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Some quantitative and qualitative traits of three apple cultivars on the MM106 rootstock

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Abstract

This research was conducted to investigate the quantitative and qualitative parameters of three apple cultivars Delbarestival, Red Monty and Fuji on the MM106 rootstock. Fruit and tree traits such as fruit set percentage, tree height, trunk diameter, leaf area, fruit weight, pH levels, sugar content and titrating acidity levels were measured. Results showed a significant difference for blossoming rate, fruit set percentage, flower and fruit drop, annual shooting length and diameter, tree height, trunk diameter, leaf area, fruit weight, fruit length/diameter ratio, pH, sugar content and titratable acidity percentage but no significant difference was found at total fruit soluble solid contents. Correlation analysis indicated that high positive correlation between the most of the vegetative parameters and some quantitative and qualitative parameters of the fruit.

Keywords: apple, rootstock, quantitative and qualitative parameters.

Introduction

Apple (*Malus Pumila* L.) belongs to Rosaceae family. The production of Apple is 2.66 MT in Iran and this country has 3th rank in the world (FAOSTAT, 2007). Apple area cultivation in Iran and Zanjan province are 222285.2 ha and 6842 ha respectively (Anonymous, 2007). Area cultivation and total production of Apple in Gheydar region (experiment location) are 1085 ha and 12453 Tone respectively.

One way for increasing of apples qualitative and quantitative yield is grafting of various cultivars on vegetative rootstocks. Thus, finding specific varieties which are compatible to a particular region is very important. In addition, the reciprocals effect of rootstock on the grafted cultivar (scion) is important too.

In countries which apples are produced in extensive scale varieties are chosen based on some factors such as climate adaptability, storability, market demand, and financial aspects. In fact, certain varieties function better than others based on their situation and location. That is why researchers today, attempt cultivating and evaluating various cultivars in different geographical locations.

Most modern orchard trees are composed of two different genetic components: A scion grafted onto a rootstock. Scions are selected in base of quality and quantity of fruit and at rootstocks for their ability to grow strong, persistent root systems in the particular soil (Cohen and Naor, 2002). Rootstocks have been chosen which can influence scion vigor, cropping, fruit quality, climatic adaptability, and susceptibility to pests and diseases (Webster, 1995).

Cultivar and the rootstock may counteract during the photosynthesis process. According to researches done on the Golden Delicious variety with five various rootstocks subjected to the same situation, The highest photosynthetic rate was measured for scions grafted on seedling although it was not significantly different from that of MM109 (Sotiropoulos,2006). Also, the leaf area index of apple trees is based on factors such as the

rootstock type, scion type pruning method, fertilizing, and other agricultural elements (Jackson, 1980). The results showed that leaf area index (LAI) was not significantly different for each rootstock even though measured leaf area (LA) per tree differed greatly (Fusheng *et al*. 2002).

The rootstock plays somewhat a role in the tree size (Parker, 1993). Rootstocks can bestow specific properties on the tree. One of the more important properties in modern orchards is a sustained reduction in vegetative growth rates, or 'dwarfing'. Several studies have hypothesized that 'dwarfing' by rootstocks results from an increase in leaf-specific hydraulic resistance, which causes reductions in canopy water status and in rates of gas exchange and subsequent growth (Kamboj *et al*. 1997) or changes in diurnal water potential variations that are related to shoot elongation (Basile *et al*. 2003). Although it is well known that there are differences to predict between apple trees and utilize this information for irrigation management. Awareness of such issues can be useful in the field of water management and future water crises (Merton *et al*. 2000).
The region of this research has ideal climate for apple production; hence, Furthermore, the results of the present study can act as a cornerstone for further research.

Materials and Methods

Geographic and Climatic features of the Study

The present survey conducted in Gheydar region at Zanjan Province that located in the northwest of Iran in 2007. This region is located between 48 degrees (55') to 45 degrees (50') longitude and 36 degrees (25') to 35 degrees (35') latitude in the northern hemisphere. Gheydar is located 1990 meters above sea level and due to its mountainous location, the area is gifted with cold and snowy winters alongside, mild and moderate summers. The average precipitation, humidity, and temperature levels of this region during 2007 are as follows (Table1):

Table1. The average precipitation, humidity, and temperature levels of experiment region during 2007

Precipitation (mm)	Min Temperature (^oC)	Max Temperature (^oC)	Humidity range (%)
496	-2	24.4	47-61

Research Design and Instrumentation

The experiment was carried out in a complete randomized block design with three cultivars grafted on the same of rootstock (MM106). The study took place under five replications and each replication had two trees of each variety. All trees were 3 years olds, and were planted at distance 2.5 x 4. In addition, certain aspects such as irrigation, fertilizing, and etc. which were in the researcher's authority were controlled for increasing the credibility and validity of the findings. Furthermore, samples were selected randomly from trees. The data was analyzed by using SPSS and means comparisons by using Duncan method at the .01 and .05 statistically levels.

