

Histological Parameters Related to Dwarfism in Some Mango Cultivars

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Abstract: The current study was conducted during season 2013 on fourteen mango cultivars namely 13/1, Ewais, Fajri Kalan, Hindi Besinnara, Keitt, Kent, Mabrouka, Maya, Naomi, Alphonso, Sediek, Tommy Atkins, Sukkary and Zebda. Stem anatomy conducted to examine the relation between internal structure and plant vigor. Measurements on stem cross section showed that vigour cultivars had high xylem and low phloem percentage and high number of the large vessels. The interaction between the different histological parameters reflects their dwarfing potential. Stem anatomy indicated that the studied cultivars may be classified according to the growth behavior into three categories Sukkary and Zebda were the most vigor cultivars while Hindi Besinnara, Naomi and Keitt were the most dwarfing cultivars.

Key words: Mango · Stem Anatomy · Xylem · Phloem · Dwarfism

INTRODUCTION

Mango tree (*Mangifera indica* L.) is an important fruit crop in the tropical and subtropical zones [1]. The huge size of mango trees is one of the most important problems in mango production [2]. The high cost of maintaining tree size through pruning can reduce fruit production and severely impact profitability of mango production [3]. Recently the high density orchard system became a new trend in fruit production. The possibility of establishment of the high density orchard depends on the availability of low vigor cultivars or dwarfing rootstocks [4]. The use of rootstock with dwarfing potential is a common practice in fruit tree industry [5]. Rootstock provides the possibility of reducing tree size and improves yield efficiency without increase the input costs [6, 7].

The mechanisms of vigour control by rootstock are not clearly understood, many hypotheses have proposed [8]. Dwarfing may be caused by water supply restrictions, production and translocation of hormones, the partial compatibility between the scions and rootstocks, also the dwarfing may be associated with hydraulic conductivity and anatomical characteristics of the vascular system [9, 10, 8, 11, 12].

Since the difference in rootstocks genotype vigour is reflected in root and young shoot anatomy, it may be possible to screen for size controlling rootstock by quick

examination of root or shoot anatomy [13]. Bark percentage and number of xylem can be used to classify mango rootstocks in the nursery stage also the number of vessel, vessel size and percentage of the small vessel considered as a good indicator of dwarfism [14, 13, 15].

The goal of the current research was to study the histological characteristics of some mango cultivars which may be associated with their growth behavior.

MATERIALS AND METHODS

The present study was carried out during 2013 season at the Nursery and Laboratory of Pomology Department, Faculty of Agriculture, Cairo University. Fourteen Mango cultivars with markedly different growth behavior were selected; namely 13/1, Ewais, Fajri Kalan, Hindi Besinnara, Keitt, Kent, Mabrouka, Maya, Naomi, Alphonso, Sediek, Tommy Atkins, Sukkary and Zebda.

Stem samples of the studied cultivars were collected and immediately fixed in F.A.A., dehydration of the samples was performed in increasing concentration of ethyl and butyl alcohol and then the samples were infiltrated with paraffin wax. The samples were cross sectioned by rotary microtome and stained with Safranin (Staining in red the lignified cell walls) and Light green (staining in blue green cellulose walls) and examined under light microscope [5, 16]. Images were captured by light microscope supplement with camera

(Panasonic WV-CP 220, Japan). The obtained images were subjected to analysis by image analysis software (Digimizer software package) and the following parameters were calculated: xylem area (mm) and percentage, phloem area (mm) and percentage, xylem /phloem ratio, number of vessel elements per cross section area, the mean vessel element size (µm), Percentage of xylem vessels in the different size classes and total conduit area (mm) (Vulnerability index).

After determination of each parameter value, each parameter scored from 1 to 4, the score in parameter related to vigor growth increased with increasing in parameter value while the scored in parameter related to dwarfism decreased with increasing in parameter value and the overall performance of each cultivar was calculated by summation of each parameter value.

