



# Influence of Forcing Methods on Vegetative Growth of Kinnow Nursery under Arid-Submontane of Punjab India

Yogesh Khokhar and Rakesh Kumar Sharma

Department of Fruit Science, Punjab Agricultural University Ludhiana-144 521, India  
E-mail: [khokhar82@pau.edu](mailto:khokhar82@pau.edu)

**Abstract:** The bud survival significantly affected by the time of forcing. Five and six weeks forcing periods were significantly superior to forcing immediately after budding. The scion growth bending method of forcing had better growth attributes in number of leaves, scion length and diameter than the rest forcing methods. In this study five weeks period of forcing increased percentage seedling survival, while this same treatment and four weeks forcing period reduced the nursery period of budling production. Bending method of forcing was best for improving bud survival and growth of Kinnow nursery plants.

**Keywords:** Bending, Forcing, Looping, Survival

The t-budding method of plant propagation is commercially used for Kinnow nursery plants multiplication in the spring and rainy seasons when the cambium is actively dividing (Carrol, 2017). It should be timed just before the spring season so that warm weather may help ensure a good bud union with root stock. Simultaneously, it should not be so late in autumn to avoid frost burn of the tender shoots of scion (Salik et al., 2015). In the semi-arid region of Punjab (Pakistan), the budding of sweet orange in the spring season gave the maximum budding success and survival (Salik et al., 2015). The demand for quality kinnow nursery plants is increasing, while the major hindrance is the 9-12 months' time period required for quality kinnow plants (Nawaj et al., 2021). The various practices viz; bending, cutting, tying, root training, and looping, are practiced for early production of nursery plants in the commercial nurseries (Neto et al., 2016). The bud forcing is a post-budding cultural operation used for the mass production of the saleable Kinnow nursery plants in a limited time (Thakur et al., 2017). Cutting off, looping or bending the citrus rootstock stem is a general practice practiced in fruit nurseries to force scion bud growth (Singh 2018). The best time of forcing is therefore necessary for a good Kinnow nursery development. Several studies were conducted in the past on Kinnow propagation at different times with the commercial method of propagation under various agro-ecological regions (Kumar et al., 2016), in sweet orange under the arid irrigated conditions of Haryana (Kanwar et al., 2015). Bhandari et al. (2022) in mid hills of Nepal. An intensive literature search did not reveal the best time of bud forcing operation in Kinnow nursery under the lower Shiwaliks of Punjab. Therefore, the present study was designed to find out the best time of post budding

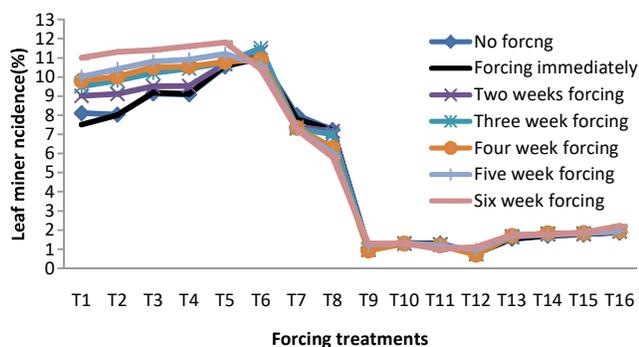
practice the bud forcing with minimum CLM damage for mass production of saleable Kinnow plants in a limited period.

## MATERIAL AND METHODS

**Location:** The study was conducted in the enceptisol of the Regional Research Station, Ballawal Saunkhri, situated in the Lower Shiwaliks with latitude of 31.092794° and longitude of 76.385244° (Fig. 1). The key features of this region include a sloping terrain, scattered small land holdings, and an irregular pattern of rainfall. The area experiences an annual rainfall of 982 mm, based on the average from 2015-19. The average monthly temperatures range between 2.9°C and 45.5°C. The sub-mountainous landscape of the Kandi region is characterized by loamy sand to sandy loam soils, which have limited moisture retention capacity. This soil composition makes dry farming agriculture in the region unpredictable and often chaotic. The lack of moisture retention in the soil poses challenges for sustaining crops, and the sloped landscape further complicates agricultural activities. Given the unpredictable nature of the rainfall and the specific soil characteristics, farmers in this region face challenges in optimizing agricultural practices. Understanding the site's conditions is crucial for contextualizing the study's findings and proposing practical solutions tailored to the unique challenges of the Lower Shiwaliks.

