Pak. J. Bot., 38(2): 311-317, 2006.

MORPHOLOGICAL DESCRIPTION OF THREE POTENTIAL CITRUS ROOTSTOCKS

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Abstract

Morphological studies showed that tree shape in Bitter sweet orange and Yuma citrange was spheroid with spreading growth habit and wide branch angle. Leaves were simple with dark green color, medium size and brevipetiolate in Sour orange while Yuma citrange had trifoliate leaves with medium and green color. Bitter sweet orange had the highest leaf lamina length (10.4 mm) than other rootstocks. These rootstock leaves had lanceolate shape with sinuate margins. Bitter sweet orange yielded the maximum fruit weight (195.9 g) while Yuma citrange and Sour orange had small and medium sized fruits, respectively. Fruit skin was rough and yellow in all rootstocks but bitter sweet orange and Sour orange showed white albedo with medium-strong adherence. Bitter sweet orange and Sour orange fruit had strong attachment to stalk. Number of segments/fruit was low in Bitter sweet orange as compared to the other rootstocks. Seeds represented clavate shape in Bitter sweet orange and Sour orange. The highest number of seeds was found in Bitter sweet orange (27.9) followed by Sour orange (14.8). Seed of Bitter sweet orange and Sour orange was polyembryonic while monoembryonic in Yuma citrange.

Introduction

Fruit growers depend primarily on yield and fruit quality to determine their net income. Their ability to achieve profitable levels of productivity and fruit quality is largely a matter of the orchard system selected and its successful management. An orchard system has been defined as "the integration of all the horticultural factors involved in establishing and maintaining a planting of fruit trees" (Barritt, 1987). Among a multitude of such factors is the rootstock.

Rootstocks differ markedly in one respect in that these are often employed as a treatment in research and as such information about them and their effects readily lends itself to occasional compilation and interpretation (Simons, 1983). A number of different citrus rootstocks are used in the various citrus-producing areas of the world. The performance of each has been selected as best adapted to the area in which it is used (Syvertsen & Graham, 1985). This variation in usage is understandable in view of the differences in soil types, environment, water relationships, nutrition, miscellaneous disease complexes involved and other factors (Sites & Reitz, 1950). Rootstocks once established are not very susceptible to change; however, occasionally something happens which requires a change. Sometimes the change is slow and gradual and at other times it is sudden and almost catastrophic. The sudden or catastrophic changes occur have dire consequences.

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Rootstock use and development had been considerably accelerated due to damaged caused by Phytophthora and tristeza (Castle, 1983). However, it is probable that these diseases, and many others, will become more widespread and disastrous in areas where they are now minor in nature. It has also been true in the past and will undoubtedly be true in the future that organisms causing disease can mutate to more virulent forms, or new disease appear which necessitate finding or developing new rootstocks which will be better suited to meet new threats, whatever they may be.

The need for dependable new rootstocks is of prime concern. Climate, diseases and physiological incompatibility all affect rootstock behavior and cultivars which are successful in one region may be quite unsatisfactory in another region to be successful. Several of the available rootstocks are limited in their use because of stock-scion incompatibilities, including adverse reaction to certain diseases. The successful rootstock must produce many seed and be highly nucellar in order to provide uniformity. Cold hardiness is desirable, particularly if it enhance cold hardiness of the scion (Soost & Cameron, 1975). Breeders are in search of such rootstocks which solve the problem faced to citrus industry and have released many rootstock hybrids of interest. However, proper identification and description of new cultivars before release is imperative. Hence this paper is focused on the identification and description of three citrus rootstocks for their tree, fruit and seed characteristics. This information will be useful for breeders and geneticist working on citrus rootstock improvement programs.

Materials and Methods

The experiment was laid out in CRBD with three replications. Description of three rootstocks (Bitter sweet orange, Yumma citrange and Sweet orange) was made on following observations where the tree morphology, fruits and seeds were described according to Descriptors for Citrus (Anonymous, 1999).

Tree description: Tree morphology was observed as tree shape (ellipsoid, spheroid, obloid), density of branches (sparse, medium, dense), tree growth habit (erect, spreading, drooping), branch angle (narrow, medium, wide), spine density (absent, low, medium, high), spine shape (curved, straight, green, purple).

