KNO_3 10 g l^{-1} (T_2) were moderately effective in production of flowering shoots in 'off' year. Different chemicals resulted early panicle emergence by 7-9 days in 'on' year and 4 – 9 days in 'off' year. Paclobutrazol (T_5) and KNO_3 10 g l^{-1} (T_2) were more effective in early panicle emergence in 'on' year and KH_2PO_4 10 g l^{-1} (T_4) in 'off' year (Table 1). Similar results of early and profuse flowering were also reported earlier with paclobutrazol (Tongumpai *et al*., 1997; Singh, 2008), ethrel (Sanyal *et al*., 1996; Debnath, 2000); KNO_3 (Sergent *et al*., 1997; Kumar *et al*., 2003) and KH_2PO_4 (Kumar *et al*., 2003); ethrel + KNO_3 (Rabelo *et al*., 1999; Hafle *et al*., 2003). In the present investigation, the better effect of combined treatment of ethrel and KNO_3 (T_3) on induction of flowering than ethrel and KNO_3 alone was also supported by Hafle *et al*. (2003).

The stronger and persistent influence of paclobutrazol as an antigibberellin might account for its higher effectiveness in promoting flowering (Abdel Rahim *et al*., 2011). Paclobutrazol, owing to its anti–gibberellin activity, could induce or intensify flowering by blocking the conversion of Kaurene to Kaurenoic acid (Webster and Quinlan, 1984; Voon *et al*., 1991). Ethylene may influence the expression of gene at the transcriptional level from DNA to mRNA, the translational level from mRNA to protein and the post–translated level for modification of proteins. This modification of protein may results in that specific enzyme which is responsible for the regulation of a specific plant physiology process, like growth, flowering or fruiting, provided other factors remain favourable. However, it is now generally accepted that ethylene action is mediated by receptor (Christoffersen and Latics, 1982; Sister and Blankenship, 1993). KNO_3 stimulated flowering in mango might be mediated by the increased levels of endogenous ethylene but later it was reported that KNO_3 induced flowering by inhibiting GA_3 (Protacio, 1992). The induction of flowering by KH_2PO_4 might be due to increased amount of potassium and phosphorus in the terminal buds. Involvement of phosphorus in fruit bud differentiation was reported by Nawadakar and Pandey (1982).

In the present investigation, shoots decapitated in the month of June + urea 5 g l^{-1} + KNO_3 10 g l^{-1} (T_7) produced lesser flowering shoots (50.1% in 'on' year and 15.7% in 'off' year) and lesser number of panicles per shoot (1.35 in 'on' year and 1.28 in 'off' year) as evidenced from table 1. This is quite obvious because new shoots came from sub apical buds just after decapitation either went for extension growth or remained dormant in majority cases. These finding are in agreement with the earlier findings of Ram (1996). Decapitation in October (T_6) resulted maximum panicles in a shoot (2.41 in 'on' year and 1.42 in 'off' year). This might be due to the fact that multiple sub apical buds directly forced to grow as panicles leading to more panicles in a shoot which is in conformity with the earlier findings of Das (2006).

Flower inducing treatments used in the present investigation had no significant influence on percentage of perfect flowers (Table 2). However, ethephon 0.625 ml/l (T_1), ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1}(T_3) and KH_2PO_4 10 g l^{-1} (T_4) were more effective for higher percentage of perfect flowers. The higher percentage of perfect flowers was also recorded earlier with ethrel (Singh and Dhillon, 1986), KNO_3 and KH_2PO_4 (Kumar *et al*., 2003) and paclobutrazol (Khader, 1992; Yeshitela, 2004). Fruit production was much higher with the treatments of paclobutrazol (T_5) and ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1}(T_3). Paclobutrazol produced maximum number of fruits plant^{-1} (399.4 in 'on' year and 190.3 in 'off' year) and yield plant^{-1} (85.5 kg in 'on' year and 48.8 kg in 'off' year) as compared to much lesser in untreated control plants (261.6 and 70.8 fruits plant^{-1} in 'on' and 'off' year respectively and 57.4 and 16.7 kg plant^{-1} in 'on' and 'off' year respectively). Treatments KNO_3 10 g l^{-1}(T_2), KH_2PO_4 10 g l^{-1} (T_4) and ethephon 0.625 ml l^{-1} were moderately effective in fruit production (Table 2). Appreciable increase in yield was recorded earlier by the treatment with paclobutrazol (Yeshitela, 2004; Singh, 2008), ethephon + KNO_3 (Rabelo *et al*., 1999; Hafle *et al*., 2003), KH_2PO_4 (Kumar *et al*., 2003), ethrel (Sanyal *et al*., 1996; Debnath, 2000) and KNO_3 (Debnath, 2000; Kumar *et al*., 2003).