**Treatments detail:** The field nursery experiments started on 12-month-old rough lemon rootstock seedlings that were budded with scions of Kinnow using the T-budding method.

**Plant material, experiment design and treatments:** The rootstock *JattiKhatti* (*Citrus jambhiri* L.) of the same age and size were selected and budded with the scions. The budding



**Fig. 1.** Leaf miner infestation on different dates of budding and forcing method

instruments viz; budding knife, scissors, transparent plastic for wrapping and sun fiber for tying the scion and stock were used. The scion wood was prepared by clipping off the leaves, leaving petiole stubs 0.5 cm long intact. Bud wood, 10 cm in length, 9 to 12 months old, rounded with white streaks, was detached from the scion trees and grafted on 18-month-old seedling at a point having a T-shaped cut at a height 10-15 cm from the ground level. All the agronomic and cultural practices were kept constant and carried out regularly with all (Rattanpal et al., 2017). There 8 periods (time) of forcing and three forcing treatment methods were employed in factorial arrangement in randomized complete block design and replicated three times. The three forcing methods were: complete cutting back/topping (CCB), Looping/partial cutting back  $\frac{1}{2}$  -  $\frac{2}{3}$  of the stem and bending and tying (B/T). Data were collected on percent scion survival. Later growth recorded included number of leaves, scion length and diameter at two-week interval. T<sub>1</sub>-T<sub>16</sub> is weekly collection of percent infestation of CLM was recorded (Mustafa et al., 2014).

**Statistical analysis:** The mean of three duplicates was used to express the results. SAS 9.3 was used to analyze the experimental data.

## RESULTS AND DISCUSSION

The forcing periods of five weeks, six weeks and no forcing influenced the percent bud survival over forcing immediately, seven weeks after budding (Table 1). Bending and tying method of forcing was superior in percent bud survival than the looping method of forcing. Five weeks of bending and tying produces highest (81.05 percent) bud survival than that of complete cut back and looping methods of forcing. There were interactions between forcing periods and method of forcing, especially for five five-week forcing periods, and the bending and tying method showed a significant effect on bud survival over other combinations (Table 1). Chahil et al. (2019) also observed a similar trend in citrus nursery. The scion length was significantly increased by delaying the time of forcing from fourteen weeks after budding; late forcing from four weeks after budding improves scion length (Table 2). The weeks forcing period was superior

**Table 1.** Effect of methods and time of forcing on percent (%) bud survival of kinnow nursery plants after seven weeks of budding

Time of forcing weeks	Method of forcing			Mean
	CCB	L	B/T	
No forcing	76.20	76.21	72.71	75.04
Forcing immediately	60.96	54.82	67.90	61.23
Two weeks	59.80	56.00	73.61	63.14
Three weeks	67.10	67.35	77.77	70.74
Four weeks	66.63	68.45	77.40	70.83
Five weeks	73.77	69.32	81.05	74.71
Six weeks	76.16	70.00	77.00	74.39
CV		17.20		17.95
CD (p=0.05)		6.89		11.52
Interaction forcing methods x time of forcing				
CV%		15.14		
CD (p=0.05)		10.38		

CCB = Complete cutting back, L = Looping, BT = Bending and tying

**Table 2.** Effect of time of forcing on scion length, diameter and number of leaves of Kinnow

Time of forcing weeks	Scion length			Scion diameter			Number of leaves		
	14	21	28	14	21	28	14	21	28
No forcing	21.87	27.21	33.56	0.29	0.30	0.41	10.21	16.45	21.45
Forcing immediately	18.23	23.59	30.14	0.27	0.27	0.29	11.45	17.82	20.18
Two weeks	22.47	27.92	35.83	0.29	0.37	0.43	10.45	22.65	28.31
Three weeks	24.21	29.42	40.23	0.29	0.41	0.54	10.76	26.94	36.72
Four weeks	29.22	37.72	44.12	0.28	0.45	0.55	12.84	25.15	35.25
Five weeks	33.58	39.25	46.14	0.28	0.46	0.63	13.94	26.31	38.73
Six weeks	30.94	36.72	42.15	0.29	0.45	0.56	11.84	24.54	34.83
CD (p=0.05)	5.85	8.04	3.18	NS	NS	0.21	NS	0.08	7.14

