ROOTSTOCK AND INTERSTOCK EFFECTS ON CARBOHYDRATE AND N, P, K CONCENTRATIONS OF APPLE NURSERY TREES

EFECTELE CONCENTRAȚIEI CARBOHIDRAȚILOR ŞI N, P, K ASUPRA PORTALTOIULUI DINTR-O PEPINIERĂ DE MĂR

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Abstract. *Different interstock combinations have been investigated for different purposes in apple growing so far. Some of them are still being applied in practice and positive results are observed. This study has been conducted to determine the effects of different variety/interstock/rootstock combinations on some physiological characteristics in apple nursery trees. For this purpose, Fuji (vigor) and Red Chief (spur) apple varieties have been grafted using three different interstock/rootstock combinations (MM106/M9, MM106/seedling, M9/seedling). The cultivar 'Fuji' had higher total leaf area than 'Red Chief'. Interstock/rootstock combinations did not have a significant effect on the leaf area. Root carbohydrate was detected as higher concentration than leave in both cultivars. On the other hand, N concentration of roots was lower than the leaves. Generally CH:N of leaf was high in nursery trees grafted on seedling. There were no significant differences among the interstock/rootstock combinations in terms of the total carbohydrates, C:N ratio, chlorophyll. However, it has been determined that cultivars have significant effects on these parameters.*
Key words: M9, MM106, seedling, interstock

Rezumat. *Diferite combinații de altoi au fost studiate până în prezent pentru diferite scopuri în cultivarea mărului. Câteva dintre acestea sunt încă aplicate în practică şi au efecte pozitive. Acest studiu s-a realizat în vederea determinării efectelor diferitelor combinații varietate/altoi/portaltoi asupra unor caracteristici fiziologice ale merilor din pepiniere. Pentru acest scop s-au folosit varietățile de măr Fuji (pentru vigoare) şi Red Chief (pentru ramificație) care au fost altoite folosindu-se trei combinații diferite (MM106/M9, MM106/răsad, M9/răsad). Cultivarul 'Fuji' a avut suprafața totală a frunzelor mai mare decât cea a cultivarului "Red Chief". Combinațiile altoi/portaltoi nu au avut efecte semnificative asupra suprafeței frunzelor. Carbohidrații din rădăcini au avut concentrații mai mari decât în frunze pentru ambele cultivare. Pe de altă parte concentrația de azot din rădăcini a fost mai scăzută decât cea din frunze. În general raportul CH:N din frunze a fost mai ridicat la pomii din pepinieră care au fost altoiți cu răsaduri. Nu s-au înregistrat diferențe între combinațiile de altoi/portaltoi în ceea ce priveşte carbohidrații, raportul C:N, clorofila. Cu toate acestea s-a determinat că aceste cultivare au efecte semnificative asupra acestor parametri.*
Cuvinte cheie: M9, MM106, răsad, altoi

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INTRODUCTION

Size controlling of apple tree using rootstock are well-known practice to effective, modern high density orchard-management systems. Also, dwarf rootstocks can provide to size control, labor shortages and enhanced tolerance to abiotic and biotic stress factors. Interstock using in the world has been applied to provide disease-pest control (Jackson, 2003), to overcome soil-borne adversities (Hrotko and Magyar, 2004), to avoid cold damage (Balkhoven *et al.,* 2000). Combination of semi-vigorous rootstocks, that are resistant to woolly apple aphid infection of roots, with a dwarfing interstem to obtain small manageable trees is studied in New Zealand (Palmer *et al.,* 1997). Dwarfing interstems, such as M9, on semi-vigorous rootstocks MM106 can be efficient small trees (Carlson, 1978, Ferree and Carlson, 1987).

On the other hand, rootstock can affect the bearing, productivity and orchard lifetime. Vigor rootstocks have some advantages such as, strong anchorage drought resistance etc. In the specific ecology as windy, wet-heavy soil or drought climate, growers can request an appropriate rootstock. In this situation a dwarf interstock grafted between vigor rootstock and scion to get a dwarf and strong-free-standing tree. These trees combine strong root system and early bearing. Many researches have confirmed that interstock controls size and increases yield and quality (Westwood, 1993; Wertheim 1998, Özongun, 2014).

