International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 244-247

Received: 19-09-2017
Accepted: 23-10-2017

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Effect of chemicals and cincturing on flowering, fruiting and yield of litchi cv. Rose Scented

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Abstract
The present experiment was conducted to study the effect of chemicals *viz.*, ethephon (400 ppm), KNO_3 (10g/l), TIBA (1g/l), SADH (400 ppm), paclobutrazol (20ml/tree), KH_2PO_4 (10g/l) and cincturing (3mm deep and 3mm wide) on flowering, fruit yield and shelf life of litchi cv. Rose Scented. The experiment was laid out in randomized block design with 8 treatments and 3 replications.The results obtained indicated that among all the treatments ethephon (400 ppm) and TIBA (1g/l) had significant effect on flowering and fruit yield of litchi. The application of ethephon @ 400 ppm was found to be more effective in advancing the flowering by 6 days, maximum number of panicles (356 panicles/tree) and highest numbers of fruits/panicle. In other treatments, application of TIBA (1g/l) increased the fruit set percentage (63.42%) and fruit retention percentage (20.10%) with minimum fruit drop percentage (60.56%) in litchi. Finally, average yields; 58.30 kg/tree and 5.83 t/ha were also improved with the application of ethephon @ 400 ppm.

Keywords: chemicals, cincturing, flowering, fruiting and yield

Introduction
Litchi *(Litchi chinensis* Sonn.) is the most popular fruit of the Sapindaceae family that includes Longan and Rambutan too. Litchi originated in the area near southern China and northern Vietnam, but has now spread to many countries. The leading litchi producer countries are China, Vietnam, Thailand and India however, this fruit is also popular in Africa (South Africa and Madagascar), Indonesia, Australia, USA, Mexico, Spain and Israel (Menzel, 2001) [16]. India ranks second in the litchi production next to China and has undergone substantial expansion in cultivation in the past 50 years. India, occupies 83,000 ha area having the production of 580 thousand Mt with average productivity of 7.0 Mt/ha. In Uttarakhand, the area, production and productivity of litchi are 9.49 thousand ha, 19.16 thousand Mt/ha and 2.0Mt/ha, respectively (Anonymous, 2014) [1].
The use of plant growth regulators or retardant such as paclobutrazol, ethephon and SADH (succinicacid-2, 2-dimethylhydrazide) and cincturing have been reported to improve flowering and restrict vegetative flushing in litchi, although the results can often be inconsistent. Menzel and Simpson (1990) [15] demonstrated an increase in flowering of 'Bengal May Pink' and Tai So' litchi with soil application of paclobutrazol in autumn after maturation of postharvest vegetative flush. Application of 2, 3, 5-Triidobenzoic acid (TIBA) and ethrel increases the number of female flowers by decreasing the male flower in cucumber (*Cucumis sativus*). It is found that TIBA acts as an auxin transport inhibitor and it blocks the transport of auxin at the basal plate resulting increase in auxin content in stems and promote early flowering and internodal elongation in *tulipa species* (Geng *et al.*, 2005) [9]. Chandola and Mishra (2015) [5] reported that significant variation in morphological, biochemical and yield characters of various cultivars. Potassium compounds like KNO_3 and KH_2PO_4 were also found promising with regard to flower induction and improving bearing potential of litchi. KNO_3 has been successfully used to induce flowering in mango (*Mangifera indica*). Data obtained indicate that the inductive effect of KNO_3 is ethylene mediated (Valmayor, 1987) [26]. However, paclobutrazol and KH_2PO_4 increases the number of pure panicle to four times. Therefore, it is important to estimate the physical and chemical characteristics of litchi after applying the certain chemicals for their usefulness in the future.