Characteristics of the cultivars and rootstocks applied in the study

Fuji: The Fuji variety is a fusion of the Red Delicious and the Ralls Janet. This variety was first introduced in Japan in 1962. Regarding its physical appearance, the fruit is 50-70 % covered in red on a yellow-greenish background with a yellow-whitish, sweet, juicy, and crisp flesh on the inside. Typically, the variety ripens between October and November, and can be stored for about eight months. This variety is considered as a "good" apple and has found many admirers in today's market (Attar, 2001).

Red Monty: This new variety which was first introduced in the United States is a hybrid of the Fuji and Red Delicious cultivar. The Red Monty's outstanding characteristic is having an oval shape – similar to the Red Spare - with light green (whitish green) mesocarp on the inside. This variety ripens relatively early (late summer) and can be stored for about 4 months.

Delbarestival: This variety which is also known as Delcorf, is a combination of the Golden Delicious and the Stark Jonagrimes, and was first introduced in 1956. The exterior of this apple bares red lines on a yellow background, while the inner flesh has a creamy color and is quite crisp and tender.

The MM106 Rootstock: The MM106 was first obtained from a combination of the Northern Spy and the Malling1. This type of stock can produce trees half the size of the seedling (Hartmann *et al*. 1914).

Research Procedure

In early August, the leaf area of each tree was measured using a leaf area meter. It is also worth mentioning that in September (after the products were harvested), tree height, trunk diameter, annual shooting length, and

annual shooting diameter were measured using a yardstick (meter) and a caliper. Moreover, the length/diameter and the weight of the fruits were also recorded by a caliper and a digital scale respectively.

One of the traits is the number of blossoms during the full bloom period. First, the inflorescences were counted and having found the average of blossoms on each inflorescence, the number of blossoms on each tree was calculated. Fifteen days after the full bloom period, the number of blossoms which had turned into fruit was tallied and the difference between the percentage of intact blossoms and the previously mentioned was gauged, giving us the percentage of blossoms dropped. Furthermore, the percentage of the primary fruit set of each tree was counted and after the *June Drop* period, the number of fruits left was recounted; from the information gathered, the difference between the fruits left and the number of intact blossoms of each individual tree was evaluated giving us the percentage of the June Drop period. It should be noted that the procedure aforementioned took place in the first week of July.

Approximately, two weeks before the harvest, the fruit left on the tree were once again counted. By calculating the difference between the number of fruits left and the intact blossoms of each tree, the percentage of fruit drop before harvest was extracted.

In addition, by counting the fruit left on the tree and comparing that figure with the number of fruit left after the June Drop, the percentage of fruit drop between the two can be calculated; thus, giving us the ability to compare the drop rate percentage of the two stages (June Drop period and harvesting period).

After extracting the juice from the picked apples (selected randomly), the following analyses were conducted:

- Total soluble solid content was measured using a refractometer,
- Sugar content was recorded through the Lane- Eynons Method,
- pH level of juices were registered using a pH meter,
- Fruit acidity was recorded by titrating the juice at the 0.1 level.

Results and Discussions

A-Vegetative traits

The results also reveal significant variation in tree height; having Red Monty with the highest average and Delbarestival with the lowest (Table 2). Furthermore, tree trunk diameter varied significantly with Fuji and Red Monty having larger tree trunk diameter in comparison to the Delbarestival variety (Table 2). In fact, it should be noted that a positive correlation was discovered between tree height and tree trunk diameter (Table 4). In regard with the annual branch shooting, results again showed significant variations; Fuji and Red Monty having a higher average of annual branch growth (Table 2). The correlation coefficient calculated for the annual branch shooting, tree height, and tree trunk diameter all shows a positive trend (Table 4). Considering branch diameter, the Fuji cultivar was registered having the highest average of branch diameter, while, the Delbarestival was registered at the lowest (Table2). Once again, a positive correlation was found between tree branches (length-diameter) and tree trunk (height- trunk diameter). The results also revealed that the cultivars differed greatly in tree leaf area. In this aspect, Fuji was found to have the largest leaf area average as opposed to the Delbarestival variety with the smallest leaf area average (Table 2). The same trend (positive) was found when a correlation analysis was conducted between tree trunk diameter, annual branch shooting, and leaf area (Table4). In regard with the vegetative traits, the results reveal that the Fuji and the Red Monty outperformed the Delbarestival variety (Table2). The scion growth and vigor is influenced by many factors such as the intrinsic vigor of the scion, Vigor potential of the chosen rootstock or interstock ,climatic factors, etc, one of the most important of which is choice of rootstock or interstock. Most of these factors interact in determining the seasonal vigour of shoot growth and the eventual size of the mature tree (Webster, 1995). It seems that certain varieties, such as the Delbarestival, have fewer vegetative tendencies than others. The order and fashion which a certain cultivar grows is based on the combination of certain genetic features, Thus, making certain varieties petite and others large (Faust, 1986). Moreover, the existence of a positive correlation between such vegetative parameters gives us a better picture in the evaluation of tree vegetation and factors which assist the process.