**Table 3.** Influence of different methods of forcing on the growth of Kinnow nursery plants

Time of forcing weeks	Scion length			Scion diameter			Number of leaves		
	14	21	28	14	21	28	14	21	28
Complete cutting back	20.46	26.49	36.18	0.23	0.36	0.50	14.14	18.32	22.71
Looping	22.16	28.83	37.43	0.25	0.42	0.55	14.05	17.58	20.42
Bending and tying	29.43	38.94	42.81	0.46	0.60	0.75	18.89	23.51	27.63
CD (p=0.05)	NS	7.12	3.08	0.18	0.12	0.11	2.58	4.78	2.83

**Table 4.** Effect of methods and time of forcing on scion length (cm) 28 weeks after budding in kinnow nursery plants

Time of forcing weeks	Method of forcing			Mean
	CCB	L	B/T	
No forcing	31.02	33.14	35.81	33.32
Forcing immediately	25.85	32.58	35.62	31.35
One week	32.87	34.56	38.92	35.45
Two weeks	30.45	34.86	40.85	35.39
Three weeks	37.73	35.14	47.49	40.12
Four weeks	45.10	38.52	48.43	44.02
Five weeks	48.15	43.82	47.56	46.51
Six weeks	38.19	44.63	46.48	43.10
CV		11.23		9.42
CD (p=0.05)		2.11		4.12
Interaction forcing methods x time of forcing				
CV%		1014		
CD (p=0.05)		4.96		

over the rest of the forcing periods. Scion diameter was influenced by time of forcing at twenty-eight weeks after budding; there were non-significant differences between no forcing, forcing immediately, one and two weeks forcing periods. Forcing time of five weeks enhanced scion diameter, twenty-eight weeks after budding than any of the above mentioned forcing periods. The number of leaves was also affected by delayed forcing periods, and the maximum number of leaves (38.73) was produced twenty eight weeks after budding (Table 2). Scion length, scion diameter, and number of leaves using the Bending and tying method of forcing were significantly superior to looping and topping /cutting back forcing methods (Table 3). Scion length was significantly higher after twenty-one weeks of different forcing methods and was maximum (38.94 cm) in the bending and tying method of forcing. Scion diameter and number of leaves recorded were significantly higher after fourteen weeks of various forcing methods. There were interactions among late forcing periods and the different methods of forcing after twenty-eight weeks of budding (Table 4). Five weeks and above had the highest bud survival

because the healing process was completed while forcing before five weeks would disturb the healing process, resulting in death of the scion, therefore reducing scion percent survival. Bending and tying method supporting higher percent bud survival might have been caused by accumulation of specific carbohydrates and high indoleacetic acid (IAA) Adam (2016). Bending and tying methods favoured more availability of metabolites and higher accumulation of growth hormones that enhance bud survival. Late forcing time that enhanced the development of scion growth might be due to forcing periods supporting the production of carbohydrates by the citrus rootstock to support citrus scion growth (Chen et al., 2015). However, no forcing method or period led to competition between the rootstock and the newly produced scion, leading to a reduction of the growth of the scion. The bending and tying forcing method has the highest kinnow scion growth among the other two methods. Bending and tying forcing methods suppress growth of the citrus rootstock sprout while also supporting photosynthesis through its undisturbed plant parts.

The significantly higher incidence of leaf miner was recorded in three (6.12 %), four (5.22) and five weeks (6.0) of bud forcing after 7 days of budding, as compared to other treatments (Table 5). However, the incidence of leaf miner was non-significant in all the treatments after 28 days of budding. Overall, there was less than 7 per cent incidence of

**Table 5.** Effect of time of forcing on incidence of citrus leaf miner on Kinnow

Time of forcing weeks	Mean incidence of citrus leaf miner (%)		
	14	21	28
No forcing	3.72	2.00	1.34
Forcing immediately	4.34	2.52	1.58
One week	3.92	3.36	1.60
Two weeks	4.16	3.54	1.72
Three weeks	5.36	4.36	1.66
Four weeks	4.80	4.24	1.82
Five weeks	5.12	4.96	1.64
Six weeks	3.96	4.56	1.28
CD (p=0.05)	0.36	0.42	NS

citrus leaf miner. Ahmed et al., (2018) observed that increases in the incidence of *P. citrella* are usually due to the greater availability of leaf flushes and new shoots. Similar results were recorded by Ahmad et al., (2021) in citrus nursery production.