RESULTS AND DISCUSSIONS

The stem anatomical features of the mango cultivars under investigation as seen in transverse sections shown in Figure (1). Generally, it is realized that the stem structure showed typically dicotyledons herbaceous stem structure that characterized by a remarkable thick cortex and pith. The histological measurements of the studied cross sections showed a relatively advanced degree of secondary growth. Moreover, it is evident, that the cortex showed complete ring of parenchyma that surround the stele.

The relation between each component of the stem cross section and the dwarfing potential were discussed under the following sections.

Phloem Area and Percentage: The data found in Table (1) showed that Fajri Kalan and Ewais recorded the highest phloem area on the other hand the lowest values recorded in Zebda, 13/1 and Hindi Besinnara. Also, it was cleared that percentage of phloem in all tested cultivars show that, Ewais, Mabrouka, Tommy Atkins, Fajri Kalan and Naomi cultivars recorded higher percentage of phloem comparing to the other cultivars. Majumdar *et al.* [14] found that the proportion of bark and xylem can be used to classify mango in various vigor classes in the nursery stage and they found a negative correlation between bark percentage and plant vigor. Also the vigorous rootstock Rough Lemon possessed lower proportions of phloem in the stem when compared with the less vigorous rootstock such *Poncirus trifoliata* [17].

Xylem /Phloem Ratio: Results of xylem / phloem ratio as shown in Table (1) indicated that the highest ratio was achieved by Sediek, Sukkary and Zebda compared to the other tested cultivars. Alphonso, Mabrouka, Keitt and Fajri Klan which recorded the lowest ratio.

The xylem / phloem ratio is one of the main anatomical characteristics which are frequently used in classification of rootstocks vigour. Kuriana and Iyer [18] in studies conducted on 24 mango cultivars of varying vigor; they indicated that low vigor of trees was associated with higher phloem to xylem ratio in shoots. The slower growth of dwarfing rootstocks like Fly Dragon was attributed to high bark /wood ratio in the stem [17]. Similar observations were recorded in the dwarfing apple peach rootstocks and olive [19-21, 15].

Table 1: Characterization of xylem and phloem tissues in the studied mango cultivars.

Cultivar	Xylem area (mm)	Xylem percentage	Phloem area mm	Phloem percentage	Xylem/ Phloem Ratio
13/1	0.383	19.574	0.287	14.638	1.337
Ewais	0.738	21.046	0.591	16.851	1.249
Fajri Kalan	0.637	17.486	0.568	15.579	1.122
Hindi Besinnara	0.331	13.155	0.279	11.071	1.188
Keitt	0.386	14.725	0.320	12.223	1.205
Kent	0.358	12.197	0.344	11.731	1.040
Mabrouka	0.411	17.713	0.358	15.456	1.146
Maya	0.394	12.432	0.291	9.176	1.355
Naomi	0.511	19.435	0.427	16.246	1.196
Alphonso	0.690	19.100	0.453	12.553	1.522
Sediek	0.468	21.058	0.289	12.979	1.622
Sukkary	0.626	21.556	0.366	12.589	1.712
Tommy Atkins	0.555	19.888	0.470	16.826	1.182
Zebda	0.436	21.391	0.252	12.388	1.727