It is evident from table 3 that paclobutrazol (T_5) and ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1}(T_3), leading to higher flowering and yield, also resulted higher total non structural carbohydrate (starch and sugar) and C/N of the leaves. The total non-structural carbohydrate and C/N of leaves in the month of December were found much

Table 1: Effect of flower inducing treatments on flowering shoot and panicle emergence of mango cv. Himsagar

Treatments	Flowering shoot (%)			Date of panicle emergence		Number of panicle shoot^{-1}		
	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled	'On' Year (2012-13)	'Off' Year (2013-14)	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled
T_1 – Ethephon 0.625 ml l^{-1}	63.3 (52.7)	24.9 (29.9)	44.1 (41.3)	27.1.11	4.2.12	1.46	1.01	1.23
T_2 – KNO_3 10 g l^{-1}	64.5 (53.5)	28.3 (32.1)	46.4 (42.8)	25.1.11	5.2.12	1.50	1.36	1.43
T_3 – Ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1}	67.3 (55.1)	37.2 (37.6)	52.3 (46.4)	26.1.11	5.2.12	1.61	1.09	1.35
T_4 – KH_2PO_4 10 g l^{-1}	68.2 (55.7)	28.7 (32.4)	48.4 (44.0)	27.1.11	31.1.12	1.81	1.22	1.52
T_5 – Pacobutrazol (4 ml m^{-1} canopy radius)	77.7 (61.9)	48.4 (44.1)	63.0 (53.0)	25.1.11	3.2.12	2.25	1.32	1.78
T_6 – Decapitation (October)	50.8 (45.5)	29.2 (32.7)	40.0 (39.1)	2.2.11	7.2.12	2.41	1.42	1.92
T_7 – Decapitation (June) + Urea 5 g l^{-1} (July) + KNO_3 10 g l^{-1}	50.1 (45.1)	15.7 (23.2)	32.9 (34.2)	27.1.11	7.2.12	1.35	1.20	1.28
T_8 – Control (water spray)	47.0 (43.3)	13.9 (21.9)	30.4 (32.6)	3.2.11	9.2.12	1.38	1.02	1.20
SEm(±)	**0.81**	**2.44**	**1.48**	**–**	**–**	**0.14**	**0.42**	**0.09**
LSD (0.05)	**4.44**	**0.85**	**2.46**	**–**	**–**	**0.28**	**0.08**	**0.24**

**Note: Data in the parenthesis are angular transformed values*

Table 2: Effect of flower inducing treatments on perfect flowers and fruit yield of mango cv. Himsagar

Treatments				'Numbers of fruits plant^{-1}			Yield plant^{-1} (kg)		
	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled
T_1 – Ethephon 0.625 ml l^{-1}	19.65 (25.87)	13.03 (21.16)	16.34 (23.52)	323.7	122.5	223.0	72.9	32.9	52.9
T_2 – KNO_3 10 g l^{-1}	13.49 (21.38)	9.16 (17.53)	11.33 (19.45)	328.3	128.8	228.6	74.2	34.1	54.2
T_3 – Ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1}	15.87 (23.46)	11.00 (19.04)	13.43 (21.25)	341.1	167.3	254.2	75.2	41.8	58.5
T_4 – KH_2PO_4 10 g l^{-1}	18.28 (25.04)	9.13 (17.44)	13.71 (21.24)	314.4	171.0	242.7	71.3	39.3	55.3
T_5 – Pacobutrazol (4 ml m^{-1} canopy radius)	10.87 (19.06)	12.29 (20.44)	11.58 (19.75)	399.4	190.3	294.8	85.5	48.8	67.2
T_6 – Decapitation (October)	13.56 (21.29)	8.49 (16.88)	11.02 (19.08)	291.6	133.2	212.4	65.8	32.4	49.1
T_7 – Decapitation (June) + Urea 5 g l^{-1} (July) + KNO_3 10 g l^{-1}	13.67 (21.69)	10.66 (18.78)	12.16 (20.24)	259.2	96.1	177.7	61.4	22.9	42.2
T_8 – Control (water spray)	13.50 (21.27)	10.31 (18.64)	11.91 (19.96)	261.6	70.8	166.2	57.4	16.7	37.1
SEm(±)	**2.57**	**1.71**	**1.63**	**16.76**	**7.10**	**6.67**	**3.74**	**1.77**	**2.08**
LSD (0.05)	**N.S.**	**N.S.**	**N.S.**	**50.25**	**21.29**	**19.32**	**11.21**	**5.31**	**6.04**

