RESEARCH ARTICLE

STANDARDIZATION OF GRAFTING TIME OF KINNOW MANDARIN UNDER NORTH WESTERN ZONE OF HARYANA

R.P.S. Dalal*, Arvind Malik and Sonu Sheoran

Department of Horticulture, CCS HAU, Hisar (Hry).125004
Email: dalal08@rediffmail.com

Received-04.03.2022, Revised-15.03.2022, Accepted-29.03.2022

Abstract: An investigation was carried out to standardize the suitable grafting time for Kinnow over rough lemon rootstocks during the years 2019, 2020 and 2021. The treatments consisting of four grafting date viz. 8th January, 22nd January, 6th February and 21st February. Scion collected from mother plants of Kinnow mandarin were grafted by wedge grafting method in open field nursery. The results showed that grafting dates significantly affected the days taken for sprouting, number of buds sprouted/ graft, sprouting, survival and final graft success. The highest graft success 71-76% was observed when wedge grafting was performed on 6th February followed by 49-62% on 21st February with considerable growth of saplings. However, leaf relative water contents and chlorophyll contents were found non-significant for time of wedge grafting. Therefore, the study revealed that 1st fortnight of February is the most suitable time of wedge grafting in Kinnow over rough lemon rootstocks under north western agro climatic zone of Haryana (India)

Keywords: Kinnow, Rough lemon, Wedge grafting, Graft success, Growth, RWC, Chlorophyll

INTRODUCTION

Citrus is the most important fruit crop grown globally in more than 140 countries covering tropical and sub tropical region of the world. Among fruit crops, citrus having third position in area in India and having potential to bring economic change to the country due to unique diversified geographical and agro-climatic conditions. Among the citrus fruits, Kinnow mandarin is gaining popularity in the north western zone of India and it occupies about 40% of the total area under fruit crops in Haryana state. Propagation is an important aspect of commercialization of fruit crops. The demand for good quality true to type Kinnow saplings is rising annually. Citrus can be propagated by seed, cuttings, layering, grafting and budding. Among various vegetative methods used to propagate Kinnow mandarin, budding is the most common method practiced in Indian citriculture industry. T-budding is generally practices from July to October in the north western zone of India. Success rate in T-budding in open field is very poor. However, bud take is about 80% but success rate is very poor (15%) in the current season (August- November) and 20% in successive spring season (March-April) and further 20% in rainy season (July-September). Moreover, the buds which sprout late results in to saplings of very poor quality and also grow very slowly with poor field establishment. Hence, a lot of resources are required to maintain these saplings in the nursery like removal of sprouts, control of insect pest and diseases and weeds etc. The main objective of nursery entrepreneur is to multiply maximum number of plants in a possible shortest period for maximise profit. So, it becomes Imperative to shift from budding to other method of propagation to meet the increasing demand of Kinnow plants in shortest possible time with minimum input cost for maximum profit.

Mandarin also shows polyembryony in nature. But plants are susceptible to different diseases like gummosis, root rot and canker etc. when grown on its own root system. For these reasons different rootstocks are used in modern citrus cultivation. In India, Kinnow mandarin is being cultivated commercially on rough lemon rootstock. Grafting is a propagation technique which is used in propagation of many fruits trees to achieve maximum success and dwarfism in trees depending on rootstock type (Simons, 1987). The success and growth of sapling is affected by the dates and methods of graftings. There are many factors that influenced grafting such as skilled grafter, temperature, relative humidity, moisture, plant water status, growth stage of scion and rootstock, method and time of grafting (Mang' omba *et al.* 2010 and Pina and Errea, 2005). Therefore, one of the most important conditions for successful outdoor grafting is selection of the correct season of grafting which is conducive for rapid graft healing process subsequently formation of graft union. Hence, method and time of grafting that gives high percentage of success will be different in different region, where one can increase the rate of success percent by providing favourable conditions (Vishnuvardhan, 2002). Few studies conducted in mid hills of Nepal revealed that winter season is suitable for grafting in mandarin. Poon (1999) Gautam *et al.* (2001) and Chalise *et al.* (2013) reported that November to January is the suitable time of grafting for mandarin in different parts of Nepal.

However, some of the nurserymen in the area are performing grafting haphazardly in citrus without considering suitable season and time which results in a lower graft success. Therefore, in the present study

*Corresponding Author

an attempt was made to standardize suitable time of grafting for Kinnow mandarin on rough lemon rootstock for the north-western zone of Haryana.