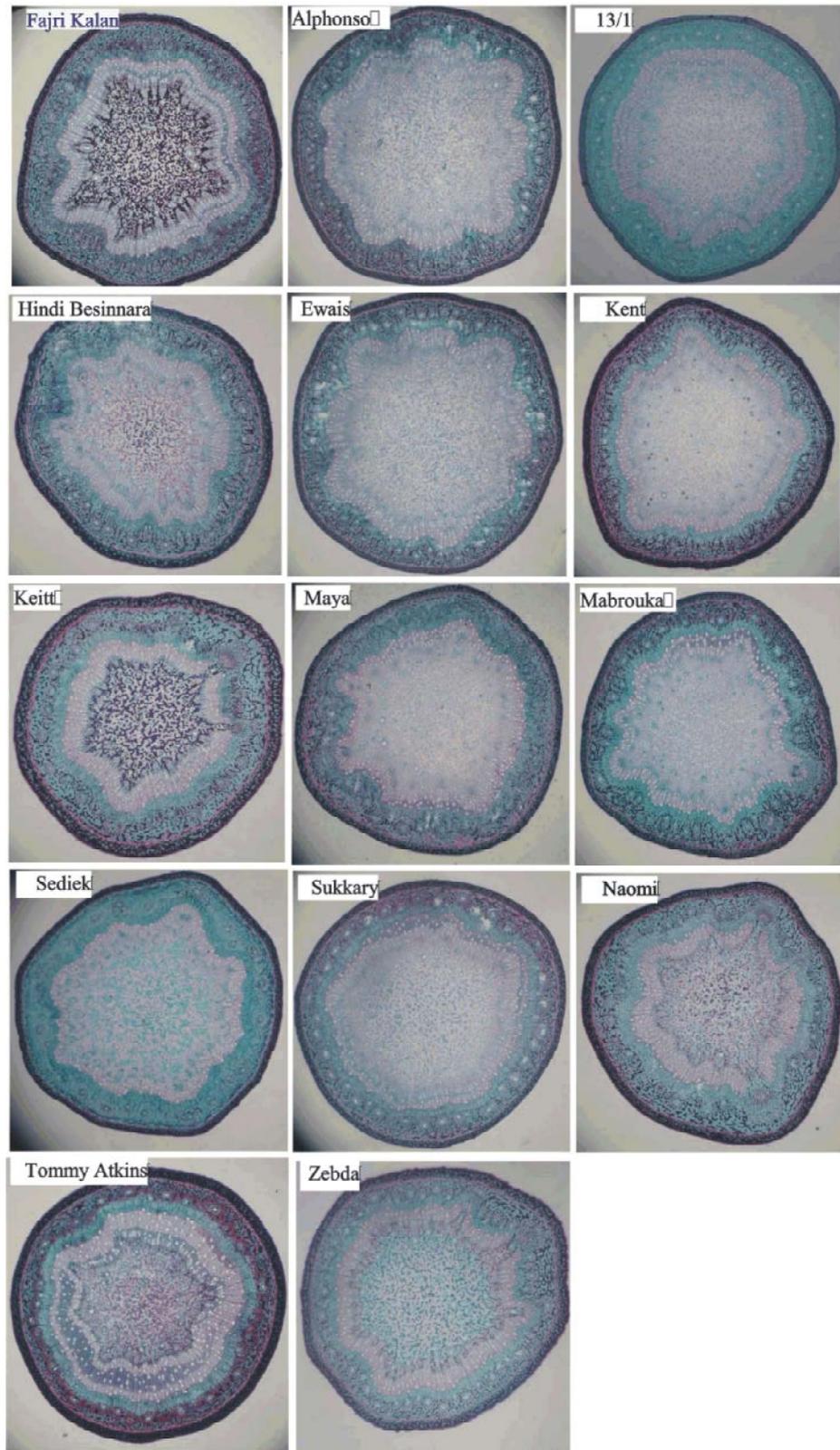


Fig. 1: Stem cross section of the studied mango cultivars (20 X).

Table 2: Vessel area, number and total conduit area in stem of the studied mango cultivars.

Cultivar	Vessel number	Average of vessel size (μm)	Total conductive area (mm)
13/1	410	0.19	0.08
Ewais	459	0.23	0.11
Fajri Kalan	488	0.26	0.13
Hindi Besinnara	333	0.14	0.05
Keitt	399	0.18	0.07
Kent	464	0.24	0.11
Mabrouka	430	0.23	0.10
Maya	299	0.27	0.08
Naomi	411	0.17	0.07
Alphonso	367	0.23	0.09
Sediek	434	0.20	0.09
Sukkary	467	0.23	0.11
Tommy Atkins	389	0.19	0.07
Zebda	432	0.26	0.11

Xylem Area and Percentage: The area of xylem tissue in the studied mango cultivars as shown in Table (1) indicated that, Ewais, Alphonso Sukkary and Fajri Kalan cultivars have a highest xylem area while, Keitt Hindi Besinnara, Kent and 13/1 recorded the lowest one.

