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Tree Growth and Fruit Quality of Some Citrus Scion/Rootstock Combinations in Afghanistan

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Summary

Improvement of citrus production was focused on during the rehabilitation process of Afghanistan. The *ex situ* germplasm center of citrus was established and a field trial in the subtropical climate of Nangarhar province was launched by grafting the eight citrus scions (Washington navel, Moro, Tarocco, Tardivo, Marsh seedless, Femminello Siracusano, Minneola tangelo, and Ortanique tangor) onto seven different rootstocks (Volkamer lemon, Carrizo citrange, Troyer citrange, X639, Rough lemon, Trifoliate orange, and Sour orange). The objective of the present study was to measure the performance of these combinations in the local climate. The rootstocks didn't significantly affect the canopy growth, while they affected the compatibility index (CI) of some citrus scions. Tarocco grafted on Volkamer and X639

rootstocks showed significantly lower CI values in comparison to the value (1.0) obtained by the Troyer, Trifoliate, and Sour orange. The CI of Sour orange (1.0) on Tardivo was significantly higher than of the Trifoliate, X639 and Carrizo. The X639 and Trifoliate produced the lowest CI in the Ortanique tangor at 0.77. The fruit quality was influenced by the scion/rootstock combinations. The Washington navel, Moro, and Femminello produced the heaviest fruit on Volkamer, whereas the Tardivo, Marsh seedless, and Minneola tangelo yielded the biggest fruits on Carrizo. The fruit of Tarocco was the largest on Rough lemon and the smallest on Troyer citrange. In a similar manner, the fruit rind of the Washington navel, Moro, Tarocco, and Femminello was the thickest on Volkamer. The thinnest fruit rind was observed on Sour orange, Rough lemon or Trifoliate. A noticeable difference in seed number was indicated by the fact that Tardivo produced the largest number of seeds (10.33) on Volkamer and the smallest (2.50) on X639 citrange. The juice percentage, TSS, and TA were also affected by the rootstocks. Washington navel and Tardivo produced the highest percent juice on Carrizo and Rough lemon, respectively. Most scions grafted on Trifoliate or Volkamer had the highest TSS contents and the lowest TA. Overall, the results provide the first empirical-based insights for the local researchers to have future exploration adding the yield parameter for the specific scion/rootstock combinations.

INTRODUCTION

Afghanistan has long been noted for many kinds of high value fruits. Such crops are spread over the country, generate revenue and provide sustenance to a significant portion of the population. Despite conflicts, strife and drought, the fruits remained the main source of the country foreign exchange earnings.

Eastern Afghanistan secures the Mediterranean climate and brings a conducive environment to grow subtropical fruits. Among them, commercial production of citrus particularly Sweet orange (*Citrus sinensis* (L.) Osbeck), Sour orange (*Citrus aurantium* L.) and lemon (*Citrus limon* (L.) Burm. f.), is predominantly practiced in this region; nevertheless, some other cold parts of the country is recently started lemon cultivation in the protected structures (Glozer and Ferguson, 2007). Because of the unstable political conditions, citrus fruit production experienced fluctuations in the last four decades. However, as per ministry of agriculture report, the acreage and production tended to increase again in the recent years ending at 13,243 tons in 2020. Based on the reported figures, Nangarhar ranked the top citrus producing province followed by Kunar, Laghman and Khost provinces.

Demand for citrus fruits is very high in the domestic market but has always been fulfilled by the imports which mostly constituted Kinnow mandarin (*Citrus reticulata* Blanco) from Pakistan. The market size of the fresh citrus is estimated at 200,000 tons per annum, while the local produce occupies 6.6% of its share (Afghanistan National Horticulture Development Organization, 2013). During the last twenty years, efforts have been made again to boost the local citriculture. The national germplasm center of fruits was established in Jalalabad, where with other fruit species, 75 accessions of citrus including new varieties of sweet oranges and mandarins (*Citrus* spp. (Sect. *Acrumen*)) are preserved.