**Note: Data in the parenthesis are angular transformed values*

Table 3: Effect of flower inducing treatments on nitrogen, total non structural carbohydrate and C:N of leaves of mango.

Treatments	Nitrogen (%)			Total non structural carbohydrate (%)			C:N		
	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled	'On' Year (2012-13)	'Off' Year (2013-14)	Pooled
T_1 – Ethephon 0.625 ml l^{-1}	1.76	1.72	1.74	11.80	10.80	11.30	6.71	6.29	6.50
T_2 – KNO_3 10 g l^{-1}	1.80	1.99	1.90	11.14	11.28	11.21	6.20	5.68	5.94
T_3 – Ethephon 0.625 ml l^{-1} + KNO_3 10 g l^{-1}	1.91	1.82	1.87	12.51	11.92	12.22	6.56	6.56	6.56
T_4 – KH_2PO_4 10 g l^{-1}	1.87	1.60	1.74	10.85	8.85	9.85	5.81	5.54	5.67
T_5 – Pacobutrazol (4 ml m^{-1} canopy radius)	1.79	1.64	1.72	14.19	12.05	13.12	7.94	7.37	7.66
T_6 – Decapitation (October)	1.83	1.71	1.77	10.30	9.29	9.795	5.64	5.43	5.54
T_7 – Decapitation (June) + Urea 5 g l^{-1} (July) + KNO_3 10 g l^{-1}	2.04	1.99	2.02	9.96	9.49	9.725	4.88	4.78	4.83
T_8 – Control (water spray)	1.88	1.70	1.79	9.04	9.11	9.08	4.81	5.36	5.09
SEm(±)	**0.03**	**0.04**	**0.03**	**0.53**	**0.14**	**0.28**	**0.35**	**0.19**	**0.20**
LSD (0.05)	**0.08**	**0.12**	**0.07**	**1.60**	**0.42**	**0.79**	**1.05**	**0.55**	**0.57**

**Note: Before starting experiment: Nitrogen – 1.48%, total non structural carbohydrate - 7.13% and C:N – 4.82*

higher with the treatments paclobutrazol (13.12% and 7.66, respectively) and ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1}(12.22% and 6.56, respectively) as compared with control (9.08% and 5.09, respectively). Application of Ethephon 0.625 ml/l (T_1) and KNO_3 10 g l^{-1}(T_2) also resulted moderate C/N ratio in leaves. So, the higher C/N of leaves might be responsible for high yield. The majority of the dormant buds of the treated trees were released from their quiescent state more or less simultaneously soon after the cold period. This situation in addition to the high level of total non structural carbohydrate (starch and sugar) and high C:N in the trees led to intense flowering and fruiting (Vijyalakshmi and Srinivasan, 2002; Hoda *et al*., 2001; Yeshitela, 2004). In the present experiment, decapitation + urea 5 g l^{-1}+ KNO_3 10 g l^{-1} (T_7) exhibited minimum C/N in the leaves which might be due to lower nitrogen content in the leaves as well as due to utilization of carbohydrate reserve for excessive vegetative growth.

It is concluded that paclobutrazol or ethephon 0.625 ml l^{-1}+ KNO_3 10 g l^{-1} may be used effectively for induction of flowering with a promising fruit yield in the 'off' year.

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