Materials and Methods

The present study was conducted at Horticultural Research Centre, Patharchatta and the Department of Horticulture, G.B Pant University of Agriculture and Technology, Pantnagar, district Udham Singh Nagar (Uttarakhand) during the period from September, 2014 to June, 2015. The experiment was performed under Randomized Block Design (Snedecor and Cochron, 1980) [24] with control. All treatments with control were replicated thrice. Thus, 24 trees were marked for conducting the experiment. Selected trees were given uniform cultural operations. The chemicals used were ethephon (400 ppm), KNO_3 (10g/l), TIBA (1g/l), SADH (400 ppm), paclobutrazol (20ml/tree), KH_2PO_4 (10g/l) and cincturing (3mm deep and 3mm wide) on litchi cv. Rose Scented. The proper weighing of different chemicals were done and stock solution of each chemical was made by dissolving them with the help of water and by adding few drops of NaOH solvent to avoid precipitation. The stock solution were stored in glass bottles and kept in a refrigerator at 4-5 ^{0}C temperature. Final volume was made with addition of water. pH of a solution was maintained to 7 by N/10 NaOH and N/10 HCL. Cincturing was done in the middle of September with the help of sharp knife. The phloem portion was removed carefully without damaging the xylem. 10-15 liter solution of chemical was enough for spraying of one tree and chemicals were sprayed by using Knapsack sprayer on a particular date except in the case of paclobutrazol in which 15 l of solution was poured around the main tree trunk in a 20 cm deep trench. The reproductive or fruiting parameters were recorded by visiting the experimental orchard frequently after bud emergence to fruit maturity. The physical parameters of fruit *viz.*, length and breadth of the fruits from three replications were recorded using digital Vernier calipers. The weight and volume of fruit were recorded by physical balance and water displacement method, respectively. The yield in kilogram of fruit per tree was calculated manually using physical balance. The significance of variation among the treatment was estimated by the "f" test and critical difference at 5 per cent level was calculated to compare the mean value of treatments for all the characters. (Fisher, 1935) [8].

Results and Discussion

Effect on flowering parameters

As shown in Table 1 the duration of panicle initiation was delayed by 2 days in $KH_2 PO_4$ treated trees and advanced by 4 days in paclobutrazol and 3 days in cinctured trees and SADH, 2 days in TIBA and ethephon treatments in comparison to control and in other treatments, duration of panicle initiation was simultaneous. In terms of date of start of flowering, ethephon, $KNO_{3,}$TIBA, SADH, cincturing and paclobutrazol treatments were proved effective in advancing the date of flowering by 6, 4, 6, 4, 3 and 4 days, respectively. While, the date of flowering was delayed by 2 days under KH_2PO_4 treated trees in comparison to control. The results obtained from this experiment indicate that treatment ethephon, KNO_3, TIBA, SADH, cincturing and paclobutrazol advanced flowering and KH_2PO_4 treated trees delayed flowering. Ethephon resulted in maximum number of panicles per tree (356) followed by TIBA (345) whereas, minimum number of panicles per tree were recorded in cincturing (270) followed by treatment control (290). Data presented also showed that most of the treatments *viz.* KNO_3, SADH, cincturing, paclobutrazol and KH_2PO_4 took less time to bloom included control (25 days) from the period of start of flowering to end of flowering, while other treatments ethephon and TIBA took maximum time to bloom by 27 and 26 days, respectively as compare to control.

Table 1: Effect of different treatments on panicle initiation, start of flowering, total number of panicles/tree, duration of blooming and Date of end of flowering in litchi.

Treatments	Date of panicle initiation	Date of start of flowering	Total number of panicles/tree	Duration of blooming (Days)	Date of end of flowering
Ethephon (400 ppm)	5-Feb	12-Mar	356	27 days	7 Apr
KNO_3 (10g/l)	4-Feb	14-Mar	333	25 days	7 Apr
TIBA (1g/l)	5 Feb	12-Mar	345	26 days	5 Apr
SADH (400 ppm)	4-Feb	14-Mar	300	25 days	7 Apr
Cincturing (3 mm wide and 3 mm deep)	4-Feb	15-Mar	270	25 days	8 Apr
Paclobutrazol (20ml/tree)	3-Feb	14-Mar	330	25 days	7 Apr
$KH_2 PO_4$ (10g/l)	9-Feb	20-Mar	312	25 days	13 Apr
Control	7-Feb	18-Mar	290	25 days	11 Apr