Leaf description: Leaf morphology was recorded as leaf division (simple, bifoliate, trifoliate, pentafoliate), intensity of green color (light, medium, dark), leaf lamina attachment (sessile, brevipetiole), leaf lamina length (mm) recorded from petioles base to lamina tip), lamina width (mm) recorded at the widest point, leaf lamina shape (elliptic, ovate, obovate, lanceolate, orbicular, obcordate), leaf lamina margin (crenate, dentate, entire, sinuate), leaf apex (attunate, accuminate, acute, obtuse, round and emarginate), petiole wings (absent / present) and petiole wings width (narrow, medium, broad).

Fruit description: Fruit characteristics were studied as fruiting season (early, mid, late), fruit weight (g), fruit diameter and length (mm, average diameter/length of five fruit was recorded), fruit shape (speroid, ellipsoid, pyriform, oblique, obloid, ovoide), shape of fruit base (necked, convex, truncate, concave, collarade), fruit skin (green, green yellow, yellow), fruit surface texture (smooth, rough, papillate, pitted), adherence of albedo (weak, medium, strong), albedo color (greenish, white, yellow, pink), fruit attachment to stalk (weak, medium, strong), number of segment (average of five well developed segment were noted), adherence of segment walls (weak, medium, strong), segment shape uniformity (no, yes), thickness of segment wall (thin, medium, thick), fruit axis (solid, semi solid, hollow), pulp color (white, green, yellow, orange), pulp texture (crispy, fibrous, fleshy), vesicle length (short, medium, long) and juice content in endocarp (low, medium, high).

Seed description: Seeds characteristics were observed as seed shape (fusiform, clavate, ovoid, spherical, cuneiform), seed number per fruit (average of five fruit was recorded), seed surface (smooth, wrinkled, hairy), seed color (white, yellowish, creamy, green, brown), cotyledon color (white, light yellow, green, dark green, brown) and seed embryony (monoembryonic, polyembryonic, mixture of both).

Results and Discussion

Tree description: Study on tree shapes of three rootstocks was made to describe their morphological characteristics. All the tree of Bitter sweet orange and Yuma citrange have spheroid shape, while Sour orange tree has ellipsoid shape (Table 1). The density of branches of these rootstocks showed that tree rootstocks have variable branch density. The Bitter sweet orange and Sour orange had similar branch density, but Yuma citrange had medium density. The tree growth habit of three rootstock was similar. The branch angle of three rootstocks was found to have wide angle in these rootstocks branches Spines in Bitter sweet orange were absent on exterior side of tree but present in interior (Table 1). Yuma citrange had high spine density. Spine shapes of the Bitter sweet orange, Yuma citrange and Sour orange rootstocks were also evaluated as curved and straight and were found only with straight spine (Table 1). Frost (1935) also described tree characteristics while releasing new citrus cultivars.

Leaf description: Observations regarding leaf morphology in three citrus rootstocks are presented in Table 2. The leaves of Bitter sweet orange and Sour orange were of simple type but Yuma citrange had trifoliate leaf division. Leaf morphology varied from unifoliate to trifoliate (Dass *et al*., 1998). Similarly, the intensity of green color in leaves of Bitter sweet orange and Sour orange was dark green while Yuma citrange with medium green color. All three rootstock had brevipetiolate leaf lamina attachment. Bitter Sour orange had the highest length of leaf lamina (10.4 mm) followed by Sour orange (9.3 mm). Yuma citrange had significantly the smallest lamina with 5.7 mm length.

Table 1. Tree description of Bitter sweet orange, Yuma citrange and Sour orange rootstocks.

	Rootstock		
	Bitter sweet orange	**Yuma citrange**	**Sour orange**
Tree shape	ellipsoid	spheroid	spheroid
Density of branches	dense	medium	dense
Growth habit	spreading	spreading	spreading
Branch angle	Wide	Wide	Wide
Spine density	absent	high	absent
Spine shape	straight	straight	straight

Table 2. Leaf description of Bitter sweet orange, Yuma citrange and Sour orange rootstocks.

	Rootstock		
	Bitter sweet orange	**Yuma citrange**	**Sour orange**
Leaf division	simple	trifoliate	simple
Color intensity	dark	medium	dark
Lamina attachment	brevipetiolate	brevipetiolate	brevipetiolate
Lamina length	10.4 a	5.7 c	9.3 b
Lamina width	195.9 a	59.2 b	121.9 a
Lamina length/Width	2.8 a	2.2 b	2.3 b
Lamina shape	lanceolate-ovate	Lanceolate-ovate	lacneolate-ovate
Lamina margin	sinuate-crenate	sinuate	sinuate
Leaf apex	accuminate-acute	accuminate-obtuse	acute-accuminate
Petiole wing	present	present	present
Petiole width	narrow	medium	medium

Leaf lamina shape was lanceolate and ovate in Bitter sweet orange and Yuma citrange, respectively. The Sour orange and Yuma citrange showed sinuate leaf lamina margin. Presence or absence of petiole wing was studied (Table 2) and were found winged petiole leaves in all three rootstocks. Bitter sweet orange had narrow petiole wings as compared to medium petiole wing width in Yuma citrange and Sour orange. Width of petiole wing is a morphological marker for screening of hybrids in citrus (Ballve *et al.*, 1997; Blanco *et al*., 1998).

