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Pectinifera rootstock for quality fruits and high density planting in mandarins under Thar desert

Rootstock is a key factor in citriculture for better climatic adaptability, compatibility with canopy architecture, higher production, quality harvest, and a healthy and longer orchard life. After evaluation of different scion-rootstock combinations at ICAR-Central Institute of Arid Horticulture (CIAH), Bikaner, Pectinifera (*Citrus pectinifera)* has been found to be a superior rootstock in Kinnow, Daisy and Fremont cultivars of mandarin for horticultural interests like high density planting, compact canopy, early harvesting and high yield with quality fruits. It was also least affected by biotic and abiotic stresses of the arid region such as fruit cracking, sun-burning, citrus canker, and sucking moth. This promising rootstock will be beneficial for mandarin growers in the recently expanded citriculture industry under Indira Gandhi Nahar Pariyojana (IGNP) command area, which has good quality water supply in the Thar desert.

CITRUS is a major fruit crop worldwide, largely dependent on scion-rootstock combinations for stionic index, plant growth, fruit yield, quality fruits, and stress tolerance (biotic and abiotic). Citriculture employs a wide range of rootstocks. Rough lemon and Rangpur lime are utilized commercially in Indian citrus industries for kinnow and Nagpur mandarin, respectively. These rootstocks are highly susceptible to phytopthora, tristeza, greening, black fly, fruit sucking moth, and nutritional deficiencies, which adversely affect their productivity and lead to decline in yield in early age. In addition, sub- and supra-temperature, heat waves, salinity, drought, and nutrients poor soil also play a significant role in defining plant physiological and metabolic functions.

Thus, ICAR-CIAH has taken initiative on citrus rootstock research and made different combinations of mandarin cultivars like Kinnow, Fremont and Daisy onto various rootstocks during 2015. The experiment consisted of six rootstocks for Daisy, four rootstocks for Fremont and Kinnow mandarin cultivars each, which were established and evaluated for the best scion-rootstock combinations under hot arid environmental conditions. The Pectinifera rootstocks was found to be superior in plant growth, stionic index, fruit quality and both biotic and abiotic stress tolerance in all mandarin cultivars (Kinnow, Daisy and Fremont) based on a decade long study.

Plant growth and stionic index

The Stionic Index refers to the compatibility index of the scion and rootstock. It is a ratio used to assess their compatibility in grafting by comparing their respective stem diameters. It is calculated as the ratio of the scion diameter (measured above the graft union) to the rootstock diameter (measured below the graft union). This index serves as an indicator of vascular continuity, physiological integration, long-term graft stability, and the overall longevity of an orchard. The Stionic Index significantly influences plant growth and development by affecting the absorption and translocation of nutrients. Stionic index was observed highest in Pectinifera followed by Rough lemon rootstock while it was lowest in Troyer citrange in using all mandarin cultivars of Kinnow, Daisy and Fremont. Plants exhibited mortality as stunting growth, die back, nutritional deficiency, bark-splitting and blackening in all mandarins plants grafted with Troyer citrange after nine years of plantation. Incompatible rootstocks adversely affected and led to swift decline during fruiting stage of plantation. Among them, Pectinifera rootstock showed highest dwarfing effect (28.33-39.09%) with compact

Effect of rootstocks on plant growth (height and width) in Kinnow mandarin

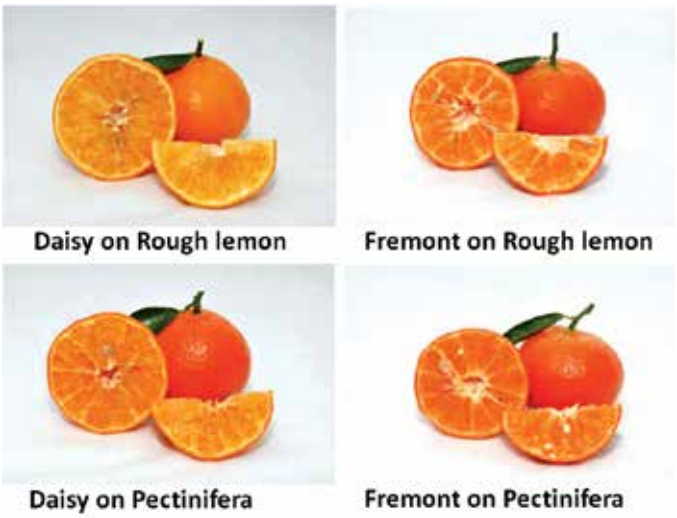
Table 1. Impact of rootstocks on plant growth, stionic index, fruit yield and quality attributes on mandarin cultivars

Plant/fruit trait	Rough lemon rootstock			Pectinifera rootstock		
	Kinnow	Daisy	Fremont	Kinnow	Daisy	Fremont
Plant height (cm)	319	306	268	240	220	209
Stionic index	0.94	0.81	0.90	0.96	0.91	0.92
Fruit weight (g)	202.93	199.80	157.60	206.93	246.40	139.80
Fruit yield/plant (kg)	117.60	113.60	100.60	79.20	53.20	71.58
Rind thickness (mm)	4.51	2.74	3.19	4.15	2.15	2.95
Juice (%)	42.61	37.70	45.69	45.08	41.41	52.04
TSS (°Brix)	9.84	11.02	10.98	11.64	13.44	13.24
Ascorbic acid (mg/100g fresh juice)	107.52	87.68	65.28	144.02	69.12	46.08
Fruit maturity (days)	314.24	270.54	286.87	301.70	261.76	275.20
Alternate bearing	Yes	Yes	Yes	No	No	No
HDP suitability	No	No	No	Yes	Yes	Yes

canopy and lesser suckering habit on mandarin scion rootstock combinations under hot arid environmental conditions.