The results obtained are also in accordance with Singh *et al.* (2004) [22] who concluded from his experiment that TIBA applied at 100 or 200 ppm resulted in earlier panicle initiation in mango by 2-8 days. The ethrel has been reported in advancing the flowering which might be due to the early maturation of shoots that induced early flowering and promoted lateral expansion and induced compact flower panicles (Zhang *et al*., 1988) [27]. This may be due to the fact that girdling and growth retardants might have suppressed vegetative flush in winter and promoted early flowering. This might be due to because paclobutrazol caused an early reduction of endogenous gibberellins levels within the shoots causing them to reach maturity earlier than those of untreated mango trees (Anonymous, 1984) [2]. KH_2 PO_4 treated trees delayed flowering and similar result was also found by Liu Juan *et al.* (2011) [13] who observed that foliar application of KH_2PO_4 at 3.00% had the longest flowering period of 42-114 days than that of control in gold grass (*Antenoron filiforme var.* Neofiliforme). The results obtained are similar to the findings of Sinha and Mandal (2000) [23] they found that ethephon @ 100 ppm increased the number of nodes, female flowers in cucumber. This might due to the positive relation between flower bud formation and cytokinin level, ethephon increased the level of cytokinin due to which auxin content decreased in shoot tissues. Similar results were obtained by Roa and Srihari (1998) [20] who observed that foliar application of TIBA at 100 ppm promoted early flowering on fruited shoots in off year mango cv. Alphanso. Valmayor (1987) [26] concluded from his experiment that KNO_3 has successfully induced early flowering in mango. Application of paclobutrazol (3 ml a.i./m^2 canopy surface area) advanced the flower emergence by six to seven days in litchi cultivar 'Bombai' (Mandal *et al.*, 2014) [14]. Combination of ethephon at 250 ppm and girdling significantly increased early flowering in two mangos cv. Langra and Ewaise (Stino *et al.*, 1981) [25]. These all results revealed by different workers on early flowering by different treatments supported our findings because early flowering is directly correlated with the date of end of flowering. The results obtained are in conformity with the findings of Geng *et al.* (2005) [9] they found that TIBA acts as an auxin transport inhibitor and it blocks the transport of auxin at the basal plate resulting increase in auxin content in stems and it promotes early flowering and internodal elongation in tulip which may be the reason of delayed harvesting by treatment TIBA. The results obtained are also in conformity with the findings of Reboucas *et al.* (1997) [19], they observed that the Girdling 60 and 75 days before the application of KNO_3 advanced the harvest date by 23 days and girdled plants had less vegetative growth as compare to control. Negi *et al.* (2012) [18] also found the similar results and reported that cincturing at the 3 mm deep resulted less flowering shoots percentage and early harvest of the fruit. According to Haung *et al*. (2002) [11] the twig girdling at different shoot stage in spring and autumn inhibited new flush, due to this callus formation above the girdles became thick and massive accumulation of starch in the twig takes place. De Villiers *et al.* (1990) [6] studied that cincturing advanced the harvest date because cincturing did not increase the growth rate during growth stage III and it causes early harvest due to the four days reduction in the duration of growth stage II. It was also found that TIBA advanced the date of end of flowering by 6 days and ethephon, KNO_3, SADH and paclobutrazol by 4 days, treatment cincturing advanced the date by 3 days, while KH_2PO_4 delayed by 2 days in comparison to control.

Fruiting and yield parameters

The data pertaining to fruiting and yield parameters are presented in Table 2. The scrutiny of data clearly indicates that the different treatments significantly affected the number of fruits/panicles however, maximum number of fruits was recorded in treatment ethephon (17.63) followed by TIBA (16.80) and KNO_3 (16.20) whereas, minimum number of fruits was observed in treatments cincturing (14.26) which was statistically at par with control (14.33).The highest fruit set percentage was recorded with treatment TIBA (63.42%) which was statistically at par with the KNO_3, SADH, cincturing, paclobutrazol and KH_2PO_4 treatments while, minimum fruit set percentage was recorded in treatment ethephon (58.20%) which is at par with the SADH treatment and control. The minimum fruit drop was observed in treatment TIBA (60.56%) which was statistically at par with treatments ethephon (62.30%), SADH (61.10%), cincturing, (61.10%), paclobutrazol (60.89%) and KH_2PO_4 (62.10%). The maximum fruit drop was found in control (65.30%) which was statistically at par with treatment KNO_3 (65.10%). These two characters; fruit drop and fruit retention percentage are inversely correlated with each other thus, low fruit drop percentage automatically means high fruit retention. Treatment TIBA found minimum fruit drop with maximum fruit retention percentage (20.10%) followed by paclobutrazol (18.80%) and KH_2PO_4 (16.70%) however, minimum fruit retention percentage was recorded in treatment KNO_3 (13.97%) followed by control (14.10%) and ethephon (15.50%).The maximum average yield per tree (58.30 kg/tree) and per hectare (5.83 t/ha) was recorded with treatment ethephon followed by 56.11 kg/ tree and 5.61 t/ha with TIBA. Finally, date of harvesting was advanced by 2 days in treatment ethephon, cincturing and paclobutrazol, while date of harvesting was delayed by TIBA and KH_2PO_4 by 3 days, SADH and KNO_3, treatments delayed the harvesting date by 2 and 1 day, respectively as compere to control. TIBA leads to delayed maturity while, cincturing and KH_2PO_4 led to early maturity and other treatments took nearly the same time as control. Days taken from panicle initiation to harvesting were found maximum in TIBA and minimum in cincturing.