MATERIALS AND METHODS

Study location: The present investigation was carried out at fruit plant nursery of Haryana Agricultural University, Hisar situated at 215.2 m amsl with coordinates of 29º 10´ N latitude and 75º 46´ E longitudes. Hisar has a typical semi-arid climate with hot and dry summer and extremely cold winter. The mean monthly maximum and minimum temperature show a wide range of fluctuations both in summer and winter. The maximum temperature goes to 45ºC during summer. In winters temperature is as low as 4°C and sometimes frost occurs in the region. The total rainfall as well as its distribution in the region is subjected to large variations. About 80% the annual rainfall (about 450 mm) is received during rainy months. The rainfall is highly erratic with 20-30% annual and 30-50% seasonal variations.

Table 1. Mean fortnightly temperature and relative humidity of the experimental site.

Dates	Temperature (^{0}C)			Relative Humidity (%)		
	2019	2020	2021	2019	2020	2021
8th Jan.-21st Jan.	12.6	10.4	10.8	74.5	85.5	85.7
22nd Jan. – 5th Feb.	11.3	11.8	10.3	80.7	78.0	73.7
6th Feb. – 20th Feb.	14.4	13.1	15.4	77.2	67.2	75.7
21st Feb. – 6th March	15.0	18.1	18.9	71.2	75.0	67.0
7th March – 20th March	16.6	17.2	22.3	66.2	75.7	65.7
21st March – 4th April	21.6	21.6	23.4	57.7	72.2	56.5

Raising of rootstocks: Seeds of rough lemon extracted from single plant were sown in the nursery in the month of August. The rootstock seedlings were allowed to grow for 1.5 months until the seedlings becomes pencil thickness (7-8mm) thick at the height of above 25cm. weeding, irrigation, fertilization and insect pest control were done regularly for the entire period.

Selection and preparation of scion: About 10-12 months old scion shoots, 15cm. in length, rounded with white streaks having 6-9 active buds from 10 years old bearing mature Kinnow plants were detached having 6-7 mm diameters.

Grafting techniques: The prepared scions were grafted on to rough lemon by wedge grafting at 25 cm height from the collar region. The rootstock was headed back at 25 cm height and a vertical cut of 2-3 cm was made from the centre extending downward from the top of the rootstock. Similarly scion was prepared by making a slanting cut on both side of scion (wedge shape) on lower side with a sharp knife. The prepared scion was inserted gently in the vertical cut of rootstock so as to fit their cambium layer properly. The joint surface was tightly tied with grafting tape covering some portion of the above and below part of the union. The scion wood along with grafting portion was covered with polythene cap to avoid desiccation of scion shoots. Sprouts arising from the stock below the graft union were removed continuously since time of grafting. All the agronomical and cultural practices were kept constant and carried out regularly with all treatments.

Layout and design: The experiment was laid out in CRD with four treatments and five replications, comprising grafting of Kinnow over rough lemon rootstock on dates (8th January, 22nd January, 6th February, 21st February). There were fifteen grafts per replication.

Data collection: Standard procedure was used for data collection. The days taken for sprouting were calculated by taking the days between grafting date and date of first visible sprout on scion shoots. Total buds sprouted on each scion shoot was counted for each replication and treatments and expressed in number of buds sprouted/ graft. The number of scions shoot sprouts out of total graft made were counted and expressed in percentage for each replication. Mortality of some sprouted graft observed during study and survival percentage was calculated by using the formula in relation to total number of sprouted graft

Survival (%) = [(Number of survived graft / total number of sprouted graft)] X 100.

Out of these sprouted graft, the survived scion were counted and expressed in percentage on the basis of total sprouted shoots. Similarly, the final graft success percentage was calculated by the formula in relation of total no. of grafts.

Graft success (%) = [(No. of survived graft / Total number of grafts made)] X100

Growth parameters: The data regarding growth parameters i.e. sapling height and increment in rootstock and scion diameters were recorded in the 1st week of July every year. The data were taken from randomly selected five representative saplings for each replication. The sapling length was measured from collar region of the rootstock to maximum height with the help of meter scale and averaged. Rootstock and scion diameter were measured 3cm. below and above the grafting point at the time of grafting and 1st week of July with the help of vernier caliper and difference was noted down in respect of their initial diameter and expressed as

increase in rootstock and scion diameter, respectively during the year under study.

