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Effect of pruning and KNO_3 sprays on flowering attributes of litchi (*Litchi chinensis* Sonn.) cv. rose scented

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Abstract
The present investigation was conducted at Horticultural Research Centre, Patharchatta, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (Uttarakhand) to study the effect of pruning and KNO3 sprays on flowering in litchi cv. Rose Scented during 2015 - 2016. The trial was laid out using Factorial Randomized Block Design with three replications. The treatments consisted of three factors i.e., pruning time (29th June, 11th July, 23rd July and 04th August), pruning intensity (20 cm and 40 cm) and KNO3 sprays (2% and 4%) and were compared with control. The results revealed that the flowering was significantly affected by pruning time, pruning intensity and KNO3 sprays. The treatments comprising pruning on 29th June at 40 centimeter pruning intensity and 4 per cent KNO3 (T4) and pruning on 11th July at 40 cm intensity and 4 per cent KNO3 (T8) were found to be more effective in terms of early and profuse flowering, higher sex ratio (female: male). Delayed pruning after 23rd July showed adverse effect on flowering characters. On the basis of the results obtained in the present study, it can be concluded that under Tarai region of Uttarakhand, early pruning after harvesting up to 11th July with 40 centimeter pruning intensity and 4 per cent KNO3 sprays on vegetative shoots has better effect on flowering of litchi cv. Rose Scented.

Keywords: Histochemistry, immunohistochemistry, madras red ewe, udder, teat

Introduction
Litchi (*Litchi chinensis* Sonn.) is an evergreen subtropical fruit tree grown throughout the world for its delicious juicy fruits. It belongs to the family Sapindaceae and subfamily Nephaleae which consists of about 125 genera and 1,000 species. Litchi is believed to have originated in Southern China and Northern Vietnam region and became widely distributed in the Subtropics (Menzal and Simpson, 1986) [10]. In India it reached via Burma by the end of 17th century (Goto, 1960) [8]. India is second largest litchi producer in the world next to China. The annual production of litchi in India accounts to 583 thousand metric tonnes from an area of 85 thousand hectare with an average productivity of 6.3 metric tonnes/ha (Anonymous, 2017) [2]. In India major litchi growing states are Bihar, West Bengal, Uttar Pradesh, Uttarakhand, Punjab, Arunanchal Pradesh, Karnataka and Tripura. In Uttarakhand, annual production of litchi accounts for 19.16 thousand metric tonnes from an area of 9.49 thousand hectares. The major litchi producing areas in Uttarakhand are Dehradun, Haridwar, Nainital, Udham Singh Nagar districts with minor production in Pithoragarh and Pauri Garhwal districts. It has a vast potential of cultivation in the entire *Tarai* belt of Uttarakhand.
The litchi requires dry and warm sub-tropical climate. Frost free winters and long hot summers with high rainfall and humidity are required for better flowering, fruit set and development. Irregular flowering in litchi is noticed due to variation in the timing of flushing. A cool weather condition is a prerequisite for flower induction in litchi (Stern and Gazit, 2003) [17]. Winter temperature more than 25°C, favours vegetative growth rather than floral induction. Flower panicle initiation takes place when the temperature during swelling of buds is 20°C or cooler (Menzel and Simpson, 1988) [11]. On the other hand, the flush will be vegetative if warm or cool weather persists when the buds are longer than a few millimeters (Batten and McConchie, 1995) [3]. One of the major factors affecting the production of this subtropical fruit in many countries is low yields. The trees may fail to flower some seasons or fail to set and

carry a reasonable crop (Menzel, 2001). In litchi, the panicle emergence and flowering depends on the number of flushes and maturity of new shoots when conditions are conducive. Generally, litchi tree produces three vegetative flushes in a year i.e. early (after harvest), mid (August to October) and late (after November). Out of these three vegetative flushes, the early and mid flushes influence the yield and the late flush do not have any contribution towards yield (Singh *et al*., 2012). Removal of late flush or new shoots developing in late winter increases flowering in litchi (Chaitrakulsub *et al*., 1992) [5], indicating that during the period when conditions are ideally inductive the terminal shoots must be adequately mature. The lack of flowering is usually related to the weather or the timing of shoot growth during the cooler months of the year. In litchi, flowering is affected by the cycle of shoot development (Olesen *et al*., 2002) [13]. The maturity of terminal shoots is directly related to floral initiation. Terminal shoots matured at the time when conditions are ideally inductive results in late bud-break while terminal shoots fully matured prior to the stage when conditions are ideally inductive causes early bud break and flowering is adversely affected. The effect of pruning on flower bud formation and quality of fruits has been studied by various workers in different crops. Pruning is a practice of removal or heading back of the laterals of a branch, has direct effect on growth response of a tree. Pruning not only restricts excessive vegetative growth but also maintains a balance between vegetative and reproductive stage of a tree. The photosynthetic translocation towards the roots get enhanced which indirectly regulates flower bud formation and improves fruit size, fruit colour and fruit quality during the fruit development stage. Heavy pruning causes excessive vegetative growth, which results reduction in flowering and fruiting. Pruning just after harvesting has been found to be beneficial for improving flowering (Goren, 1990) [7].