Moreover, Sukkary and Zebda cultivars were recorded the highest percentage of xylem comparing to the other tested cultivars. On the other hand Keitt, Kent, Maya and Hindi Besinnara achieved the lowest percentage of xylem.

The area of the xylem determines the potential of water and soluble transport through the plant stem and thereby it had a direct effect on the plant growth vigor. According to Majumdar *et al.* [14] the vigor mango seedling characterized by a high xylem percentage Also Tombesi *et al.* [13] reported that the anatomical analysis of xylem could be a useful means of predicating the vigor control capacity of selected rootstocks genotype.

Number of Vessel Elements per Xylem of Stem Cross Section: The number of xylem vessel varied between the studied cultivars, data in Table (2) show that Hindi Besinnara, Keitt, Maya, Alphonso, Tommy Atkins recorded lower number of xylem vessels compared with the other cultivars.

According to Goncalves *et al.* [22] there was a lower xylem conduit in trees grafted on dwarfing rootstocks than trees on the vigor rootstocks. Also plant height had a negative correlation with the number of vessel elements in the xylem of stem, the dwarf Fly Dragon had the highest vessel frequency (140.6 vessel/ mm), while the vigor Rough Lemon rootstock had the lowest vessel frequency (48.7 vessel/ mm) [17]. According Raimondo *et al.* [23] the number of conduits was higher in the dwarf olive

rootstock 'LD' (233 conduits/ mm), while the number was only 209 conduits/mm in the vigor olive rootstock 'LM'.

The average area of the vessel unit of the studied cultivars is shown in Table (2), Zebda, Maya and Fajri Klan recorded the highest vessel size comparing to the other tested cultivars, on the other hand Hindi Besinnara cultivar was recorded the lowest value of vessel size comparing to the other tested cultivars so it may lead to use this cultivar as a dwarf rootstock thus decreasing the vessel size means decreasing in growing strength, Naomi and Keitt cultivars were near in vessel size to Hindi Besinnara cultivar, the other cultivars were achieved the intermediate vessel size comparing to the tested cultivars, so it may consider these cultivars as intermediate activator growing rootstocks.

The Average of Vessel Size: The mean xylem vessel diameter is a genetically trait associated with rootstocks vigor that was expressed in the roots and stems of peach rootstocks genotypes [24]. The anatomical measurement showed that olive cv. Leccino Dwarf had narrower xylem conduits than Leccino Manerva clone [23].

Total Conduit Area (Vulnerability Index): According to data presented Table (2) Fajri Kalan, Kent, Zebda, Ewais and Sukkary cultivars recorded the highest total conductive area while, Hindi Besinnara followed by Naomi, Keitt and Tommy recorded the lowest total conductive area. Vulnerability index affecting the growth vigor, according to Reyes-Santamria *et al.* [25] Fuerte and Hass avocado cultivars had higher value compared to the dwarf Colin V-33 which had lower vulnerability index.

Table 3: Percentage of xylem vessels in the different size classes per stem cross section

Cultivars	Size classes of xylem vessels			
	Less than 0.1	0.1-0.19	0.2-0.29	0.3 _≥
13/1	0.00	63.33	36.66	0.00
Ewais	0.00	26.66	63.33	10.00
Fajri Kalan	0.00	30.00	45.66	23.33
Hindi Besinnara'	3.33	90.00	6.66	0.00
Keitt	0.00	73.33	23.33	3.33
Kent	0.00	6.66	83.33	10.00
Mabrouka	0.00	23.33	66.66	10.00
Maya	0.00	3.33	60.00	36.66
Naomi	0.00	83.33	16.66	0.00
Alphonso	0.00	23.33	76.66	0.00
Sediek	0.00	50.00	50.00	0.00
Sukkary	0.00	43.33	40.00	16.66
Tommy Atkins	0.00	60.00	36.66	3.33
Zebda	0.00	0.00	83.33	16.66