B-Fruit formation traits

It should be pointed out, the average of intact blossoms of the different cultivars significantly differed, with the Fuji and Red Monty having a higher average in comparison with the Delbarestival variety (Table 2). The cultivars significantly differed in fruit production, giving Delbaestival and Red Monty the highest percentage of primary fruit set production respectively (Table 2). Moreover, a negative correlation was found between the number of intact blossoms and percentage of fruit production (Table5). It can be claimed that when a tree with

high potential is placed in an “ideal situation”, surely the tree will be able to blossom in greater numbers; thus, due to greater amounts of blossoming, the number of blossom drop will indeed increase at the same rate. Results also show a significant difference among the percentage of the June Drop and the blossoms counted on each variety. Red Monty and Delbarestival received the highest and lowest percent of fruit drop respectively (Table2). In addition, a positive correlation was found between the number of intact blossoms and the percentage of the June Drop (Table5). It is also noteworthy to mention the results revealed a significant difference between the percentage of each cultivar’s fruit Pre-harvest drop in ratio to the counted blossoms of each cultivar; with Red Monty receiving the highest and Fuji having the lowest proportion of fruit drop (Table 2). When contrasting the percentages of fruit drop before the harvest and the June Drop period, it can be seen that the Delbarestival had the most amount of fruit drop, with Fuji having the least. What is quite interesting is that while Fuji performed the weakest in primary fruit production, it operated better in preserving its produced fruits in comparison with the other two varieties; whereas, Red Monty and Delbarestival (while having a high percentage of primary fruit production) had a high percentage of fruit drop. The first and foremost prerequisite for suitable fruit production is having strong and powerful blossom growth, which is rooted in factors such as condition of previous autumn, specific amount of photosynthesis, sufficient nitrogen supply, and specific temperature degree during the blossoming process. A subsequent factor for fruit preservation will be providing the tree with sufficient amounts of photosynthesis nutrients during the fruit growth process (Faust, 1986). The results revealed that fruit-set was positively correlated with leaf numbers and to a less extent with flower numbers. These results showed that fruit-set is an outcome of a chain of causally – related events, basically involving the inflorescence position within the tree architecture, which affects the vegetative growth of the subtending stem,and in turn strongly determines inflorescence development(Lauri *et al*. 1996). Noting the fact that different varieties in the present study were subjected to similar climatic situations and having same rootstocks, it can probably be concluded that the genetic characteristics of each variety has a crucial role on the amount of blossoming, fruit production, and fruit drop.

Table 2. Mean Comparison of vegetative and Fruit formation traits

cultivar	tree height [m]	tree trunk diameter [cm]	annual branch diameter [mm]	annual branch shooting [cm]	tree leaf area [cm^2]	intact blossoms	primary fruit set [%]	June Drop [%]	Pre-harvest Drop [%]
Delbarstival	2.178^{b}	3.81^{b}	5.801^{b}	33.566^{b}	27.014^{b}	401.60^{b}	16.922^{a}	47.143^{c}	76.777^{ab}
Red Monty	2.460^{a}	4.70^{a}	6.400^{ab}	50.640^{a}	28.826^{b}	585.50^{a}	14.466^{a}	77.277^{a}	87.851^{a}
Fuji	2.452^{a}	5.37^{a}	6.775^{a}	56.200^{a}	32.902^{a}	691.25^{a}	9.852^{b}	62.987^{b}	69.978^{b}
DNMRT	5%	1%	5%	1%	1%	1%	1%	1%	1%

