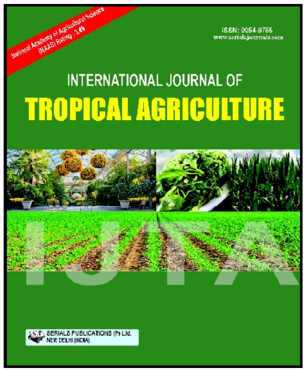


INTERNATIONAL JOURNAL OF TROPICAL AGRICULTURE

ISSN : 0254-8755

available at http: www.serialsjournals.com



Volume 36 • Number 1 • 2018

# Rootstock and Cultivar Effect on Seasonal Nutrient Variations in Apple Trees

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***Abstract:*** The study aimed to investigate the influence of leaf nutrient concentrations among different exotic cultivars on various rootstocks growing in the same conditions. As for as the rootstock are concerned $MM_{106}$ had the highest level of nutrient concentrations whereas $M_9$ had the lowest. The exotic cultivars like Vista Bella recorded highest leaf N and Fe content whereas, Cu content was observed in Cooper IV on both rootstocks. Similarly lower concentration of N and Fe was recorded in Cooper IV and Vista Bella recorded the minimum Cu content indicating a definite effect of rootstocks on translocation of nutrients within the plant system.

The seasonal variation of leaf nutrient concentrations during growth period indicate that early maturing cultivars viz, Vista Bella and Mollies Delicious recorded increase in nutrient content upto 30$^{th}$ of June, thereafter the trend decreased, while as the mid-season cultivars like Starkrimson and Cooper IV observed a similar trend upto 15$^{th}$ of July and decreased thereafter. The seasonal variation of nutrients in leaves indicate stability period of various nutrients like N, Fe and Cu in early maturing cultivars like Vista Bella and Mollies Delicious from 15$^{th}$ of June to 15$^{th}$ of July, while as in mid-season cultivars Starkrimson and Cooper IV the stability in nutrient concentration was recorded from 30$^{th}$ June to 30$^{th}$ of July indicating the appropriate leaf sampling period for these exotic cultivars as against the sampling time of existing cultivars which is from mid-July to mid-August under similar conditions.

***Keywords:*** Rootstock, cultivar, seasonal variations, nutrient concentrations

## INTRODUCTION

Mineral nutrients are greatly influenced by rootstocks, similarly different scion cultivars exhibit variable quantities of nutrients from different rootstocks (Richardson *et al.,* 2003). Wide fluctuation in nutrient concentration occur in tissues during growth period, however, most suitable leaf position and sampling time are those which gave rise to least variation in its mineral concentration, the nutrient accumulation curves of apple trees are good indicators of nutrient requirement in each plant development stage, (Hirzel and Best, 2009). The knowledge of seasonal variation in leaf nutrient concentrations is necessary in order to understand the physiology of apple nutrition, and helpful in the interpretation of leaf analysis. It will used to strength the knowledge of seasonal variations in nutrient levels of leaf that would be important to accurate prescription of subsequent fertilizer additions and will play theoretical and basic roles in practical steps for production (Nachtigall *et al.,* 2006). Nutrients are essential for the productivity and quality of different fruits; hence the determination of nutritional needs for efficient production of high quality fruit is an important aspect of nutrient management for the orchardists. Leaf is the principle site of metabolism and the optimum concentrations of nutrient in the leaf at specific growth stage have positive relationship with the leaf nutrient content and yield. Besides giving anchorage to the tree, rootstock is also responsible for the absorption of water and nutrients, storage of photosynthates and synthesis of hormones making the scion part more tolerable (Kacar, 1995).