Physiological parameters: Relative water content and leaf chlorophyll contents were measured in the 1st week of July. The leaf relative water contents were measured with the following formulae: RWC = [(FW – DW) / (TW-DW)] X 100

FW, DW and TW denote fresh, dry and turgid weight, respectively. Chlorophyll contents was measured with the help of Chlorophyll meter and expressed as SPAD value.

RESULTS AND DISCUSSION

Time of wedge grafting in Kinnow significantly influenced the various graft success parameters i.e. days taken for sprouting, number of bud sprouted per graft, sprouting percentage, survival percentage and final graft success percentage (Table 1 & 2). Days taken for sprouting decreased gradually with the increase in calendar days during all three years under study. Minimum number of days taken for sprouting 27, 29 and 30 were noticed when grafting was performed late on 21st February, whereas, maximum days 48.33, 49.0 and 42% were recorded in early grafting (8th January) during 2019, 2020, 2021, respectively. Less number of days was taken in all most all the treatments during the year 2021. Number of buds sprouted per graft influenced significantly during 2019 & 2020 where it was non significant during 2021. Maximum number of buds sprouted/ graft (6.16, 6.26 and 5.44) was observed when grafting was done on 6th February and it was at par with treatment 22nd January. Lowest number of bud sprout/ graft was recorded in early (8th January) and late (21st February) grafted saplings. There was a continuous decrease in days taken for sprouting with the delay in calendar dates of grafting. Maximum days taken for sprouting in early grafting sapling may be due to low temperature which is not conducive for graft union formation, whereas, with onward grafting dates there was gradual rise in temperature in February onwards which is becoming suitable for cambial cell activity and results in to decrease in time of graft union formation and ultimately late grafting sapling (21st February) took minimum time for sprouting. Similarly a very low concentration of GA within the scion taken in severe winter may be one of reason for less sprouting on 8th January graft saplings, as GA determines the breaking of dormancy of bud. These findings are in accordance with Gautam *et al*. (2001), Chalise *et al*. (2013) and Bhandhari *et al*. (2021) in citrus. Whereas, in late grafting saplings (21st February) lower bud sprouting may be due to desiccation of upper buds due to slightly more temperature in the second fortnight of March.

Table 1. Effect of time of wedge grafting in Kinnow mandarin over rough lemon on days taken for sprouting and number of buds sprouted per graft.

Grafting time	Days taken for sprouting			Number of buds sprouted/ graft		
	2019	2020	2021	2019	2020	2021
D1: 8th January	48.33	48.80	42.00	4.83	4.50	4.35
D2: 22nd January	39.00	43.80	39.00	6.14	6.30	5.32
D3: 6th February	31.67	37.60	33.00	6.16	6.26	5.44
D4: 21st February	27.00	29.20	30.00	4.54	4.36	4.86
CV (%)	2.27	5.39	4.18	6.78	12.65	13.15
CD (p=0.05)	2.38	2.99	3.68	0.54	1.54	NS

Sprouting percentage varies between 36 to 84% among various treatments irrespective of years (Table-3). During 2019, maximum sprouting (83.60%) was recorded in treatment D_1, which was at par with D_4 (77.60%). But in the successive years 2020 & 2021, the maximum sprouting (76.00 & 72.43%) was observed in treatments D_3, respectively. The minimum values were observed in treatment D_2 (53.60 & 36.00%) during 2019 & 2020, respectively, whereas, in treatment D_1 (42.04%) during 2021. More consistent results were obtained when grafting was conducted during first fortnight of February (6th February). The high temperature and relative humidity are very congenial for union of stock and scion in grafting. The congenial conditions prevailing during grafting will influence the various growth parameters including days required for sprouting, number of leaves per graft, number of sprouts, scion stock diameter, scion length and mortality etc. which are direct indication of a successful graft. All these factors favour the graft success when grafting was done on 25th January (D_2) and 6th February (D_3) grafted saplings compared to early grafting D_1(8th January) and late grafting D_4(21st February). Gautam *et al*. (2001) has reported higher success (87.50%) when grafting was done at 31st January as compared to the grafting (85.00%) which was carried out during 16th January at, Lumle, Kaski, Nepal.

Table 2. Effect of time of wedge grafting on graft success in Kinnow mandarin over rough lemon rootstock.

