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Evaluation of Bare Rooted Transplanting Methods of Kinnow Mandarin for Enhanced Field Establishment

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ABSTRACT

An experiment was carried out at the Department of Horticulture, Agricultural Research Station, Sriganganagar under the S. K. Rajasthan Agricultural University, Bikaner, Rajasthan, India during July to October and February to April months of 2014–15 and 2015–16. The objective of the study was to evaluate the feasibility of the bare root transplanting method with the optimum time to establish Kinnow mandarin seedlings. The findings of the study revealed that bare rooted Kinnow mandarin seedlings can be successfully transplanted in the month of August to October during the monsoon period and February to March during the spring months with 94–96% transplanting success. Transplanting at 48 hours after packaging was reported 91% establishment success whereas, it was 87% at 72 hours after the bare rooted packaging. However, the highest transplanting success (100%) was noted with polythene bag plants (intact soil) followed by bare rooted buddlings treated with IBA 200ppm plus Carbendazim 0.1% plus Defoliation which was recorded as 97% success. In the control treatment, it was recorded minimum with 76 percent transplanting success.

KEYWORDS: Bare root, IBA, Kinnow mandarin, transplanting success

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1. INTRODUCTION

Citrus is one of the most popular fruit crops due to its refreshing flavour, nutritional values and relished fruit. It contains a decent quantity of vitamin A, vitamin C, amino acids and flavonoids along with few bioactive compounds having superb pharmaceutical activity (Singh et al., 2016). It's being grown in subtropical and tropical areas in 140 countries around the world between approximately 40°N and 40°S latitudes. (Chen et al., 2019; Cuenca et al., 2018). The northern hemisphere is leading the world's citrus production, followed by the southern hemisphere and Mediterranean region. Citrus is a group of fruits which mainly includes oranges 55%, mandarins 25%, lemons/ limes 13% and grapefruits 7% percent with of the world production (Anonymous, 2017). Approximately two thirds of the whole production is destined mainly for fresh eating and the remaining third to juice making and the industrial processes (Zema et al., 2018). Among the citrus fruits, the mandarin occupies a prominent position, it accounts for over 50% of the total area (Prasad et al., 2015). Kinnow mandarin is a higher yield potential hybrid that was developed by crossing 'King' (*Citrus nobilis*) and Willow Leaf (*C. deliciosa*) mandarins by Dr. H.B. Frost at California, the USA in 1935 (Sharma et al., 2016). Kinnow mandarin has become the most popular amid citrus growers and revolutionized citrus industry in India during the past 3 decades. It has precocious bearing, higher yield potential with excellent quality of fruits than others citrus crops. It is grown extensively in the Punjab, Rajasthan, Haryana and Himachal Pradesh in India (Ilame and Singh, 2018; Kumar, 2015).

The recommended time of transplanting of Kinnow mandarin plants is during monsoon (July to September) and during spring months (February to March). At the time of transplanting, the demands of disease free quality planting materials have been tremendously enhancing day by day due to the rapidly increasing areas under Kinnow mandarin cultivation. Although, the availability of quality planting materials at a specific time of transplanting of seedlings has created a bottleneck to expansion of area under Kinnow mandarin cultivation. In most of the nurseries, planting materials have been available with soil (Earth ball), which required more bulk transportation. However, the transportation of these quality planting materials with soil in polythene bags from nursery to the site of planting is highly expensive, cumbersome practice and may also carry soil borne pathogens (Bajwa et al., 1997). Diseases like *Phytophthora* stem rot is also carried by the soil, which is the one of the major causes of the mortality of newly planted plants and cause enormous losses in nurseries as well in orchards (Dwiastuti, 2020). Supply of diseased planting materials is the one of the main reasons to expand the *Phytophthora* diseases from infested nurseries to virgin areas (Siddiqui et al., 2019). Recent advances within the cultural practices used for the production of fundamental citrus propagation materials and nursery progenies had been additionally crucial to assure the competitiveness and efficiency of orchard (Carvalho et al., 2019). Bare rooted plants owing to the absence of bulk soil around the roots having reasonable low shipping costs, convenient to carry and handling also reduce drudgery to the farmers. Therefore, the practice is convenient to carry, easy to handle and free from soil borne pathogens (Anella et al., 2008; Goyette et al., 2014). Nonetheless, the season or time of transplanting is extremely affected the survival rate of bare-root seedling in the field (Repac et al., 2011; Klavina et al., 2013). It further allows the recycling of topsoil and the use of polyethylene bags over and over again. Scanty literature is available regarding bare rooted transplanting method of citrus. Hence, to address this concern, the present study was conducted to evaluate the feasibility of bare rooted method of transplanting to establish Kinnow mandarin seedlings and to find the optimal time for this practice.