## MATERIAL AND METHODS

The study was conducted at Central Institute of Temperate Horticulture Srinagar, India during 2013-2014 growing seasons. Starkrimson, Cooper IV, Mollies Delicious and Vista Bella grafted on $M_9$ dwarf and $MM_{106}$ semi vigrous rootstock was used in the study. Leaf samples was taken in eight different seasons (15$^{th}$ of May, 30$^{th}$ of May, 15$^{th}$ of June, 30$^{th}$ of June, 15$^{th}$ of July, 30$^{th}$ of July, 15$^{th}$ of August and 30$^{th}$ of August). Before analysis, samples was washed thoroughly with fountain water, dilute acid (0.2 N HCl) and distilled water to remove surface residues, then they kept at 65±5°C until they reached to stable weight. Nitrogen (N) concentration in samples was determined according to Modified Kjeldahl method in which 0.5 g sample digested in concentrated H2SO4 and distilled with NaOH (40%). The ammonium N was fixed in H3BO3 (2%) and titrated with 0.1N H2SO4. In order to determine Iron (Fe) and Copper (Cu) concentrations, 1 g of samples were dry ashed at 500 ± 50 $^0$C for 8 h, and the ash was dissolved in 4 ml 3N HCl and filled up with pure water. Fe and Cu concentrations were determined using atomic absorption spectrophotometer (Inal and Kacar, 2008).

Statistical analysis: Nutritional statues of apple plants were evaluated depending on the values given by Jones *et al.* (1991). Analysis of variance was performed on the data obtained from the treatments. The level of the significance (LSD at $P< 0.05$) was used in the SAS to test significance.

## RESULTS AND DISCUSSION

The data revealed that among rootstocks, semi vigrous rootstock $MM_{106}$ had significantly higher leaf N, Fe and Cu content compared to minimum on $M_9$ dwarf rootstock during the study period. The difference in the nutrient content between semi vigrous and dwarfing rootstock can be attributed to the structure of root system, rhizosphere pH and volume of root system as the dwarf rootstocks such as $M_9$ and $M_{26}$ have smaller root system so it can be the major reason for having lower nutrient concentrations in dwarfing rootstock than others (Fallahi *et al.*, 2001). This is supported by the findings of Aguirre *et al.* (2001) who observed that nutrient content of various cultivars on $M_9$ was comparatively lower than that of $MM_{106}$. This can also be attributed to the earlier start of vegetation in $M_9$ rootstock compared to $MM_{106}$ besides this $MM_{106}$ ends its vegetation late due to which it could have taken up nutrients for longer time and thus higher content of nutrients in leaves of trees on $MM_{106}$ compared to $M_9$ rootstock (Rejman *et al.*, 2002). The lower leaf nutrient concentrations in trees of $M_9$ rootstock could be due to less vigor of these trees Kucukyumuk and Erdal (2009), Dwarf rootstocks such as $M_9$ and $M_{26}$ have smaller root systems, so it can be the major reason for having lower nutrients compared to others (Erdal *et al.*, 2008).

Leaf nitrogen: The nitrogen content of different cultivars on both rootstocks showed a significant variation with maximum leaf nitrogen content was recorded in Vista Bella and Mollies Delicious where as minimum was observed in Cooper IV. The results revealed a significant difference within different sampling dates between Spring and Autumn season flushes (Fig. 1). It can be visualized from the data the highest leaf nitrogen content was recorded on 30th of June and 15th of July and the minimum on 30th of August during the studies. These higher levels of nitrogen early in the season may be due to mobilization of nitrogen from reserve source of plant taken up through the roots, rather than from recent nutrient absorption and the relationship between nitrogen accumulated in the apple during previous season and amount of reserve nitrogen remobilized for new shoots and leaf growth Fereguson and Watkins (1989). Chuntanaparb and Cummings, 1980) related this decreasing trend of nutrient content with growth dilution effect during the season. Furthermore the decrease of nitrogen at the end of sampling season may be due to remobilization of nitrogen prior to leaf fall (Clark and Smith, 1990).

Least variation period in early maturing cultivars like Vista Bella and Mollies Delicious recorded on 15th of June to 15th of July, while as in mid maturing cultivars like Starkrimson and Cooper IV it was observed on 30th of June to 30th of July (Fig. 1). This might be due to least requirement of nitrogen by the growing fruit during this period and minimum changes occurring in developed leaves. The study are in line with those of Boynton and Cain (1943) who recommended that nutrient content of apple leaves follows stability during June to August and with those of Kamboj *et al.*, (1987).