In Afghanistan, the sour orange is used to be the most common rootstock for the citrus nursery production (Glozer and Ferguson, 2007); however, due to the slow growth of the seedlings and insufficient seed supply, it can't fulfill the current need of saplings in the market. Hence, the Afghan nurseries are now widely relied on imported seeds of Rough lemon to produce the rootstocks. In order to locally build a strong foundation of sustainable citrus production, it has always been suggested to test the long-term performance of the available citrus scions against various rootstocks. Although a trial has been run evaluating some citrus scion/rootstock combinations, no single report has been published yet on the relevant topic. Therefore, this study aimed to present the performance of the tree growth and fruit quality of eight citrus scions budded to seven rootstocks.

MATERIALS AND METHODS

Plant materials and growing conditions

In Feb 2012, the citrus trial was run by planting the grafted saplings in Jalalabad perennial horticulture development and research center (PHDC). Jalalabad is the capital of Nangarhar province which also serves as a regional center for eastern Afghanistan. The location of the experimental site is 566 m above sea level where the annual low and high average temperature respectively falls 3 ^{0}C and 40 ^{0}C. The weather is mostly sunny and dry with <500 mm annual rainfall. Three trees assigned to each scion-stock combination were distanced 5 m apart and headed north to south in a straight row. The distance between the adjacent rows was also 5 m and the soil type was sand clay loam having 8.9 pH. The eight scions are Washington navel, Moro, Tarocco from *C. sinensis*, Tardivo di Ciaculli mandarin (*C. reticulata* Blanco), Marsh seedless grapefruit, (*C. paradisi* Macfad.) Femminello Siracusano lemon, (*Citrus* × *limon* L.) Minneola tangelo (*Citrus* × *tangelo*), and Ortanique tangor (*Citrus reticulata* × *sinensis*). The seven rootstocks are Volkamer lemon (*C. limonia* Osbeck), Carrizo citrange (*C. sinensis* × *P. trifoliata*), Troyer citrange (*P. trifoliata* × *C. sinensis*), X639 (*P. trifoliata* × *C. reticulata*), Rough lemon (*Citrus* × *jambhiri* Lush.), Trifoliate orange (*P. trifoliata* (L.) Raf.), and Sour orange.

Determination of tree vegetative growth and quality attributes of fruit

Tree growth and fruit quality characteristics were measured on the existing trial during late December 2020. According to Zhu et al. (2020), circumferences of the trunk were measured at 5 cm above and below the graft union, and termed as Cs and Cr, respectively. Compatibility index (CI) was calculated with the equation CI = Cs/Cr. The height of the tree and diameters in both parallel and perpendicular directions of the tree to the row were measured as H, Dl and Dr, respectively. The canopy volume was estimated with the equation: $V= (\pi/6) \times H \times Dl \times Dr$.

Totally twelve fruits from four directions of three plants were randomly sampled on each scion-stock combination and subjected to the fresh weight, diameter, height, rind thickness, seed number, juice content, total soluble solids (TSS), and titratable acid (TA) measurements. The weight of the fruit was determined by using a digital balance. The fruit diameter, height and rind thickness were measured with a Vernier caliper. The fruit rind was gently peeled from the flesh and referred to a high precision micro-digital caliper for thickness determination. Only fully developed mature seeds were counted as seed numbers. Juice was squeezed with the help of a manual squeezer and then weighed for each fruit. The juice percentage was determined by following formula (juice % = (juice weight x 100) / whole fruit weight). The TSS content of juice was measured by a digital refractometer (PAL-1, Atago, Japan) and expressed as a percent. The TA was determined by titrating 10 mL of juice dilution (10x dilution) with 0.1 N NaOH (pH = 8.1).

Data analysis

Data on tree growth and fruit quality parameters were prepared in Microsoft Excel spreadsheet and then subjected to one-way analysis of variance using SPSS 16.0 statistical software. Means were compared with Tukey's HSD test at p-value 0.05.

RESULTS AND DISCUSSION

Tree canopy and compatibility index

In the present study, the rootstocks did not significantly affect the growth of the tree canopy evaluated for the individual citrus scions, but some slight changes were evident (**Fig. 1**).