### CONCLUSION

The forcing periods of four and above weeks improved the percent bud survival and scion growth of kinnow nursery plants. The superiority of a five-week forcing period on citrus scion development over early forcing periods made it the most preferred forcing period. The bending and tying forcing method also enhanced percent bud survival and scion growth more than cutting back and looping forcing methods. The vegetative growth and number of leaves affect the CLM population and can be used in future citrus IPM programs as a tool to suppress the CLM population.

### REFERENCES

- Adam SW 2016. *The effects of rootstock, scion, grafting method and plant growth regulators on flexural strength and hydraulic resistance of apple*. Ph.D. Dissertation. Utah State University, Logan.
- Ahmed H, El-Afify, Shreef RM, Ghanim NM and Hendawy MA 2018. Seasonal activity of the citrus leafminer, *Phyllocnistis citrella* Stainton in navel orange orchards during autumn season." *Journal of Agriculture and Veterinary Science* **11**(1): 16-21.
- Bhandari S, Basenet M and Khanal S 2021. Standardization of grafting time under the central mid hills of Nepal. *International Journal Fruit Science* **21**(1): 599-608.
- Bhusari RB and Jogdande ND 2012. Response of different environments and dates of shield budding on success and bud take in nagpur mandarin. *Asian Journal of Horticulture* **7**: 235-236.
- Carrol B 2017. *Propagation of fruit trees by budding*. Extension Manual. Oklahoma State University 1-5.
- Chahil TS, Singh H, Arora and Singh NP 2019. Producing healthy citrus seedlings. *Indian Horticulture*, **64**(1). <https://epubs.icar.org.in/index.php/IndHort/article/view/87809>.
- Chaudhary NA and Ishfaq M 2004. Citrus and climate. In: *Citrus fruit*. Ahmad S (Eds). The Horticultural Foundation of Pakistan, Islamabad 23-26.
- Kanwar J, Kumar R and Kaul MK 2015. Micropropagation studies of sweet orange (*Citrus sinensis* Osbeck) cv. Blood Red *Progressive Horticulture* **47**(1) DOI:10.5958/2249-5258.2015.00003.2.
- Kumar S, Choudhary VK Kanwat M and Sangeetha A 2016. Evaluation of different rootstocks on the performance of some mandarin cultivars under mid-hill conditions of Arunachal Pradesh. *Indian Journal of Horticulture* **73**(4): 489.
- Mustafa M, Imran M, Rasool A, Azeem M, Riaz A, and Afzal, M 2014. Evaluation of commercial citrus cultivars for resistance to citrus leaf miner and its management. *Journal of Entomology Zoological Studies* **2**: 213-216.
- Nawaz R, Abbasi NA, Hafiz IA, Khan M.F and Khalid A 2021. Environmental variables influence the developmental stages of the citrus leaf miner, infestation level and mined leaves physiological response of Kinnow mandarin. *Science Report* **11**: 7720.
- Neto HB, Silva SR, Fiho FA and Caputo MM 2016. *The Citrus Nursery Production Practice*. Vivecitrus Organização Paulista de Viveiros de Mudanças Cítricas. Brazil, ISBN: 978-85-67321 p. 69.
- Rattanpal HS, Singh G, Singh S and Arora A 2017. *Citrus cultivation in Punjab*. Additional Directorate of Communication for Punjab Agricultural University Ludhiana (1st Eds) Punjab. 35-37.
- Salik MR, Khan MN, Ahmad S, Muhammad BA and Ahmad M 2015. Grafting time affects scion growth in sweet orange under arid environment. *Pakistan Journal of Life Society Science* **13**: 58-61.
- Singh J 2018. *Basic Horticulture* Kalyani Publisher (5<sup>th</sup> Edn). p 180
- Thakur A, Dhaliwal H and Kashyap P 2019. Protected citrus nursery production is a profitable enterprise. *Indian Horticulture* **62**(5). <https://epubs.icar.org.in/index.php/IndHort/article/view/87650>