Table 4: The overall performance of the studied mango cultivars

Cultivars	Vessel No.	Average of		Phloem area	Xylem area	Phloem %	Xylem %	Xylem/ Phloem	Total Score
		vessel Size	conductive area						
13/1	3	2	2	4	1	3	4	2	19
Ewais	4	4	4	1	4	1	4	2	24
Fajri Kalan	4	4	4	3	4	1	3	1	26
Hindi Besinnara	1	1	1	4	1	4	1	1	14
Keitt	3	2	2	4	1	3	2	1	18
Kent	4	4	4	3	1	3	1	1	21
Mabrouka	3	4	4	3	2	1	3	1	21
Maya	1	4	2	4	1	4	1	2	19
Naomi	3	2	2	2	2	1	4	1	17
Alphonso	2	4	3	2	4	3	4	3	25
Sediek	3	3	3	4	2	3	4	4	26
Sukkary	2	4	4	3	4	3	4	4	28
Tommy	2	2	2	2	3	2	4	2	19
Zebda	3	4	4	4	2	3	4	4	28

Percentage of Xylem Vessels in the Different Size Classes per Stem Cross Section: The xylem vessels varied in area of each stem section, the xylem vessels are classified into 4 categories.

- Class 1 less than 0.1 μ m
- Class 2 from 0.1 to 0.19 μ m
- Class 3 from 0.2 to 0.29 μ m
- Class 4 more than 0.3 μ m

The percentage of the vessels in the different categories varied greatly between the studied cultivars, the presented data in Table (3) indicated that for the lowest vessels diameter/ size (less than 0.1) only Hindi Besinnara cv. recorded the highest values compared to the other cultivars. While vessels in category (0.1-0.19)

Hindi Besinnara, Naomi and Keitt recorded the highest values while, Maya and Kent followed by Alphonso recorded the lowest values.

With regard to the class size between (0.2-0.29) the presented data cleared that Kent, Zebda and Alphonso recorded the highest values where the lowest observed in Hindi Besinnara, Naomi and Keitt. Finally with respect to the highest vessels size Maya and Fajri Kalan followed by Sukkary recorded the highest values while 13/1, Hindi Besinnara, Naomi, Alphonso and Sediek have no vessels in this category.

The dwarfing rootstocks had more vessels in the smaller size classes, while the more vigor rootstocks had more vessels in the larger size classes [13]. According to Tirifilo *et al.* [5] more than 65% of the xylem conduits of the Leccino Manerva ranged between 15 and 25 μ m in

diameter whereas only 15% were less than 15µm in diameter. On the other hand, shoots of the Leccino Dwarf plants had significantly narrower conduits *i.e.* over 90% of the conduits were less than 25µm and conduits wider than 25µm were about 12%.

The Overall Performance of the Studied Mango Cultivars: According to data illustrated in Table (3 and 4) the studied cultivars can be classified into 3 groups according to their histological characteristics which give an indicator about growth behavior of the studied cultivars:

- The dwarf group: this group including Hindi Besinnara, Keitt and Naomi cultivars which recorded the lowest total value comparing to the other tested cultivars.
- The Semi-dwarf group: this group including 13/1, Kent, Mabrouka, Tommy and Maya cultivars.
- The vigor group: the cultivars belong to this group including, Sukkary, Zebda Ewais, Fajri Klan, Sediek and Alphonso, which recorded the highest total value of the studied characteristics compared to the other tested cultivars.

In conclusion, it is possible to screen the dwarfing potential of different mango cultivars by examination of the stem anatomy. Phloem and xylem percentage and the percentage of xylem vessels in different size classes appear to be a good indication of the dwarfing potential.

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