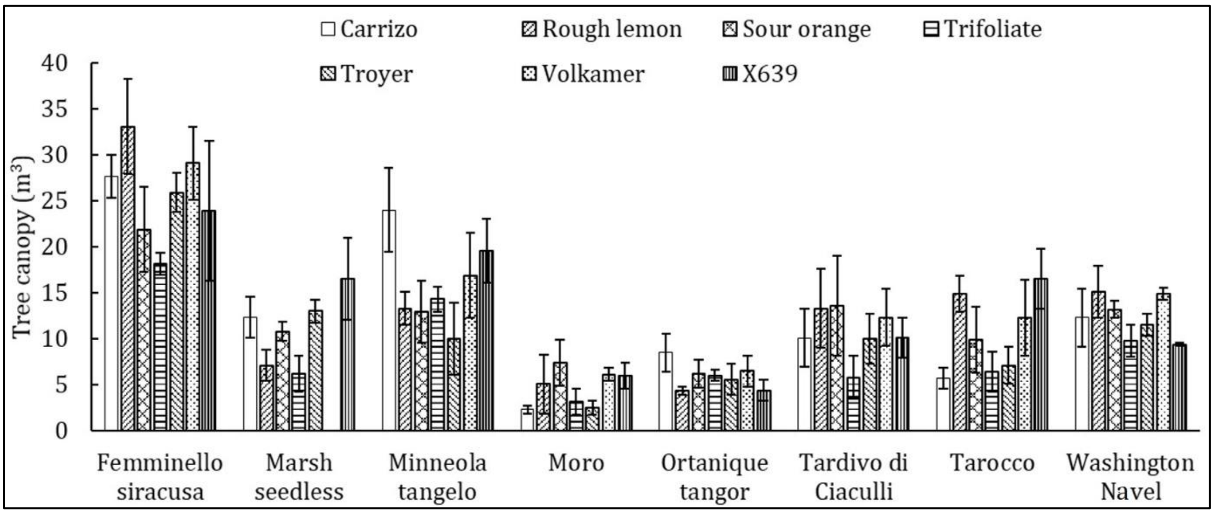

Figure 1. Tree canopy of the eight scions grafted on seven different rootstocks. Error bars show SE of the means of replicates

Although the differences were nonsignificant, Washington navel grafted onto Rough lemon demonstrated vigorous growth at 15.1 m^3 canopy volume, while the same scion onto X639 tended to be smaller of the canopy at 9.4 m^3. Femminello also had greater canopy growth (33.1 m^3) on Rough lemon but lowered (18.2 m^3) when Trifoliate was used as rootstock. Moro sweet orange and Tardivo mandarin showed vigorous growth on Sour orange, whereas the insignificant lower of their growth was noticed on Carrizo and Trifoliate, respectively. The trees of Tarocco and Marsh seedless were larger on X639, while they were smaller when grafted respectively on Carrizo and Trifoliate. Minneola tangelo and Ortanique tangor showed vigorous trees on Carrizo rootstock, whereas the canopy was reduced to the minimum on Troyer, X639 or Rough lemon, respectively. The present findings agree with the studies of Gora et al. (2022) and Zhu et al. (2020). Zhu et al. (2020) evaluated the performance of three late-ripening navel oranges on seven rootstocks. Among them, Carrizo citrange proved the most vigorous rootstock and Trifoliate the smallest for the canopy volume.

Gora et al. (2022) referred the superior canopy growth of the scion at relevant rootstock to the well-adapted characteristics to soil conditions such as an effective root system. Because of the dwarf growth, Trifoliate might be suggested for high dense planting, while other vigorous rootstocks would be considered for sparse planting (Zhu et al., 2020). The citrus rootstocks are probably regulating hormonal induction, anatomy and physiology of the tissue, and through affecting the canopy growth (Gaona-Ponce et al., 2018; Liso et al., 2004; Noda et al., 2000).

The rootstocks significantly affected the compatibility of Tarocco grapefruit, Tardivo mandarin, and Ortanique tangor (**Fig. 2**).