b- Fruit quality traits

The results also indicate a significant difference in fruit L/D ratio at the .01 level (Table3). Red Monty received the highest fruit L/D ratio, giving it an oval shape; whereas, the Fuji was given the lowest L/D ratio giving it a wide and stubby shape. When looking at the varieties at the .05 level, Red Monty, Delbarestival, and Fuji were placed in groups *a*, *b*, and *c* ranks respectively. This categorization indicates the additional evilness of the Red Monty in comparison to the other varieties. The outcome of the present study further showed a noticeable variation in average fruit weight (Table 3). To this end, Fuji was registered with the highest average, while; Delbarestival received the lowest weight average. Average fruit weight was most affected by number of fruit per tree when Mark was the rootstock (Marini & Barden, 2002). The present study also indicates a significant difference among the sugar content, pH levels, and titratable acidity of the cultivars (Table 3). In contrast, no noticeable variation was found in the total soluble solid contents. It can be claimed that comparing the findings, Delbarestival had the highest mean of sugar content, and the Red Monty had the highest pH level among the cultivars (Table 3). Interesting enough, Fuji was found to have the most titratable acidity while Delbarestival had the lowest among the varieties (Table3). A high positive correlation between the sugar content and the soluble solid content implies that the more soluble solid content, the higher the sugar content (Table 6). The high negative correlation between the sugar content and the acidity level implies the fact that the two have a counteractive effect on one another (Table 6). Furthermore, a negative correlation between the pH and the acidity level points out the idea that the two factors also have a counteractive association (Table6). The performance of the apple cultivar was investigated on five rootstocks, and quality parameters at harvest and after storage of fruits for 4 months were not significantly different among the rootstocks (Sotiropoulos, 2006). Fruit quality is greatly affected by the innate features of each cultivar rather than its rootstock (Autio *et al*. 2005).

Factors such as pruning and exposure to sunlight are of more importance in fruit quality than compared to the rootstock (Yahya *et al*. 2004), and many factors affect fruit quality, including genetics, soil properties, and weather conditions, but further add that fruit quality varies from year to year, and depends largely on growing conditions during the vegetative season. Nonetheless, the changes in fruit quality parameters that occur during the ripening period follow the same pattern every year (Kvikliene *et al*. 2005). However, acceptance by consumers (Gala and Elstar) seemed less dependent on firmness, soluble solids content and acidity but dependent on aroma quality and juiciness (Gasser *et al*. 2001). It seems that since identical rootstocks were employed in the present study, the role of each cultivar had a significant impact on the fruit quality.

Table3. Mean Comparison of quantitative and qualitative traits

Cultivar	fruit weight [g]	fruit length/diameter ratio	soluble solid contents [%]	sugar content [%]	titrating acidity [%]	Juice pH
Delbarstival	129.175[b]	.835[a]	15.800[a]	13.700[a]	.298[b]	3.513[b]
Red monty	152.000[ab]	.870[a]	15.600[a]	10.558[b]	.380[b]	3.685[a]
Fuji	165.225[a]	.780[b]	14.520[a]	9.742[b]	.578[a]	3.328[c]
DNMRT	5%	1%	5%	1%	1%	1%

Table4. Correlation among of vegetative traits

Traits	tree height	tree trunk diameter	annual branch diameter	annual branch shooting	tree leaf area
tree height	1.00	0.67**	0.77**	0.72**	0.42
	.	0.01	0.00	0.00	0.12
Tree trunk		1.00	0.87**	0.59*	0.74**
diameter		.	0.00	0.02	0.00
annual branch			1.00	0.75**	0.72**
diameter			.	0.00	0.00
Annual branch				1.00	0.49
shooting				.	0.07
tree leaf area					1.00

** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed)

Table 5. Correlation among of productive traits

Traits	intact blossoms	primary fruit set	June Drop	Pre-harvest Drop
intact blossoms	1.00	-0.70**	0.56*	-0.10
	.	0.00	0.03	0.72
primary fruit set		1.00	-0.32	0.39
		.	0.24	0.15
June Drop			1.00	0.50
			.	0.06
Pre-harvest Drop				1.00

**significant at the 0.01 level (2-tailed)
*significant at the 0.05 level (2-tailed).

Table 6. Correlation among of quantitative traits

Traits	sugar content	soluble solid contents	titrating acidity	Juice pH
sugar content	1.00	0.71**	-0.66*	0.24
	.	0.01	0.01	0.43
Soluble solid			-0.42	0.42
contents			0.15	0.15
titrating acidity				-0.68*
				0.01
Juice pH				1.00

** Significant at the 0.01 level (2-tailed)
* Significant at the 0.05 level (2-tailed).

Conclusion

In modern apple cultivation, other than the production of suitable and acceptable products for the market, objectives such as an increase in income from enhanced production (both qualitative and quantitative) are of great essence. On the other hand, the examination and investigation of fruit quality is not a one-dimensional task and must be evaluated from various aspects. In fact, with the consideration of aspects such as administrative decisions based on regional and cultural demand, agriculturists must be in pursuit of newer, more enhanced methods to fulfill these ends. One of the most effective methods for doing so is by choosing and producing varieties which function better (both qualitatively and quantitatively). With a systematized marketing plan, this itself, can lead to the economic developments and become a major source of income for that particular nation. In order to choose suitable varieties which function better, the investigation of the qualitative and quantitative parameters of various cultivars in potentially vegetative locations is necessary. This matter can only be accomplished through the systematic investigation of the cultivars over several vegetative seasons (a period of 6-8 months). In order to gaining at a reliable and valid conclusion, it is recommended that the study be conducted over a number of consecutive years, while taking all influential factors into consideration.

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