Floral initiation is also being greatly influenced by foliar application of plant nutrients is quite efficient and helpful to fulfill the nutrient requirement of the proper nutrition management especially when nutrient uptake by the root system is restricted. Potassium helps in the cell division, synthesis and translocation of carbohydrates (Chadha, 2001) [4]. Timely application of potassium and its availability results resistance against various abiotic and biotic stresses in the plants and also has role in adjusting excessive vegetative growth by inhibiting nitrogen absorption and thereby encouraging floral initiation. More application of potassium fertilizer also helps in a delay in harvest time. In leaves, high potassium content in the month of November-December has been found to reduce vegetative growth and induce early flowering and fruiting (Mitra and Sanyal, 2001 and Kumar *et al*., 2003) [12, 9]. Keeping the above into consideration, the present experiment was conducted to study the effect of pruning and KNO_3 on flowering, fruiting and physic-chemical characteristics of litchi cv. Rose Scented under *tarai* condition.

Material and methods

The experiment was carried out at Horticultural Research Centre, Patharchatta, Pantnagar during 2015-16. Geographically, Pantnagar is located in the *Tarai* region at the foot hills of Himalayas between 29° N latitude, 79.3° E longitude and at an altitude of 243.84 meters above the mean sea level. Fifteen years old litchi trees of cv. Rose Scented planted at 5×5 m distance in square system were selected for the experiment. All the selected trees were of uniform vigour and size. The trial was laid out using Factorial Randomized Block Design with three replications. The treatments consisted of three factors i.e., pruning time (29th June, 11th July, 23rd July and 04th August), pruning intensity (20 cm and 40 cm) and KNO_3 sprays (2% and 4%) and were compared with control. One tree served as a unit of treatment in each replication. The detail of the treatments is given below:

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Treatments	Treatments details
T_1	Pruning on 29 June, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_2	Pruning on 29 June, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_3	Pruning on 29 June, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were prayed with 2% KNO_3
T_4	Pruning on 29 June, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_5	Pruning on 11 July, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_6	Pruning on 11 July, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_7	Pruning on 11 July, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_8	Pruning on 11 July, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_9	Pruning on 23 July, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_{10}	Pruning on 23 July, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_{11}	Pruning on 23 July, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_{12}	Pruning on 23 July, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_{13}	Pruning on 4 August, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_{14}	Pruning on 4 August, 2015 by removing 20 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_{15}	Pruning on 4 August, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 2% KNO_3
T_{16}	Pruning on 4 August, 2015 by removing 40 cm terminal shoot growth and the newly emerged shoots were sprayed with 4% KNO_3
T_{17}	Control (Neither pruned nor sprayed with KNO_3)

During the period of experiment uniform cultural practices like nutrition, irrigation, weeding etc. were performed in all the trees. The observation on flowering intensity (%) was recorded on the basis of shoot flowered divided by total shoots tagged and multiplied by 100. Advancement/delay in flowering was assessed through flowering time of control tree taken as bench mark and any delay or early flowering was indicated with prefix (– and +, respectively) sign before numerals. Number of male and female flower per panicle was estimated by counting floral shoots of tagged branches in individual trees. Sex ratio was calculated by number of female flower divided by number of male flowers per panicle counted from randomly selected flowering shoot in each direction. The data was statistically analyzed in factorial Randomized Block Design (FRBD) for analysis of variance.