Arora *et al.* (1987) [3] they observed that ethrel at 100 mg/l results in maximum number of fruits on ridge gourd (*Luffa acutangula* Roxb.) which be due to the increased in the number of panicles per tree resulted in maximum number of fruits per panicle. Bini and Giannone (1985) [4] they observed that 100 ppm aqueous solution of TIBA to cv. Moraiolo of olive (*Olea europaea*) trees (a year of low bearing) increased fruit set in both the years of investigation. Mandal *et al.* (2014) [14] reported that application of Ethrel at concentration of 1.0 and 2.0 ml/l had the highest fruits set per panicle at initial stage (63.92%) and also at harvest (23.09%). Natesh *et al.* (2005) [17] also observed the similar results and they found that TIBA 25 or 50 ppm increased fruit set in chili. This might be because of TIBA prevents the formation of abscission layer in apple (*Malus domestica*) which may result in maximum fruit set initially (Greene, 2006) [10]. Bini and Giannone (1985) [4] who reported that TIBA with 100 ppm reduced the fruit drop in both the years. however, the results obtained are supported by Dhaliwal *et al.* (2002) [7] who observed that fruit drop was increased by 0.25 to 0.5%, 4 to 6% by the application of potassium iodide and potassium nitrate, respectively at full bloom stage in guava (*Psidium guajava*) cv. Sardar. Data also showed that all the treatments except cincturing resulted in more fruit yield per tree and per hectare as compared to control. However, maximum average yield per tree (58.30 kg/tree) and per hectare (5.83 t/ha) was recorded with treatment ethephon. Kumar (1992) [12] they found that ethephon @ 250 to 500 ppm was quite effective in increasing the yield of Rose Scented cultivar of litchi under Pantnagar condition. The results obtained are also supported by Saxena (1994) [21] who suggested that application of ethrel 25 days before harvesting @ 200 ppm gave maximum yield of litchi cv. Rose Scented. This might be due to the positive relation between total number of panicle/tree, total number of fruit/tree and fruit weight which automatically will lead to higher average yield per tree.

Table 2: Effect of different treatments on Number of fruits/panicle, Fruit set (%), Fruit drop (%), Fruit retention (%), Average yield (kg/tree), Average yield (t/ha) and Date of harvesting in litchi.

Treatments	Number of fruits/panicle	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Average yield (kg/tree)	Average yield (t/ha)	Date of harvesting
Ethephon (400 ppm)	17.63	58.20	62.30	15.50	58.30	5.83	9 Jun
KNO_3 (10g/l)	16.20	62.30	65.10	13.97	54.35	5.43	12 Jun
TIBA (1g/l)	16.80	63.42	60.56	20.10	56.11	5.61	14 Jun
SADH (400 ppm)	15.88	60.40	61.10	16.70	52.02	5.20	13 Jun
Cincturing (3 mm wide and 3 mm deep)	14.26	60.20	61.60	16.10	48.21	4.82	9 Jun

Paclobutrazol (20ml/tree)	16.30	62.80	60.89	18.80	54.12	5.41	9 Jun
KH_2PO_4 (10g/l)	15.67	62.10	62.10	16.70	53.64	5.36	14 Jun
Control	14.33	59.82	65.30	14.10	51.40	5.14	11 Jun
CD at 5%	0.374	0.91	0.71	0.30	2.788	0.165	-
SE(m)±	0.123	2.8	2.18	0.92	0.919	0.544	-

Conclusion

The findings of the present investigation revealed that foliar application of ethephon (400 ppm) and TIBA (1g/l) was an effective way for improvement of flowering and fruiting quality of litchi cv. Rose Scented. Whereas, TIBA (1g/l) alone was most effective for maintaining fruit set percentage, fruit drop percentage and fruit retention percentage in litchi.

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