Leaf iron: Among different cultivars significantly maximum leaf iron content was recorded in Mollies Delicious and Vista Bella during the study period. Kucukyumuk *et al.* (2009) also reported that leaf iron concentrations of different apple varieties on $MM_{106}$ was highest whereas, iron concentrations were lowest on $M_{26}$ and $M_9$ rootstocks. In a study conducted by Erdal *et al.* (2008), it was also observed that leaf iron concentrations of different apple cultivars showed differences. Leaf iron content varied significantly and showed some fluctuations on various sampling timings in $M_9$ and $MM_{106}$ rootstocks with maximum leaf iron content was recorded on 15th of July and 30th of July, while as minimum leaf iron content was recorded on 15th of May during the studies. Leaf iron content indicating an increasing from 15th of May to 15th of August thereafter it decreased upto 30th of August. Iron concentrations in apple leaves increased throughout the seasons due to the low or intermediate mobility in phloem of these elements. The results are in accordance with the findings of Nachtigall Dechan (2006) who reported similar variation in leaf iron content throughout the season.

As for as the data concerning various cultivars on both the rootstocks during the study period, periodic sampling dates clearly indicate that leaf iron nutrient stability period in early maturing cultivar Vista Bella was observed on 15th of June to 15th of July and Mollies Delicious 30th of June to 30th of July where as in mid maturing cultivars Starkrimson and Cooper IV leaf nutrient stability period was observed on 15th of July to 15th of August (Fig. 02). Moreover, these results could be useful as standard reference values for the leaf analysis. Previously, similar rootstock and cultivar effects on apple leaf mineral status have also been demonstrated by Volz *et al.* (1993). The relative effects of rootstock and time of the growing season on the levels of other minerals were reasonably stable from year to year. While as variation in the levels determined by time when the leaves were sampled, the trends in mineral levels over the course of the growing season were similar among rootstocks for most of the elements studied, but significant interactions between rootstock.

Leaf copper: Leaf copper content of apple was significantly affected by rootstocks, varieties and sampling timings. The comparison between the two rootstocks indicates that significantly higher leaf copper content was recorded on $MM_{106}$ rootstock compared to $M_9$ rootstock during the study period. Rootstock and variety effects on nutrient concentration of apple trees can be explained with the genetic effect leading to different nutrient uptake capacity (Tsipouridis and Thomidis, 2005). Among the cultivars significantly maximum leaf copper content was recorded in Cooper-IV and Mollies Delicious, while as minimum was recorded in Vista Bella and Cooper-IV during the study period. Similar results were obtained by Jimenez *et al.* (2007) who reported that leaf copper concentrations significantly varied depending on the cultivars leaves of 'Monte Gala' contained higher mineral nutrients compared to the other cultivars. Mean values representing rootstocks and cultivars showed that leaf nutrient concentrations for all nutrients indicated differences within the seasons, and these variations were significant. Leaf copper content exhibited significant variation among different sampling dates with maximum recorded on 30th of May and minimum observed on 30th of August during both the years. Leaf copper content during both the years of study depicted an increasing trend from 15th of May to 30th of May thereafter it decreased upto 30th of June, then increased up to 15th of July and finally decreased upto 30th of August. Hilmelrich & Walker (1982) also reported that leaf copper concentrations decreased along the apple tree vegetative cycle. Maier Chvyl (2002) also reported that leaf copper concentration followed a cubic model for all cultivars. In general interaction effects of seasonal changes and rootstocks were found significant in copper concentrations. With regard to the micronutrients in leaves, copper showed significantly lower values in June and August than those observed during the rest of the year.

Copper concentrations showed significant differences among sampling dates and cultivars. Leaf copper content in early and mid maturing cultivars exhibited a significant variations and it was concluded leaf copper nutrient stability period in early maturing cultivar viz, Vista Bella and Mollies Delicious was observed on 15th of May to 15th of June were as in mid season maturing cultivars like Starkrimson and Cooper IV it was observed on 30th of May to 30th of June indicated a precise sampling time (Fig.03).