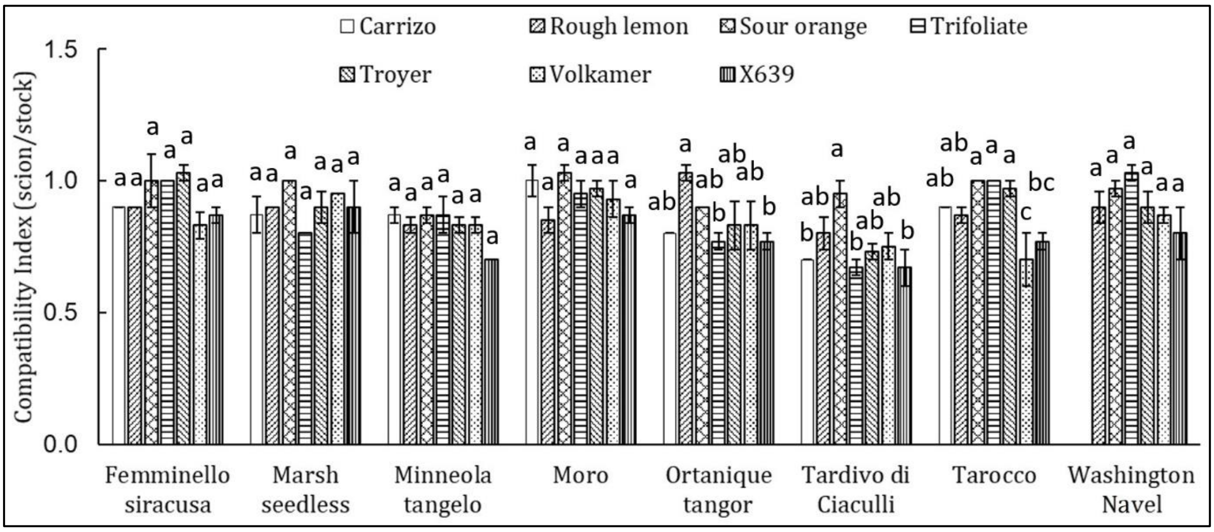

Figure 2. Compatibility index of the eight scions grafted on seven different rootstocks. Values with different lowercase letters are significantly different in an individual scion. Error bars show SE of the means of replicates.

The means of the compatibility index (CI) of all tested combinations fell in the range of 0.67 to 1.0. In Tarocco scion, the CI values of the Troyer, Trifoliate, and Sour orange were at 1.0, significantly higher than of Volkamer and X639. In Tardivo mandarin, the highest CI (1.0) obtained by Sour orange, significantly greater than the values recorded for Trifoliate, X639, and Carrizo. Compared to the highest value of Rough lemon and Sour orange, X639 and Trifoliate produced a significantly lower compatibility index in Ortanique tangor at 0.77. Zhu et al. (2020) also conferred lower CI of three navel orange varieties to Swingle and Trifoliate rootstocks. In general, the closer the index to 1, the high would be the compatibility or affinity. The better compatibility might be associated with the closer genetic relationship between the scion variety and rootstock (Nito et al., 2005).

Fruit quality

The effects of seven rootstocks on the fruit quality of eight citrus scions were shown in Table 1. All scions were significantly affected in fruit weight by the rootstocks except of the Ortanique tangor which was insignificant not only in fruit weight but also in fruit diameter, height, rind thickness, seed number, and juice percentage. In Washington navel, the Volkamer rootstock produced the highest fruit weight (285 g) significantly different from the lowest (189 g) of the Trifoliate. The Volkamer rootstock also produced the heaviest fruit in Moro and Femminello lemon. The fruit of Tarocco was the biggest (253 g) on Rough lemon, significantly different than the lowest (161 g) weighed on Troyer citrange. Tardivo, Marsh seedless, and Minneola Tangelo produced the biggest fruits on Carrizo rootstock, while the significantly smallest fruits of them respectively resulted on Sour orange, Trifoliate, and X639 citrange.