2. MATERIALS AND METHODS

An experiment was carried out at the Department of Horticulture, Agricultural Research Station (SK Rajasthan Agricultural University, Bikaner), Sriganganagar, Rajasthan, India during July to October and February to April months of 2014–15 and 2015–16. It is a canal irrigated area located between 28.40° to 30.60° North latitude and 72.30° to 75.30° East longitude under North-Western Plain Zone (1b) of Rajasthan. Uniform sized and vigour Kinnow mandarin seedlings, budded on Rough lemon (*Citrus jambhiri* Lush.) rootstock were used.The bare rooted (without soil) seedlings were treated with different hormones and chemicals viz. T_1. Control (No hormonal treatment - roots soaked in water), T_2. IBA (200 ppm)+Carbendazim(0.1%), T_3. IBA (200 ppm)+Carbendazi m(0.1%)+Defoliation and T_4. Polythene packed plants (with soil) without hormonal and fungicide treatment (Figure 1). Each treatment was replicated thrice. Immediately after hormonal treatments, bare rooted seedlings wrapped with moist sphagnum moss grass. Transplanting was carried out at monthly intervals during July to October and February to April months after 48 and 72 hours of hormonal treatments. Transplanting success was also assessed at 48 and 72 hours after bare rooted practice. The survival percentage and growth parameters such as plant height (cm), plant girth (mm) and plant spread (cm) were recorded using standard procedures (Santana et al., 2018). The pooled data of experiments were statistically analyzed by analysis of variances (ANOVA).

3. RESULTS AND DISCUSSION

Results indicated in table 1 showed that among the hormonal treatments, cent percent transplanting success was observed with polythene packed buddlings followed by bare rooted buddlings treated with IBA 200 ppm plus carbendazim 0.1% plus defoliation which was recorded 97% success and IBA 200 ppm plus carbendazim 0.1% without defoliation treatment with 95% success. In the control treatment, it was recorded minimum with 76 per cent transplanting success. The success rate per cent in the established plants after 60 days of transplanting was also recorded significantly highest with IBA 200 ppm plus carbendazim 0.1% plus defoliation (96%) followed by IBA 200 ppm plus carbendazim 0.1 percent without defoliation (93%). Plant growth characters in terms of plant height (76.64 cm), girth (12.20 mm) and spread (22.81 cm) after 60 days of transplanting were recorded significantly higher with treatment IBA 200 ppm plus carbendazim 0.1 per cent without defoliation followed by IBA 200 ppm plus carbendazim 0.1% plus defoliation and lowest plant growth characters were recorded in the control. Although the time of transplanting had a significant influence on the growth of Kinnow mandarinin the month wise transplanting success rate, the highest (96%) success was recorded in both February and October months followed by September (95%). In the month of March and August, it was slightly lower whereas the lowest success was recorded in the month of July (79%). The per cent success rate of plant establishment after 60 days of transplanting was recorded in the month of February (94%) and October (94%) followed by September (93%). The maximum plant height (70.22 cm), plant girth (11.51 mm) and plant spread (21.25 cm) was recorded in the buddlings, planted in the month of February followed by the month of April and October. Whereas sudden increasing in the temperature and reducing atmospheric humidity, combined with environmental stresses after February, thus late transplanted plants don't get enough time to establish and thereby make lesser plant survival rate with little growth in the transplanted Kinnow plants.