Fruit yield

Dwarfing and compact canopy rootstocks have high fruit setting and retention as compared to vigorous rootstocks. Mandarin cultivars produced medium to large size fruit on Pectinifera rootstock but smaller fruits vigorousing on rootstocks like Rough lemon, Karna Khatta and Rangpur lime. Interestingly, these mandarin cultivars responded to alternate bearing habit except Pectinifera rootstock. This dwarfing rootstock also showed enhanced (10-15 days early) fruit maturity as compared to commercialy Rough lemon rootstock. The highest fruit yield of mandarin cultivars was observed in Kinnow (117.60 kg/plant), Daisy (113.60 kg/plant) and Fremont (100.6 kg/plant) on Rough lemon rootstocks in nine years old plantation as compared to Pectinifera rootstock. However, the Pectinitero rootstock was regular bearer and had a consistently increasing yield with the age of plantation which is more important for the growers.



Effect on rootstocks on peel and flesh colour development

Fruit quality

Mandarin cultivars fruit quality traits like juice percent, total suspended solid (TSS), acidity, ascorbic acid, ripening index, and total antioxidants were highly enhanced by Pectinifera as compared to Rough lemon rootstock. Kinnow, Daisy, and Fremont mandarins had higher juice percentage (5.48, 8.96 and 12.20) and TSS (15.46, 18.01 17.07%) on Pectinifera as compared to Rough lemon rootstock. Fruit peel and juice flesh colour are prominent marketing criteria for luring consumers, which effectively developed on Pectinifera rootstock. Ripening index and post harvest shelf-life were superior with Pectinifera rootstock. Overall, mandarin's fruit on Pectinifera rootstock performed better in the organoleptic evaluation. Daisy mandarin fruits were observed to be granulation free with Pectinifera and Rangpur lime rootstocks.

Tolerance to biotic and abiotic stresses

In spite of the fruit yield and juice quality parameters, plant health is also an important factor in orchards to harvest high-quality fruits with least input expenses. Citrus plant has a tendency to produce water sprouts on leaves which are highly infested by sucking and caterpillar pest due to luxurious availability of growth promoters, i.e. tender, dark green and larger leaves. Mandarin plants grafted with vigorousing rootstocks like Rough lemon, Sour orange, Karna khatta, Rangpur lime and Volkamericana were highly plagued by sucking pests like aphids, thrips, black fly, leaf minors and lemon butterflies due to their high suckering tendency. These sucking pests are carriers of viruses and canker diseases, and spread them in citrus orchards. Furthermore, high suckering growth habit also leads to an imbalanced canopy shape and breakage of branches due to the heavy fruit load, which exposes fruits to scorching sunlight. Water sprout is susceptible to frost injury and it was observed more in mandarins grafted with vigorousing rootstocks. As a result, it was found that citrus orchards grafted with vigorousing rootstock like Rough lemon were declining in India at an early age of plantation.

Effect of incompatible (A) and compatible (B) rootstocks on plant health and survivability

Mandarin plants on Pectinifera rootstock were dwarf in plant growth with less-suckering behaviour (water sprouts). That's why, Pectinifera rootstock was less-infected or tolerant to sucking pest, citrus canker, sun scald and fruit cracking among all rootstocks under hot arid environmental conditions.

Tree survivability

The longer orchard survivability is an important factor for the economic return from the citrus plantation, and it is predominantly governed by the stionic index (graft compatibility), root architecture, and disease-free orchards. All the evaluated rootstocks had a high compatibility index in mandarin cultivars except Troyer citrange. Mandarin plants exhibited small and nutrients-deficient leaves, meager canopy, and drying twigs on Troyer citrange rootstock in their initial years. Plants began to decline after 4-5 years, and 100% died within 9–10 years of planting. Among them, Pectinifera was found better in compatibility, high water-nutrient absorption, compact and green canopy with less-suckering tendency. It supports longer orchard life, quality fruits, and disease-free plants.

SUMMARY

The Pectinifera rootstock performed outstanding in horticultural traits and found to be a potential rootstock for Kinnow, Daisy and Fremont mandarin cultivars. It contributes significantly not only to high-quality fruit production, but also to better orchard life. It can also be used in high-density planting to maximize productivity per unit area under hot arid environmental conditions of Thar desert.

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Varieties of vegetable crops for release and notification

Dolichos bean (Bush): VRBSEM 3-Days to first picking: 80–85 days, Peak fruiting period: December to March. DYMV disease free in cropping period with temperature tolerance up to 35°C. Yield: 360 q/ha in five pickings. Identified for cultivation in Zone VI (Rajasthan, Gujarat, Haryana and Delhi), Zone VII (Madhya Pradesh, Maharashtra and Goa) and Zone VIII (Karnataka, Tamil Nadu, Kerala and Puducherry).

Indian (Dolichos) bean/Sem: Arka Neelachal Pushti, is high yielding, pole type, round podded variety. The pods are rich in protein (4.61 g/100 g) and micronutrients (iron: 15 ppm, zinc 37 ppm). Duration of crop is 95 days from sowing to green harvest. Rabi season is ideal for its cultivation in Eastern India. Average yield is 24 tonnes/ha in 120 days.

French bean (Bush): VRFBB 91 is bush-type, early, short duration, flowers at 32–35 days after sowing. Pods are green and bright, fleshy, tender, straight, cylindrical and free from parchment. Bears about 20–25 pods/plant. Resistant to sclerotinia rot (Sclerotinia sclerotiorum). Tender pod yield potential is 125–150 q/ha. Recommended for Zone I: Humid Western Himalayan Region (Jammu and Kashmir, Himachal Pradesh and Uttarakhand).

Source: ICAR Annual Report 2021-22