Rootstocks significantly affected diameter of the fruits. More in a similar pattern to the result of the fruit weight, fruit diameters of Washington navel, Moro, and Femminello were remarkably the greatest on Volkamer. The fruit diameter of Tarocco was the biggest on Rough lemon followed by Volkamer in a significant difference with the lowest on Troyer citrange. Tardivo, Marsh seedless, and Minneola Tangelo produced the biggest fruit diameters on Carrizo rootstock, whereas the significantly lowest of them were obtained on Sour orange and Trifoliate, respectively.

The height of fruits of the individual scion was significantly different on various rootstocks but did not change for the Minneola tangelo and Ortanique tangor fruits. Washington navel, Moro, and Femminello followed a similar trend for the fruit height as they formed the tallest on Volkamer rootstock and the shortest on Trifoliate or Rough lemon. Conversely, Tarocco shaped the tallest on Rough lemon and the shortest on Trifoliate. The Trifoliate rootstock also yielded the shortest for the fruit of Tardivo and Marsh, while the tallest of these scions were occurred on Carrizo. Yildiz et al. (2013) also reported the heaviest fruit of 'Valencia Late' sweet orange onto Carrizo rootstock.

Except of Tarocco, Femminello, and Ortanique, the rootstocks significantly affected the rind thickness of the rest of other scions. In a similar manner, the fruit of Washington navel, Moro, Tarocco, and Femminello developed the thickest rind on Volkamer, while the significantly thinner of the first two of them were recorded for the Sour orange and Rough lemon, respectively. In Moro, Rough lemon reduced the rind thickness (3.55 mm) to almost half of that of Volkamer (6.21 mm). Tardivo produced a thicker rind on Troyer compared to significantly thinner on Rough lemon. Marsh seedless and Minneola Tangelo developed the thickest fruit rind on Carrizo, while the thinnest of them was observed on Trifoliate and Sour orange, respectively. On the other hand, a positive correlation was found between the fruit weight and rind thickness at $R^2 = 0.5799$ (**Fig. 3**). The thicker rind might preserve better post-harvest life of fruits but would be considered detrimental if it tends to lower the juice content and pulp (Gora et al., 2022).

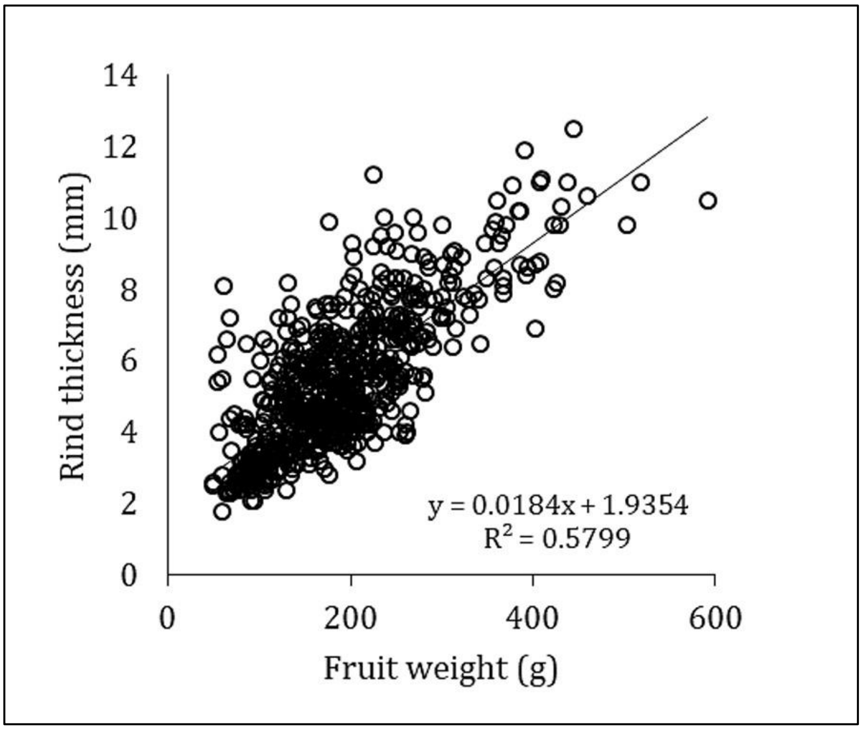

Figure 3. Relationship between fruit weight and rind thickness.