Table 1: Effect of hormonal treatment, month and time on transplanting success, survival percentage and growth characteristics of bare rooted Kinnow plants

Variance	Trans-planting success (%)	Survival percentage at 60 DAP	Plant height (cm) at 60 DAP	Plant girth (mm) at 60 DAP	Plant spread (cm) at 60 DAP
H_1	76.00	72.00	47.77	07.73	14.83
H_2	95.00	93.00	76.64	12.20	22.81
H_3	97.00	96.00	69.89	10.85	19.17
H_4	100.00	96.00	67.16	09.95	16.50
SEm±	0.80	0.34	1.03	0.06	0.12
CD (p=0.05)	1.96	0.83	2.53	0.17	0.30
M_1	79.00	77.00	58.61	09.17	15.25
M_2	94.00	92.00	68.26	09.90	17.86
M_3	95.00	93.00	68.97	10.36	18.91
M_4	96.00	94.00	69.63	10.83	19.41
M_5	96.00	94.00	70.22	11.20	21.25
M_6	94.00	91.00	69.71	11.51	21.01
M_7	89.00	85.00	52.15	08.31	14.61
SEm±	0.87	0.81	0.82	0.18	0.17
CD (p=0.05)	1.77	1.64	1.66	0.37	0.36
T_1	94.00	91.00	66.07	10.45	18.82
T_2	90.00	87.00	64.66	09.92	17.83
SEm±	0.32	0.37	0.44	0.07	0.06
CD (p=0.05)	0.64	0.74	0.89	0.15	0.13

Where: H_1: Control (No hormonal treatment roots soaked in water); H_2: IBA 200 ppm+Carbendazim 0.1%; H_3: IBA 200 ppm+Carbendazim 0.1%+Defoliation; H_4: Untreated polythene packed plants; M_1: July, M_2: August; M_3: September, M_4: October, M_5: February; M_6: March, M_7: April; T_1: Transplanting after 48 h; T_2: Transplanting after 72 h; DAP: Days after transplanting

The data presented in table 1 showed that buddlings, transplanted after 48 hours having the highest success of survival i.e. 94 per cent as well as 60 days after transplanting (91%). The buddlings transplanted after 72 hours was recorded a lower success rate as compared to 48 hours.

The data on root length, root spread, root fresh weight, root dry weight, shoot fresh weight and shoot dry weight at 60 days after transplanting was also recorded (Table 2, Figure 1). The significantly maximum root length (46.10 cm), root spread (8.00 cm), root fresh weight (25.67 g), root dry weight (13.69 g), shoot fresh weight (84.07 g) and shoot dry weight (37.33 g) was recorded in buddlings treated with IBA 200 ppm plus carbendazim 0.1% and without defoliation treatment followed by buddlings treated with IBA 200 ppm plus carbendazim 0.1 per cent with defoliation. These parameters were recorded lowest in the untreated buddlings. The month wise root and shoot data shown in table 2 found that the buddlings transplanted in the month of February and March having maximum root length, root spread, root fresh weight, root dry weight, shoot fresh weight and shoot dry weight. The month of July and April was found less effective for root and shoot

Table 2: Effect of hormonal treatment, month and time on shoot and root growth characteristics of bare rooted Kinnow plants (pooled data for years 2014-15 and 2015-16)