Grafting time	Sprouting (%)*			Survival (%)*			Graft success (%)*		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
D1: 8th January	83.60 (66.58)	62.00 (52.00)	42.04 (40.39)	96.12 (78.78)	90.95 (76.28)	84.60 (67.07)	84.20 (67.32)	56.00 (48.44)	35.59 (36.58)
D2: 22nd January	53.60 (47.08)	36.00 (36.81)	57.41 (49.27)	100.00 (89.39)	78.33 (64.93)	90.46 (72.35)	53.60 (47.08)	28.00 (31.87)	52.01 (46.14)
D3: 6th February	66.00 (54.44)	76.00 (61.17)	72.43 (58.52)	100.00 (89.39)	100.00 (90.00)	98.93 (84.72)	66.00 (54.44)	76.00 (61.17)	71.62 (57.88)
D4: 21st February	77.60 (62.11)	66.00 (54.48)	56.28 (48.60)	92.20 (73.85)	94.64 (81.41)	86.41 (68.63)	62.50 (58.00)	62.00 (51.95)	48.81 (44.29)
CV (%)	11.76	11.91	5.69	1.24	14.09	5.88	11.32	9.58	6.97
CD (p=0.05)	7.72	8.48	3.88	2.10	15.35	5.99	7.22	6.64	4.49

*Values in parenthesis are angular transformed values.

Maximum survival percentage 100, 100 & 98.93% was recorded in treatment D_3 (7th February) during the year 2019, 2020 & 2021, respectively, whereas, minimum survival 92.20, 78.33 & 84.60% was noticed in treatment D_4, D_2 &D_1 during the year 2019, 2020, 2021, respectively. Maximum final graft success 84.20%, 76.00 & 71.62% was recorded in treatment D_1, D_3 & D_3 during the 2019, 2020 and 2021, respectively. However, minimum graft success 53.60, 28.00 &35.00% was noticed in treatments D_2, D_2 and D_1 during 2019, 2020 & 2021, respectively. Lower survival/ higher mortality in early and late grafting sapling may occur due to the transpiration losses from tender leaves due to lack of cuticle layer and high number of stomata on young leaves. Similarly high temperature is also another factor which causes the mortality in young emerging leaves. Similar results were earlier reported by Hussain *et al*. (2017) in citrus.

Sapling height influenced significantly during 2019 and non significantly during 2020 & 2021 (Table 3). However, the maximum sapling height 50.82, 53.36 & 49.22% was recorded in treatments D_4, D_3 &D_1 during 2019 2020 & 2021, respectively. Maximum sapling height (52.82 cm) was recorded during 2019 which was significantly more over D_2 and at par with D_3 & D_1. Numerically maximum height 53.36 & 49.22cm were recorded in D_3 & D_1 during 2020 & 2021, respectively. This might be due to favorable environmental conditions from the time of graft union formation up to growth phase in all the grafting time either early or late grafted saplings. It has been previously reported that temperature plays a significant role with respect to vegetative growth in different horticultural crops such as in sweet orange and Salik *et al*. 2015) in pummel. Increase in rootstock and scion diameter could not be influenced significantly in all the three years under study. Minimum increase in rootstock and scion diameters was recorded in treatment D_1 and maximum in D_3 during all the three years under study. The highest increase in rootstock and scion diameter in 22nd January and 6th February grafted sampling might be due to sprouting of more number of buds/ graft resulted in to higher leaf area and production of more photosynthates and their subsequent translocation to different parts of plants as compared to early (8th January) and late (21st February) grafted saplings.

Table 3. Effect of time of wedge grafting on graft growth in Kinnow mandarin over rough lemon rootstock

Grafting time	Sapling height (cm)			Increase in rootstock dia. (mm)			Increase in scion dia. (mm)		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
D1: 8th January	50.40	52.34	49.22	0.32	0.36	0.38	0.27	0.26	0.31
D2: 22nd January	45.50	47.62	48.53	0.44	0.47	0.43	0.38	0.37	0.38
D3: 6th February	49.87	53.36	43.26	0.46	0.49	0.43	0.38	0.42	0.39
D4: 21st February	50.82	53.22	42.87	0.38	0.41	0.39	0.30	0.30	0.33
CV (%)	4.27	15.17	14.56	1.24	2.25	2.85	1.20	1.97	2.11
CD (p=0.05)	3.57	NA	NS	NS	NA	NS	NS	NA	NS