The seed number of the scions was not affected by the rootstocks, with the exception of Tardivo mandarin that significantly produced the highest numbers of seeds (10.33) on Volkamer and the lowest (2.50) in combination with X639 citrange.

The quality of fruit including juice content, TSS, and TA, was affected by the rootstocks (**Table 1**). The significant effects in juice content were observed only for the Washington navel and Tardivo fruits. The fruits of Washington navel on Carrizo possessed the highest percent of juice at 26.62 %, while that on Rough lemon was the least at 7.67 %. In contrast, Tardivo produced the greatest juice percentage (42.03%) on Rough lemon compared with the lowest (29.99%) on Troyer citrange.

TSS was greatly affected by the rootstocks. Except for the Tardivo and Femminello, the highest content of TSS of the scions was found on Trifoliate, whereas the significantly lowest was on Volkamer, except for Moro and Minneola tangelo. The highest TSS of Tardivo and Femminello was observed on Sour orange and rough lemon, respectively.

Rootstocks demonstrated significantly different impact over TA of the fruits of individual scions. TA of Moro, Tarocco, Tardivo, Femminello, and Minneola tangelo were the highest on Sour orange, while the lowest of Moro, Tarocco, Marsh seedless, Minneola tangelo, and Ortanique tangor recorded on Volkamer rootstock. The lowest TA values of Tardivo and Femminello were observed on Troyer citrange and the highest of Marsh seedless and Ortanique were on Trifoliate and X639 citrange, respectively. In Washington navel, the TA value of the fruits was the highest (0.84 g ·100 mL^{-1}) on both Carrizo and Troyer, but not significantly differed from the TA (0.82 g ·100 mL^{-1}) of Rough lemon and Trifoliate. However, the significantly lowest TA of Washington navel had noted when budded on X639 citrange, followed by Volkamer and Sour orange.

Table 1. Fruit quality of eight citrus scions grafted on seven rootstocks.