Variance	Shoot fresh weight (g) 60 DAP	Shoot dry weight (g) 60 DAP	Root length (cm) at 60 DAP	Root spread (cm) at 60 DAP	Root fresh weight (g) 60 DAP	Root dry weight (g) 60 DAP
H_1	38.21	12.82	18.70	3.41	10.28	5.05
H_2	84.07	37.33	46.10	8.00	25.67	13.69
H_3	78.55	34.22	37.53	7.08	23.13	11.14
H_4	44.69	16.77	25.31	5.65	11.39	6.28
SEm±	2.03	1.17	0.69	0.10	0.22	0.14
CD (p=0.05)	4.97	2.88	1.70	0.25	0.55	0.34
M_1	40.83	15.27	27.61	4.68	14.14	7.08
M_2	65.24	27.55	32.42	6.01	17.89	9.57
M_3	66.98	28.57	33.40	6.27	18.99	9.32
M_4	71.29	29.05	33.22	6.66	19.63	10.23
M_5	72.05	30.41	35.41	7.15	19.37	10.21
M_6	72.61	30.17	35.83	6.98	19.67	9.91
M_7	42.65	16.52	25.47	4.50	13.64	6.97
SEm±	1.17	0.90	0.86	0.16	0.30	0.33
CD (p=0.05)	2.38	1.84	1.85	0.34	0.62	0.68
T_1	62.92	26.17	32.46	6.32	18.22	9.58
T_2	59.84	24.40	31.36	5.75	17.02	8.50
SEm±	0.23	0.13	0.36	0.07	0.06	0.08
CD (p=0.05)	0.47	0.27	0.73	0.15	0.12	0.17

Where: H_1: Control (No hormonal treatment roots soaked in water), H_2: IBA 200 ppm+Carbendazim 0.1%, H_3: IBA 200 ppm+Carbendazim 0.1%+Defoliation, H_4: Untreated polythene packed plants; M_1: July, M_2: August, M_3: September, M_4: October, M_5: February, M_6: March, M_7: April; T_1: Transplanting after 48 h and T_2: Transplanting after 72 h, DAP: Days after transplanting

growth. The buddlings transplanted after 48 hours recorded maximum root length (32.46 cm), root spread (6.32 cm), root fresh weight (18.22 g), root dry weight (9.58 g), shoot fresh weight (62.92 g) and shoot dry weight (26.17 g) as compared to buddlings transplanted after 72 hours. Root growth is very sensitive to plant moisture stress. The severity and duration of transplanting shock depend on the interactions of seedling performance potential and site environment. If transplanting shock is protracted, reserved carbohydrates may be exhausted before replenishment from photosynthesis, and the seedlings will starve to death. These findings were more or less supported with the findings observed by Marler and Davies (1988) in 'Hamlin' orange; Sandhu and Uppal (1987); Bajwa et al. (1997) in Kinnow mandarin; Sandhu and Dhillon (1994) in Kagzi lime and Baramasi lemon, Ndubuaku (2005) in Cocoa and Sourav and Saralch (2019) in *Populus deltoids* under nursery conditions.

The various bare rooted methods are convenient and helpful to the farmers who can not afford polythene packed plants (with earth wall) method for transplanting to get acceptable success at lower cost without any soil borne pathogens. The root system architecture plays a crucial fundamental role in the establishment of a plant species through supplying water, nutrients and anchoring the plant into the soil (Khan et al., 2012). Adventitious roots induction and development is a complicated procedure and regulated by various factors such as temperature, light intensity, soil moisture, nutritional status, phytohormones and plant genetic characteristic, etc. (Da Costa et al., 2013). Although, phytohormones particularly auxin (IBA, IAA and NAA) play a vital role to regulate root initiation and development, hence helpful in improving the rate of seedling survival (Testolin and Vitaglian, 1987). This vital role of IBA was also evident from the present study where the application of IBA positively enhanced the number of adventitious roots as

Figure 1: Effect of hormonal treatment on barerooted transplanting method of Kinnow mandarin; A: Uprooted seedlings from nursery, B: Harmonal and fungicide treatment application, C: Bare rooted defoliated seedlings; D: Bare rooted seedlings with leaves; E: Bare rooted seedlings packing after treatment; F: Packed bare rooted seedlings ready for transportation; G: Effect of hormonal treatment on bare rooted seedling roots

compared with the control treatments. Kaur (2017) IBA treatment can help to prolificate healthy root system which enhanced higher nutrients and water uptake, thus, leads to produce more number of leaves. The application of chemical based fungicides such as carbendazim to control pathogens is the significantly effective, reliable method and therefore, become an integral part of agriculture (Ons et al., 2020). Mansour and El-Shimy (2009) reported that citrus bare root were coated with bioagent (*Trichoderma harzianum*) reduced root rot disease incidence and also had positive effects on the shoot and root growth. The above literatures were also advocating our present study.