The interactive relation with scion and interstock-rootstock is not fully explained, but many researchers have produced many hypotheses such as nutrient and water transportation, carbohydrate distribution, hydraulic and hormone communication (Jackson, 2003; Özongun, 2014). The aim of this work was to test some rootstock and interstock combination influences on carbohydrate (C), SPAD and N, P, K concentration of apple nursery trees. The experiments were assessed during two consecutive year period with consistent results; the data presented here are from the second experimental year.

MATERIAL AND METHOD

The trial was conducted at the Fruit Research Institute situated in Isparta province (lat. 37^o 48' 52.16'' N and long. 30^o 52' 39.66'' E; altitude: 920 m) of Turkey. 'Red Chief' (spur) and 'Fuji' (vigour) varieties were used as scion in the trials. The interstocks (M9 and MM106) were grafted with whip graft at 10 cm height of rootstocks (*Malus sylvestris* seedling and M9) in late February (tab. 1). Then, these materials were planted in graft plots and were sprouted in same vegetation season for T-budding. In August, scion varieties budded onto interstock above 30 cm.

Table1.

Rootstock and interstock combinations of trail

Treatments	Rootstock	Interstock	Number of graft
MM106/Seedling	Seedling	MM106	2
M9/Seedling	Seedling	M9	2
MM106/M9	M9	MM106	2
Seedling	Seedling	-	1
MM106	MM106	-	1
M9	M9	-	1

Total leaf area was assessed on the 10 leaves randomly collected from each block in the last week of July. 10 leaves for each selected tree were measured using a digital roller-type planimeter (Placom KP-90N, Koizumi, Japan). The chlorophyll meter Spad-502 Plus portable device (Konica Minolta, Osaka, Japan) was used for measure to leaf greenness. The non-destructively measures of leaf greenness were assessed with using 30 leaves per replicate. This experiment was applied afternoon in a day. Leaves samples for the physiological analyzes *i.e*., total carbohydrates and nutrient contents, were collected in the last week of July. The root sample collected from defoliated nursery plants. Initially, leave and root samples were decontaminated and rinsed with tap water, 2 N HCl and distilled water. Then, samples were dried at 35 ^{o}C during 1 day and at 70^{o}C till constant weight, and then ground for sieving. Total carbohydrates were determined with a spectrophotometer (UV-1800, Shimadzu, Kyoto, Japan) according to the anthrone method described by Kaplankıran (1992). The total nitrogen (N) was determined using Kjeldahl method with a distillation unit (Gerhardt, Königswinter, Germany). The ratio of the total carbohydrate to N (C:N) was calculated. Concentrations of phosphorus (P), potassium (K) were determined with an inductively coupled plasma spectrometer (Perkin-Elmer, Optima 2100 DV Optical Emission Spectrometer, Shelton, CT 06 484, USA). The concentrations of total carbohydrates and some macro elements (N, P and K) in leaf and root tissues were expressed on a dry-mass basis.

The treatments employed in a randomized complete block design with three replicates and each replicate contains 25 plants. The variables were subjected to an analysis of variance (ANOVA) using SAS-JMP software version 7.0. Results were expressed at the $P < 0.05$ level of significance.

RESULTS AND DISCUSSIONS

Through the propagation method in this research, nursery plants with interstock were obtained in two vegetation period as well as classic nursery propagation. Also, the graft success has been remarkable high although these nursery plants have 2 graft unions.

The vigour cultivar ‘Fuji’ had higher total leaf area than ‘Red Chief’. The differences in cultivar’s vigour affected directly leaf area, and this result might be attributed to nutrition reserve of scion cultivar (Atay and Koyuncu, 2013). Jackson

(1997) reported that the extent of leaf area depends on the cultivar. Interstock/rootstock combinations did not have a significant effect on the leaf area for both cultivars. However, M9 was able to produce more leaf area for 'Fuji' (42.4 cm^2) and 'Red Chief' (34.2 cm^2) (tab. 2) compared to other rootstocks. Similar findings were reported by Gjamovski and Kiprijanovski (2011) which 'Grany Smith' trees grafted on Jork 9, Pajam 2 and M.9 EMLA have the highest leaf area per tree.