	Rootstock	Scion							
		Femminello Siracusa	Marsh seedless	Minneola tangelo	Moro	Ortanique tangor	Tardivo di Ciaculli	Tarocco	Washington navel
Fruit weight (g)	Carrizo	197 ab	402 a	223 a	104 bc	163 a	118 a	221 abc	248 ab
	Rough lemon	161 b	280 bc	204 ab	87 c	182 a	87 cd	253 a	222 ab
	Sour orange	192 ab	339 ab	182 ab	110 bc	190 a	79 d	230 ab	224 ab
	Trifoliate	169 b	204 c	177 b	129 ab	178 a	90 bcd	177 bc	189 b
	Troyer citrange	172 ab	267 bc	198 ab	87 c	176 a	107 ab	161 c	224 ab
	Volkamer	217 a	299 b	188 ab	163 a	189 a	106 abc	235 ab	285 a
	X639 citrange	197 ab	282 bc	174 b	112 bc	179 a	97 bcd	173 bc	224 ab
Fruit diameter (mm)	Carrizo	68.3 ab	100.1 a	74.8 a	55.3 b	71.0 a	62.7 a	73.4 abc	83.9 ab
	Rough lemon	64.0 b	86.0 bc	71.2 ab	51.5 b	72.2 a	55.7 bc	77.4 a	79.6 abc
	Sour orange	67.5 ab	92.8 ab	69.3 ab	57.3 b	74.8 a	53.4 c	75.4 ab	76.5 bc
	Trifoliate	64.3 b	77.5 c	68.3 b	59.5ab	72.8 a	56.3 bc	68.3 bc	72.7 c
	Troyer citrange	65.8 ab	86.2 bc	71.3 ab	52.4 b	71.8 a	60.1 ab	66.6 c	77.7 abc
	Volkamer	70.2 a	90.3 ab	70.0 ab	66.0 a	74.7 a	59.0 ab	77.3 a	86.7 a
	X639 citrange	68.6 ab	86.3 bc	68.4 ab	58.0ab	73.4 a	59.8 ab	67.8 bc	79.0 abc
Fruit height (mm)	Carrizo	87.7 ab	84.5 a	76.6 a	57.7bc	60.6 a	56.3 a	73.8 abc	83.1 ab
	Rough lemon	79.0 b	76.4 ab	76.8 a	54.0 c	62.5 a	49.4 b	79.3 a	80.7 ab
	Sour orange	84.1 ab	79.7 ab	72.1 a	60.2 bc	63.2 a	49.4 b	77.5 ab	76.7 ab
	Trifoliate	85.3 ab	65.8 c	72.3 a	63.8 ab	62.1 a	51.0 b	68.0 c	74.3 b
	Troyer citrange	83.6 ab	71.4 bc	73.2 a	54.2 c	61.3 a	53.6 ab	68.5 bc	78.8 ab
	Volkamer	91.0 a	78.4 ab	71.5 a	71.1 a	62.8 a	52.4 ab	75.1 abc	87.5 a
	X639 citrange	86.6 ab	74.9 bc	70.0 a	58.4 bc	60.9 a	52.8 ab	66.5 c	79.3 ab
Rind thickness (mm)	Carrizo	5.86 a	9.71 a	4.96 a	4.38 bc	4.32 a	3.17 ab	6.37 a	7.21 ab
	Rough lemon	4.96 a	7.95 bc	4.21 ab	3.55 c	4.57 a	2.64 c	7.14 a	6.89 ab
	Sour orange	5.58 a	8.73 ab	3.76 b	5.02	4.65 a	2.58 c	5.98 a	5.72 b
	Trifoliate	5.57 a	6.78 c	4.52 ab	5.17 ab	4.88 a	2.83 bc	5.32 a	5.75 b
	Troyer citrange	5.38 a	7.44 bc	4.62 ab	5.22 ab	4.37 a	3.39 a	5.53 a	6.52 ab
	Volkamer	5.88 a	8.68 ab	4.61 ab	6.21 a	4.55 a	3.00 abc	6.76 a	7.67 a
	X639 citrange	5.49 a	7.64 bc	3.98 b	5.17 b	4.10 a	3.23 ab	5.30 a	7.04 ab
Seed number	Carrizo	4.67 a	3.08 a	2.50 a	1.00 a	14.00 a	5.00 bc	0.08 a	0.17 a
	Rough lemon	4.83 a	2.00 a	4.67 a	2.10 a	12.25 a	5.75 bc	0.17 a	0.75 a
	Sour orange	3.25 a	2.75 a	8.08 a	1.25 a	13.08 a	7.50 ab	0.17 a	0.50 a
	Trifoliate	4.92 a	3.33 a	6.50 a	0.92 a	11.83 a	6.92 ab	0.17 a	0.08 a
	Troyer citrange	3.67 a	2.17 a	2.75 a	0.50 a	14.25 a	3.75 bc	0.08 a	0.17 a
	Volkamer	4.75 a	2.58 a	6.00 a	1.33 a	13.33 a	10.33 a	0.42 a	0.25 a
	X639 citrange	4.33 a	1.83 a	7.42 a	1.17 a	14.25 a	2.50 c	0.08 a	0.67 a
Juice (%)	Carrizo	33.65 a	35.36 a	44.15 a	32.20 a	43.93 a	32.05 cd	32.18 a	26.62 a
	Rough lemon	36.85 a	35.61 a	48.80 a	39.15 a	42.30 a	42.03 a	25.06 a	7.67 c
	Sour orange	34.71 a	38.14 a	48.23 a	33.83 a	39.99 a	39.24 ab	30.57 a	21.62 ab
	Trifoliate	34.90 a	38.03 a	45.85 a	36.50 a	42.64 a	38.13	28.53 a	12.71 bc
	Troyer citrange	35.08 a	37.62 a	48.10 a	28.37 a	41.22 a	29.99 d	30.85 a	10.88 bc
	Volkamer	34.07 a	36.10 a	47.39 a	31.07 a	40.49 a	33.27	29.29 a	9.31 bc
	X639 citrange	36.01 a	36.46 a	46.57 a	35.45 a	42.5 a	31.62 d	27.87 a	16.65 abc
TSS (%)	Carrizo	7.10 de	8.65 bcd	8.45 b	7.60 b	8.4 bc	8.90 cd	9.15 a	7.80 a
	Rough lemon	7.85 a	8.75 bc	7.60 c	7.30 b	7.9 d	9.65 bc	8.80 ab	8.05 a
	Sour orange	7.35 bc	9.05 b	9.25 a	7.85 b	8.2 bcd	10.60 a	9.15 a	7.95 a
	Trifoliate	7.55 b	10.45 a	9.35 a	8.95 a	9.35 a	10.35 ab	9.50 a	8.05 a
	Troyer citrange	6.90 ef	8.75 bc	8.60 b	7.45 b	8.50 b	10.05 ab	8.00 c	8.00 a
	Volkamer	6.75 f	7.95 d	7.70 c	7.55 b	7.35 e	8.55 d	8.00 c	6.75 b
	X639 citrange	7.15 cd	8.15 cd	8.60 b	8.00 b	8.05 cd	10.30 ab	8.40 bc	7.80 a