Table 4. Effect of time of wedge grafting on physiological parameters in Kinnow mandarin over rough lemon rootstock

Grafting time	Leaf Relative Water content (%)			Chlorophyll content Index (SPAD)		
	2019	2020	2021	2019	2020	2021
D1: 8th January	95.56	95.26	95.18	31.60	35.84	32.44
D2: 22nd January	95.14	95.00	94.96	34.10	36.18	34.19
D3: 6th February	95.72	95.68	95.15	32.74	32.66	33.78
D4: 21st February	94.50	94.25	94.65	26.59	31.52	30.74
CV (%)	1.40	1.48	1.34	11.92	3.18	3.64
CD (p=0.05)	NS	NA	NS	4.03	NA	NS

Chlorophyll contents influenced significantly during 2019 and non significantly in the successive years. Chlorophyll content was recorded maximum (34.10 SPAD) in treatment D_2 during the year 2019 which was at par with D_3 & D_1. Minimum values 26.59 SPAD was recorded in treatments D_4. Similar trend was observed in the succeeding years 2020 & 2021. Relative water content (RWC) could not be affected significantly with various dates of grafting. However, numerically maximum values were observed in treatment D_3 during all the years. Sapling height and RWC and Chlorophyll contents of leaves could not be affected significantly among the grafted date during the year under study. This shows that successful graft results in to better organogenesis of conducting tissues irrespective of grafting time. It is further evident from the present investigation that sapling growth is almost similar in all the treatments which experiences better environmental conditions during sprouting to growth phase.

Overall, it may be concluded that 1st fortnight of February is the best time of wedge grafting of Kinnow over rough lemon rootstock under north western zone of Haryana. However, the sapling quality in respect of growth, RWC and chlorophyll contents was not affected significantly when grafted was conducted during January- February.

REFERENCES

Bhandari, N., Basnet, M. and Khanal, S. (2021). Standardization of grafting time of mandarin (Citrus reticulata Blanco) in central mid hill of Nepal. International Journal of Fruit Science, 21 (1): 599-608.

Google Scholar

Chalise, B., Baral, D.R., Gautam, D.M. and Thapa, R.B. (2013). Effect of grafting dates and methods on success and growth of mandarin (Citrus reticulate Blanco) Sapling. Nepal J. Sci. Technol. 14 (1): 23-30.

Google Scholar

Gautam, I.P., Sah, D.N. and Khatri, B. (2001). Effect of time of grafting and budding on trifoliate rootstocks for appropriate mandarin orange sapling production. Lumle Working Paper No. 2001/20. Lumle Agricultural Research Station, Lumle, Kaski, Nepal.

Google Scholar

Hussain, Z., Khadima F., Aziz A., Khan M.N., Salik M.R. and Anwar, R. (2017). Evaluation of different grafting methods to citrus cultivars. Citrus Research & Technology. 38 (2):198-203.

Google Scholar

Mng'omba, S.A., Akinnifesi, F.K., Sileshi, G. and Ajayi, O.C. (2010). Rootstock growth and development for increased graft success of mango (*Mangifera indica* L.) in the nursery. African Journal of Biotechnology 9: 1317-1324.

Google Scholar

Pina, A. and Errea, P. (2005). A review of new advances in mechanism of graft compatible – incompatible Prunus spp. Scientia Horticulturae 106: 1-11.

Google Scholar

Poon, T.B. (1999). Effect of grafting methods and time on mandarin sapling production at Dailekh, p. 65-68. Proceed. of the Second Nat. Hortic. Res. Workshop, Khumaltar, Lalitpur, 13-15 May, 1998.

Google Scholar

Salik, M.R., Khan, M.N., Bashir, M.Z. and Ahmad, M. (2015). Grafting time affects scion in sweet orange under arid environment. Pakistan Journal of life Society of Science,13(1): 58-61.

Google Scholar

Simons, R.K. (1987). Compatibility and stock scion interactions as related to dwarfing. In: Rom RC & RF Carlson (Eds). Rootstocks for fruit crops. New York: Wiley & Son Inc, p.79-106.

Google Scholar

Vishnuvardhan, L. (2002). Softwood and epicotyls grafting studies in cashew nut under different propagation structures. Ph.D. thesis submitted to University of Agricultural Sciences, Bangalore.

Google Scholar