## Rootstock and varietal effect on quality and vegetative characteristics of apple

Fruit length and fruit diameter: The data revealed a significant difference in fruit length on various rootstocks and cultivars $MM_{106}$ rootstock recorded maximum fruit length (67.98 and 70.14 mm) as compared with $M_9$ rootstock (62.65 and 67.50 mm) during the studies. As for as the cultivars are concerned, highest fruit length (72.52 and 73.71 mm ) was recorded in Starkrimson and lowest (57.29 and 59.48 mm) was recorded in Vista Bella. Fruit diameter was maximum (77.92) recorded on $MM_{106}$ rootstock as compared to $M_9$ rootstock respectively. While as the fruit diameter was significantly affected by cultivars and recorded (82.20 and 68.16mm) fruit diameter in Starkrimson and Vista Bella respectively. Studies have shown that fruit size is smaller on the

**Table 1**

**Rootstock effect on fruit quality parameters in various exotic cultivars of apple**

| *Treatment* | *Fruit length (mm)* | | | | | | *Fruit diameter (mm)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Year 2013* | | | *Year 2014* | | | *Year 2013* | | | *2014* | | |
| | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* |
| | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | |
| SK | 71.01 | 74.03 | 72.52 | 72.04 | 75.38 | 73.71 | 73.58 | 77.28 | 75.43 | 76.05 | 82.20 | 79.12 |
| C.IV | 66.42 | 73.30 | 69.86 | 68.81 | 71.56 | 70.19 | 75.48 | 78.00 | 76.74 | 75.99 | 78.76 | 77.38 |
| MD | 57.50 | 66.30 | 61.90 | 70.40 | 73.45 | 71.92 | 67.61 | 79.87 | 73.74 | 73.68 | 75.85 | 74.76 |
| VB | 56.28 | 58.30 | 57.29 | 58.76 | 60.20 | 59.48 | 75.11 | 75.55 | 75.33 | 65.13 | 68.16 | 66.65 |
| Mean | 62.80 | 67.98 | 65.32 | 67.50 | 70.15 | 68.82 | 72.94 | 77.92 | 75.31 | 72.71 | 76.24 | 74.48 |

CD ($p \leq 0.05$)

2013= R 2.68 V 3.79 RXV 5.36 | 2013= R 4.68 V NS RXV NS

2014= R NS V 5.47 RXV NS | 2014= R NS V 5.17 RXV NS

Legend= SK= Starkrimson C.IV= Cooper IV MD= Mollies Delicious VB= VistaBella

R= Rootstock, V= variety,

**Table 2**
**Rootstock effect on agro morphological characteristics in various exotic cultivars of apple**

| *Treatment* | *Tree girth (mm)* | | | | | | *Tree height (m)* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Year 2013* | | | *Year 2014* | | | *Year 2013* | | | *2014* | | |
| | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* | *Rootstock* | | *Mean* |
| | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | | $M_9$ | $MM_{106}$ | |
| SK | 31.33 | 31.66 | 31.49 | 32.66 | 33.33 | 32.99 | 1.95 | 2.40 | 2.17 | 2.00 | 2.50 | 2.25 |
| C.IV | 23.66 | 30.33 | 26.99 | 24.33 | 31.33 | 27.83 | 2.06 | 2.20 | 2.13 | 2.15 | 2.26 | 2.20 |
| MD | 28.33 | 29.00 | 28.66 | 30.66 | 30.33 | 30.49 | 2.31 | 2.50 | 2.40 | 2.43 | 2.60 | 2.51 |
| VB | 23.33 | 28.66 | 25.99 | 24.85 | 29.75 | 27.30 | 2.06 | 2.30 | 2.18 | 2.23 | 2.36 | 2.30 |
| Mean | 26.66 | 29.91 | 28.28 | 28.12 | 31.18 | 29.65 | 2.10 | 2.37 | 2.22 | 2.20 | 2.40 | 2.31 |

CD ($p \le 0.05$)