TA (g·100 mL^{-1})	Carrizo	5.70 b	1.72 e	1.24 f	1.33 c	2.00 b	1.96 e	0.77 bc	0.84 a
	Rough lemon	5.58 c	1.87 c	1.32 e	1.31 c	1.77 f	2.24 c	0.76 cd	0.82 a
	Sour orange	5.76 a	1.92 b	1.82 a	1.56 a	1.80 e	2.56 a	0.88 a	0.77 b
	Trifoliate	5.50 d	2.22 a	1.65 b	1.31 c	1.98 c	2.50 b	0.88 a	0.82 a
	Troyer citrange	5.24 f	1.76 d	1.56 c	1.42 b	1.88 d	1.56 g	0.74 d	0.84 a
	Volkamer	5.52 d	1.65 f	1.21 g	1.15 e	1.54 g	2.12 d	0.65 e	0.77 b
	X639 citrange	5.40 e	1.67 f	1.40 d	1.21 d	2.04 a	1.64 f	0.79 b	0.75 b

1) TSS, Total Soluble Solid; TA, Titratable Acidity.
Means followed by the same letter in a column do not differ significantly for a trait according to Tukey's HSD.

The results of the fruit weight of Washington navel, Moro, and Femminello were similar to Ahmad et al. (2007), who reported significantly highest fruit weight per tree of 'Kinnow' on Volkamer and Sour orange rootstocks. In the present study, TSS of the six out of eight scions was the highest on Trifoliate rootstock, similar to the result of the TSS content of three navel orange varieties which was the highest on *Poncirus* (Zhu et al., 2020). Khalifa and Hamdy (2015) compared Volkamer and Sour orange rootstocks for the yield and fruit quality of two mandarin varieties. Volkamer showed higher fruit yield, fruit weight, height, diameter, fruit pulp weight, fruit rind weight, rind thickness, juice, number and weight of seeds, and fruit firmness than those budded on Sour orange. However, trees budded on Sour orange had higher TSS, total acidity, and vitamin C compared with those on Volkamer. Similar results were reported when these rootstocks (Volkamer and Sour orange) were evaluated with Ruby Red, Marsh grapefruit (Ramin and Alirezanezhad, 2005) and 'Hamlin' orange (Al-Hosni et al., 2011). Gora et al. (2022) stated that large fruit with thick and rough peel, low juice percent, and lower concentrations of TSS and ascorbic acid in the juice would be often related to varieties budded on fast-growing and vigorous rootstocks.

CONCLUSION

In this study, the scions belonged to different citrus groups that produced varied results, so the results were difficult to generalize except to consider individual findings on scion/rootstock combinations. The present report is the first published insight on the citrus trial that has been launched a decade ago in Jalalabad Afghanistan condition. It would further help the Afghan researchers to have more exploration about the citrus scion/rootstock combinations in the local environment, but data on yield and productivity over several years is highly desired.

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