Results

Findings of the present investigation revealed a wide range of variability with respect to flowering and fruiting attributes Pruning along with KNO_3 spray significantly enhanced flowering intensity as compared to control. Intensity was maximum in trees pruned in July month due to maturity of terminal shoots during advanced stage, just prior to the conditions which were inductive for flowering along with sufficient amount of reserves for signaling. Maximum flowering intensity (67.60%) was observed in T_9 treatment which was statistically *at par* with T_5 and T_6 treatments, while minimum flowering intensity (26.53%) was observed in the T_{17} (Control) treatment. Potassium Nitrate (KNO_3) is known to affect the nitrogen level of the plant and specific products of nitrogen metabolism and amino acids plays a direct role in the initiation and differentiation of floral buds (Ross and Pharis, 1985) [15]. The trees pruned earlier resulted in reduced flowering which might be due to early bud break or maturation of the terminal shoots at the time when conditions were not inductive, whereas late pruning resulted in late bud break and insufficient maturity of shoots during inductive period. Exogenous applications of nitrogenous compounds containing either NH_4^+ or NO_3 have been shown to increase arginine levels, which promotes early flowering. The treatment T_9 showed earliest flowering with the advancement of 6 days as compared to control whereas, the lowest advancement in flowering *i.e.*, 1 day as compared to control was observed in T_{13}, T_{14} and T_{15} treatments. The results are in close conformity with the work of Singh *et al.* (2010) [16] who observed advanced flowering in moderately pruned trees of mango and Dalal *et al.* (2005) [6] who reported advancement in flowering of mango when treated with KNO_3. KNO_3 spray is an agent that initiates flowering from tissues already competent to flower but certainly not yet determined to be flowers. It is generally accepted that nitrate salt application stimulates bud break. Presumably, there is a threshold for nitrogen concentration that if exceeded, will allow the plant to flower. Potassium nitrate probably acts by elevating nitrogen levels over a nitrogen threshold thereby synchronizing budbreak from apices with existing floral initials. The signaling process is probably mediated by polyamines or ethylene. In addition, the role of potassium nitrate is related to increased production and translocation of sugars to the bud. The influence of treatments on duration of flowering was significant over control. The maximum duration of flowering (21.667 days) was observed in T_{12} treatment which was statistically *at par* with T_2 and T_{11} treatments while minimum duration of flowering (17 days) was observed in T_{17} (control). The results are in accordance with the findings of Singh *et al.* (2010) [16] who observed longer flowering duration in pruned trees of mango. Adhikari and Kandel (2015) [1] also reported increased flowering duration by 20 centimeter shoot tip removal in guava cv. L-49. Oosthuyse (1994) [14] reported that the late physiological maturity of new shoots enhances the duration of flowering. The maximum number of female flowers (288.81) and male flowers per panicle (745.07) was recorded in T_4 treatment which was *at par* with T_8, T_7 and T_6 treatments. On the other hand, minimum number of female flowers (87.76) and male flowers (256.56) was recorded in T_{13} treatment. The sex ratio was improved in all the pruned trees. The treatment T_2 significantly recorded highest sex ratio ((0.37).

Table 1: Effect of Pruning and KNO3 sprays on flowering attributes in Litchi cv. Rose Scented

Treatments	Flowering intensity (%)	Flowering advancement (days)	Duration of flowering (days)	Number of female flowers per panicle	Number of male flowers per panicle	Sex ratio (F:M)
T_1	52.657	3	19.000	189.970	557.050	0.343
T_2	59.660	4	21.000	220.377	596.437	0.370
T_3	50.247	3	19.667	236.210	634.873	0.372
T_4	57.860	6	20.667	288.817	745.037	0.388
T_5	66.700	3	18.667	206.583	591.763	0.346
T_6	65.907	4	19.667	248.877	684.833	0.364
T_7	50.383	3	18.667	240.733	636.353	0.378
T_8	46.613	4	19.667	268.430	706.333	0.382
T_9	67.603	3	18.667	187.893	530.187	0.353
T_{10}	61.090	5	20.333	213.930	578.913	0.370
T_{11}	59.797	4	21.000	188.980	528.860	0.357
T_{12}	61.743	5	21.667	190.737	516.633	0.371
T_{13}	29.737	1	18.333	87.767	256.560	0.343
T_{14}	37.493	1	18.667	103.670	287.067	0.359
T_{15}	29.077	1	18.667	90.027	258.103	0.350
T_{16}	26.533	2	19.000	115.830	321.260	0.362
Control (T_{17})	49.783		17.000	154.047	505.583	0.302
C.D. at 5%	16.243		1.522	65.087	176.929	0.014
S. Em. ±	5.613		0.526	22.492	61.141	0.010

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