2013 = R 2.79 V 1.06 RXV NS

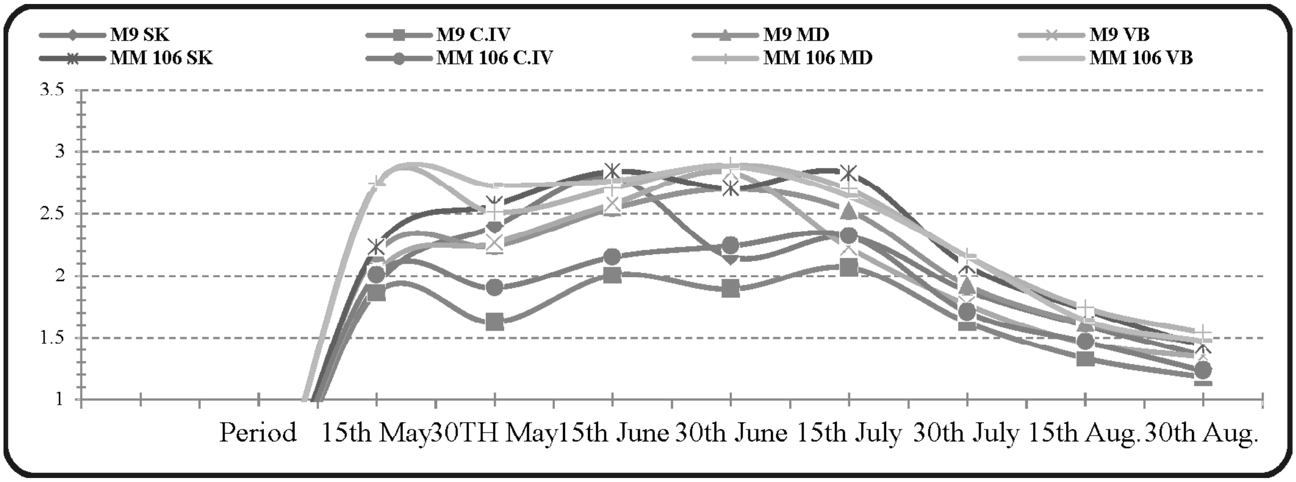
2014 = R NS V NS RXV NS

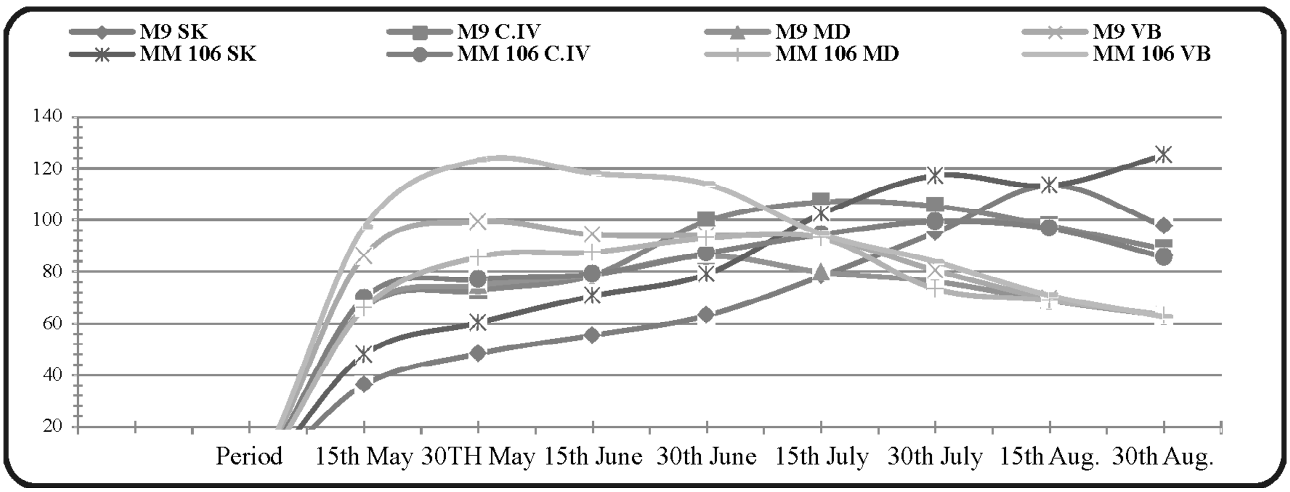
2013= R 0.07 V 0.10 RXV 0.14

2014= R 0.15V NS RXV NS

Legend = SK = Starkrimson C.IV= Cooper IV MD= Mollies Delicious VB= VistaBella

R = Rootstock, V = variety,



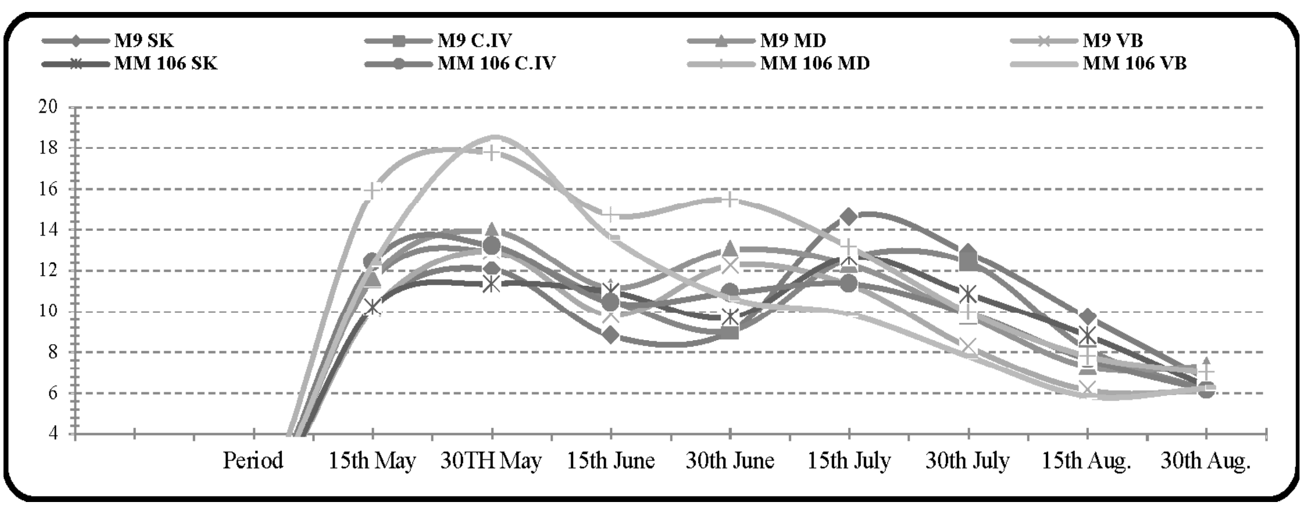




**Figure: Rootstock and cultivar effect on seasonal variation of leaf nutrient content of exotic apple cultivars**

most dwarfing rootstock like $M_9$ and large on semi-Vigrous and vigrous rootstocks such as $MM_{106}$ rootstocks. Our results are in line with those of findings of Barritt *et al*. (1995). This possibly is attributed to the fact that physiological mechanisms by which dwarfing rootstocks affect fruit characteristics can be due to the reduction in transport of nutrients and hormones, especially gibberellins across the scion/rootstock union. (El Sabagh 2012) reported that $MM_{106}$ rootstock increased significantly in Anna cultivars of apple length, size, diameter and weight compared to *Malus* rootstock.

Tree girth and tree height: Tree girth was significantly influenced by rootstock and recorded maximum tree girth of (30.75 and 30.66 cm) on $MM_{106}$ and minimum (26.66 and 29.91cm) on $M_9$ rootstock. Whereas, the cultivars showed a non significant difference during the study period. Plant height is another important characteristics of apple tree growth. During the course of studies rootstocks recorded a significant influence on tree height. Accordingly $MM_{106}$ rootstock gained a height of (2.77 and 2.40 m) and proved to be superior, while as minimum height of (2.10 and 2.20 m) was attained by $M_9$ rootstock. Hirst and Ferree (1995) reported that tree growth and development can be markedly influenced by both cultivars and rootstock. Studies also recorded scion and rootstock interaction for the size and attributed rootstock to be predominant factor controlling size. Similarly the data presented in table 2 showed that there were statistically assured difference between the cultivars for tree height, these difference could be explained only from genetic point of view. The maximum average tree height of tree was attained by Mollies Delicious (2.60 and 2.46 m) and the minimum (2.13 and 2.20 m) by Cooper IV indicating Mollies Delicious to be more vigrous than Cooper IV. These results are in accordance with the findings of Dorin *et al*. (2015). Similarly Ahmad *et al*. (2012) suggested that for the average height of trees, there are statistically assured differences between the cultivars, and the greatest tree height (325.32 cm), was obtained in 'Golab-kohans' that means this cultivar was generally more vigorous than other trees which may be result of a higher degree of shading than other cultivars.

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