Fruits description: The fruit characteristics of three rootstocks viz., Bitter sweet orange, Yuma citrange and Sour orange showed mid fruiting season were evaluated (Table 3). The fruit weight indicated that Bitter sweet orange fruits were the heaviest (195.7 g) than other rootstocks. Yuma citrange fruits had the lowest fruit weight (59.2 g) while Sour orange produced (121.9 g) fruits (Table 3). Bitter sweet orange attained the maximum fruit diameter (73.7 mm) followed by Sour orange (60.4 mm). The lowest fruit diameter (47.3 mm) was recorded in Yuma citrange rootstock. Bitter sweet orange had the maximum length of fruit (76.9 mm). Sour orange was second with fruit length of 60.1 mm.

Bitter sweet orange and Yuma citrange had ellipsoid fruit shape which was more prominent over pyriform and round (Table 3). Sour orange produced spheroid shape fruits. All three rootstocks exhibited significantly convex fruit base. In Bitter sweet orange necked and truncate base was also observed. No other shape of fruit apex was noted in these rootstocks except truncate. Fruit skin of citrus rootstocks was examined to record the differences among these three rootstocks and was found yellow in color. Adherence of albedo to pulp was noted and was found variable. Sour orange and Yuma citrange had medium while Bitter sweet orange had strong adherence of albedo to pulp. Moreover, Bitter sweet orange and Sour orange fruits had fruits with white and Yuma citrange yellow albedo color.

All the fruits of Bitter sweet orange and Sour orange had strong fruit attachment while Yuma citrange had medium attachment to stalk (Table 3). Sour orange had significantly different number of segment per fruit. The highest number of segments (10.4) was recorded in Sour orange followed by Yuma citrange (9.2). Bitter sweet orange yielded the lowest (8.3) number of segment per fruit. The adherence of segment wall to each other in fruits of three citrus rootstocks investigated showed that Bitter sweet orange and Yuma citrange had medium adherence of segment walls to each other, while Sour orange fruits had strong adherence of segment walls (Table 3). The segment shape was variable in Bitter sweet orange while Yuma citrange and Sour orange fruits showed uniformity in segment shape. Bitter sweet orange and Sour orange had medium thickness while Yuma citrange should thin wall segments. Solid fruit axis was the characteristic feature of Bitter sweet orange and Sour orange whereas Yuma citrange depicted semi hollow fruit axis. Color of the pulp in Bitter sweet orange and Sour orange was white but yellow in Yuma citrange (Table 3). The pulp texture of Bitter sweet orange was crispy while in Yuma citrange and Sour orange was fleshy. Long vesicles were observed in fruit of Bitter sweet orange and Sour orange. Juice contents measured represent that Sour orange had medium juice content while the higher juice content was found in Yuma citrange.

Table 3. Fruit description of Bitter sweet orange, Yuma citrange and Sour orange rootstocks.

	Rootstock		
	Bitter sweet orange	**Yuma citrange**	**Sour orange**
Fruiting season	mid	mid	mid
Weight (g)	195.9 a	59.2 c	121.9
Diameter (mm)	73.7 a	47.4 c	60.4 b
Length (cm)	76.9 a	45.9 c	60.1 b
Shape	ellipsoid	spheroid	ellipsoid
Shape of base	convex	convex	convex-truncate
Skin color	yellow	yellow	yellow
Surface texture	rough	rough	rough
Albedo adherence	strong-medium	medium	medium-strong
Albedo color	white	yellow	white
Fruit attachment	strong	medium	strong
Segment/fruit	8.3 a	9.2 b	10.4 a
Adherence of segment	medium	medium	strong
Segment shape uniformity	yes	yes	yes
Thickness of segment wall	medium	thin	medium
Fruit axis	solid	semi- hollow	hollow
Pulp color	white	yellow	white
Pulp texture	crispy	fleshy	fleshy
Vesicle length	long	short	long
Juice content	low-medium	high	medium

Seed description: Seed characteristics of three citrus rootstocks were compared and are presented in Table 4. Bitter sweet orange had significantly higher clavate to spheroid seed shape. In Yuma citrange not only clavate but semi deltoid seed shape were also prominent. Bowman *et al*., (1995) found the relationship between seed size and shape and confirmed that seed shape and size is related with number of seedlings produced in rootstocks. The number of seed in fruit was also recorded. Bitter sweet orange had significantly the highest number of seed per fruit (27.5) followed by Sour orange (14.8).