4. CONCLUSION

The findings confirmed the superiority of the polythene packed plants (with earth wall) method for transplanting success of Kinnow mandarin over bare rooted method. However, the mean survival transplanting success (97%) was also observed in bare rooted buddlings. There were significant differences (p<0.05) in the survival percentage of seedlings treated with different hormonal treatments. Bare rooted seedlings can successfully be transplanted in the month of August to October during the monsoon period and February - March during spring months with 94–96% transplanting success.

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6. REFERENCES

Anella, L., Hennessey, T.C., Lorenzi, E.M., 2008. Growth

of balled and-burlapped versus bare-root trees in Oklahoma, US. Arboriculture and Urban Forestry 34, 200–203.

Bajwa, G.S., Dhatt, A.S., Singh, S.N., Rattanpal, H.S., 1997. Studies on bare root transplanting of Kinnow. Proceedings of National Symposium on Citriculture organized by Indian Society of Citriculture and NRC for Citrus, Nagpur during 17-19th November, 1997.

Carvalho, S.A.D., Girardi, E.A., Mourão, F.D.A.A., Ferrarezi, R.S., Coletta, H.D., 2019. Advances in citrus propagation in Brazil. Revista Brasileira de Fruticultura, 41. https://doi.org/10.1590/0100-29452019422.

Chen, Y., Barzee, T.J., Zhang, R., Pan, Z., 2019. Chapter 9 – Citrus. In: Integrated Processing Technologies for Food and Agricultural By-Products. Academic Press, p. 217-242.

Cuenca, J., Garcia-Lor, A., Navarro, L., Aleza, P., 2018. Citrus genetics and breeding. In: Advances in Plant Breeding Strategies: Fruits (pp. 403-436). Springer, Cham.

Da Costa, C.T., De Almeida, M.R., Ruedell, C.M., Schwambach, J., Maraschin, F.D.S., Fett-Neto, A.G., 2013. When stress and development go hand in hand: main hormonal controls of adventitious rooting in cuttings. Frontiers in plant science, 4: 133. https://doi.org/10.3389/ fpls.2013.00133.

Dwiastuti, M.E., 2020. Citrus foot rot disease (*Phytophthora* spp.) control in Indonesia using good agricultural practices efforts green agroindustry. In IOP Conference Series: Earth and Environmental Science (Vol. 484, No. 1, p. 012097). IOP Publishing.

Anonymous, 2017. www.faostat.org (accessed March 07 2018).

Goyette, B., Piche, M., Brownbridge, M., McGrath, D., 2014. Impact of handling practices on the quality of bare-root plants: A review. Journal of Environmental Horticulture 32(2), 103–112.

Ilame, S.A., Singh, S.V., 2018.Physico-chemical properties of ultrafilteredkinnow (mandarin) fruit juice. Journal of Food Science and Technology 55(6), 2189–2196.

Kaur, S., 2017. Evaluation of different doses of indole-3-butyric acid (IBA) on the rooting, survival and vegetative growth performance of hardwood cuttings of Flordaguard peach (*Prunuspersica* L. Batch). Journal of Applied and Natural Science 9(1), 173–180.

Khan, N., Kazmi, R.H., Willems, L.A.J., Van-Heusden, A.W., Ligterink, W., Hilhorst, H.W.M., 2012. Exploring the natural variation for seedling traits and their link with seed dimensions in tomato. PLoS One. 7, e43991.

Klavina, D., Gaitnieks, T., Menkis, A., 2013. Survival, growth and entomycorrhizal community development of container and bare-root growth *Pinus sylvestris* and *Picea abies* seedlings outplanted on a forest clear-cut. Baltic Forestry 19(1), 39-49.