Yuma citrange yielded the lowest (11.3) number of seeds per fruit. Seed surface of Bitter sweet orange and Sour orange was significantly smooth while Yuma citrange has wrinkled seed surface. All the three rootstock showed similar white seed color. Similarly, cotyledon color of the seed was observed as light yellow color. Seed embryony observed in these rootstocks showed Yuma citrange as monoembryonic while others were polyembryonic. This was supported by Bowman (1994).

Table 4. Seed description of Bitter sweet orange, Yuma citrange and Sour orange rootstocks.

	Rootstock		
	Bitter sweet orange	**Yuma citrange**	**Sour orange**
Seed shape	clavate-spheroid	clavate-semi-deltiod	clavate-cuneiform
No of seed/ Fruit	27.5 a	11.3 c	14.8 b
Seed surface	smooth	wrinkled	smooth
Seed color	white	white	white
Cotyledon color	light yellow	light yellow	light yellow
Seed embryony	polyembryony	polyembryony	polyembryony

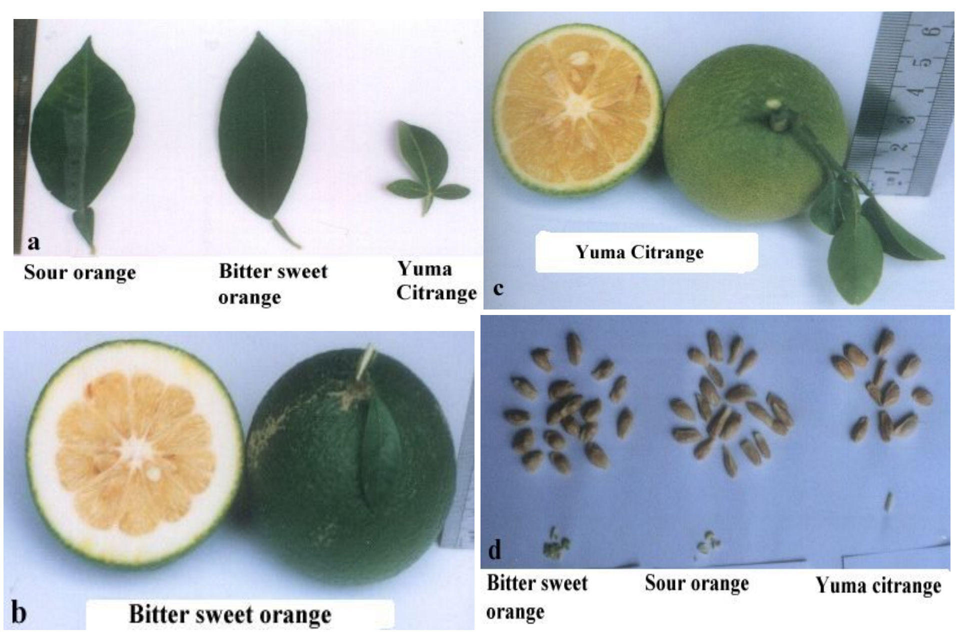

Fig. 1. a) Leaf morphology in three citrus rootstocks; b) Fruit with thick rind in Bitter sweet orange; c) Fruit of Yuma citrange with thin rind; d) Various number of seeds in rootstock fruits.

Proper identification of trees is essential to establish trueness-to-name in commercial channels. In this way identification and classification of fruit plant clones has been based on pomological description of the plant and fruit. Moreover, the testing of advanced selection and of new cultivars is an important aspect of fruit breeding (Harding, 1983) and serves two related objectives. Firstly, information from testing projects tells breeders if new cultivars are likely to fulfill their intended use and secondly, it tells growers which new items are best suited to their particular condition. The morphological descriptions are therefore very important regarding identification of different citrus rootstocks and evaluating their characteristics in breeding programs and germplasm repositories.

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(Received for publication 24 February 2006)