Kumar, V., Bhat, A.K., Sharma, V., Gupta, N., Sohan, P., Singh, V.B., 2015. Effect of different mulches on soil moisture, growth and yield of Eureka lemon (*Citrus limon*burm) under rainfed condition. Indian Journal of Dryland Agricultural Research and Development 30(1), 83–88.

Mansour, F.S., El-Shimy, H.S., 2009. Soil amendment and using bare root trees treatments as alternative fungicides for controlling root rot diseases on citrus transplanting. Egyptian Journal of Horticulture 36(1), 201–218.

Marler, T.E., Davies, F.S., 1988. Growth of bare-rooted and container-grown 'Hamlin' orange trees in the field. In Proceedings of theannual meeting of the Florida State. Horticulture Society 100, 89–93.

Ndubuaku, N.M., 2005. Evaluation of transplanted bare-rooted cocoa seedlings for enhanced field establishment under different preservation methods. The Mysore Journal of Agricultural Sciences 6(1), 24–29.

Ons, L., Bylemans, D., Thevissen, K., Cammue, B., 2020. Combining biocontrol agents with chemical fungicides for integrated plant fungal disease control. Microorganisms 8(12), 1930. https://doi.org/10.3390/ microorganisms8121930.

Prasad, H., Thakur, M., Gupta, A.K., Prasad, D., Ajender 2015. Effect of foliar application of 2,4-D, urea and zinc sulphate on fruit drop, yield and fruit quality of Kinnow mandarin. International Journal of Bio-resource and Stress Management 6(5), 619–622.

Repac, I., Tucekova, A., Sarvasova, I., Vencurik, J., 2011. Survival and growth of outplanted seedlings of selected tree species on the High Tatra Mts. windthrow area after the first growing season. Journal of Forest Science 57(8), 349–358. https://doi.org/10.17221/130 /2010- JFS.

Sandhu, A.S., Dhillon, D.S., 1994. Bare rooted transplanting of Kagzi lime and Baramasi lemon. Annual Report Department of Horticulture, Punjab Agricultural University, Ludhiana.

Sandhu, A.S., Uppal, D.K., 1987. Research note on preliminary investigations on bare rooted transplanting of Kinnow. Journal of Research, Punjab Agricultural University, Ludhiana 24(1), 57–59.

Santana, L.G.L., Souza, E.D.S., Passos, O.S., Gesteira, A.D.S., Ledo, C.A.D.S., Soares, W.D.S., 2018. Vigor and mortality of citrus progenies with potential use as rootstocks. Scientia Agricola 75, 339–345.

Sharma, R.R., Awasthi, O.P., Kumar, K., 2016. Pattern of

phenolic content, antioxidant activity and senescence-related enzymes in granulated vs non-granulated juice-sacs of 'Kinnow'mandarin (*Citrus nobilis* x *C. deliciosa*). Journal of Food Science and Technology 53(3), 1525–1530.

Siddiqui, M., Akram, M., Haque, Z., 2019. Strategies for management of Phytophthora diseases in citrus in India. In: Bio-intensive approaches: Application and effectiveness in plant diseases management (pp. 435-451). Today & Tomorrow's Printers and Publishers, New Delhi, India.

Singh, A.K., Meetei, N.T., Singh, B.K., Mandal, N., 2016. Khasi mandarin: its importance, problems and prospects of cultivation in north-eastern Himalayan region. International Journal of Agriculture Environment and Biotechnology 9, 573–592.

Sourav, K., Saralch, H.S., 2019. Effect of transplanting time and cutting size on growth parameters of *Populus deltoids* under nursery conditions. International Journal of Economic Plants 6, 021–024. https:// doi.org/10.23910/ijep/2019.6.1.0284

Testolin, R., Vitagliano, C., 1987. Influence of temperature and applied auxins during winter propagation. Journal of Horticultural Sciences 22, 573–574.

Zema, D.A., Calabro, P.S., Folino, A., Tamburino, V., Zappia, G., Zimbone, S.M., 2018. Valorisation of citrus processing waste: A review. Waste Management 80, 252–273.