A positive linear relationship has been demonstrated between SPAD measurements and total extracted chlorophyll (TCHL) for a range of plant species however, models differed between field and greenhouse grown trees (Richard *et al.,* 1990). So, in our trail there was no significant effect of rootstocks on SPAD values. Also, the SPAD values of two cultivars were almost same, and have no significant. Atay and Koyuncu, (2013) points out that leaf area and SPAD of apple trees are strongly evaluated with together for explicable as physiological. Generally, there is close relationship between leaf area and photosynthesis (Kviklys *et al*., 2008).

The total carbohydrate and C:N ratio values of root were higher than the leave of both 'Fuji' and 'Red Chief' cultivars (tab. 2). Root reserves have a role as an important and perhaps the major source of substrates for the subsequent year's early respiration, growth, and development. The sensitivity of root reserves to late-season stresses may disproportionately affect plant performance and yield, particularly for early flowering and fruiting (Wayne *et al.,* 1990). Nonetheless, the root system nearly always contains higher concentrations of nonstructural carbohydrates than any other portion of the tree, and therefore has been considered the main site of carbohydrate storage. Several kinds of data support this conclusion for apple (Abusrewil *et al.,* 1983; Chong, 1971; Grochowska, 1973). There were no evident differences among the interstock/rootstock combinations in terms of the total carbohydrates and C:N ratio. In overall, C concentration of root and leaf of nursery plant with interstock was lower than the without interstock. In consideration rootstocks and interstocks generally, C and CH:N ratio of roots were detected high values in all MM106 combination and followed by seedling. The leaf C and CH:N values of apple nursery trees which grafted on seedling were generally high. Study of rootstock and scion interactions demonstrated that certain rootstocks resulted in greater dry weight of both roots and shoots, but scion effects on the rootstock were complex (Brown *et al.,* 1985). Further work in this area may clarify the role of root reserves in rootstock and scion performance.

Table 2

Effects of rootstock/interstock combinations on mean (±s.d.) total leaf area (TLA), SPAD values, Total carbohydrate concentration and C:N of 'Red Chief' and 'Fuji' apple cultivars

Cultivar	Rootstock	TLA (cm^2)	SPAD	Total carbohydrate (%)		C:N	
				Root	Leaf	Root	Leaf
Red Chief	MM106/Seedling	33.63^{ns}	56.33	9.10	2.14	9.72	0.72
	M9/Seedling	32.00	57.60	8.28	2.86	11.15	0.96
	MM106/M9	32.14	58.30	8.64	2.75	7.87	1.17
	Seedling	29.00	55.28	10.56	4.32	9.96	1.42
	MM106	32.20	58.38	12.87	3.16	14.63	0.96
	M9	34.20	56.72	9.62	4.35	8.91	1.35
	Mean	*31.79 ±1.7*	*57.18 ±1.34*	*9.85± 1.68*	*3.26 ±0.89*	*10.37 ±2.35*	*1.10 ±0.19*
Fuji	MM106/Seedling	40.85	56.43	8.38	2.40	12.36	0.72
	M9/Seedling	41.79	55.78	7.92	2.86	8.32	0.91
	Seedling	36.00	57.65	11.73	4.41	16.29	1.25
	MM106	35.10	57.00	12.64	3.34	19.45	1.04
	M9	42.40	57.99	8.39	3.53	8.93	1.02
	Mean	*39.22 ±3.41*	*56.97 ±0.89*	*9.81 ±2.19*	*3.31 ±0.75*	*13.07 ±4.77*	*0.99 ±0.19*

ns: nonsignificant p≤0.5

On the other hand, N concentration of roots was lower than the leaves for two cultivars (tab. 3). There was no significant difference between all rootstocks and interstock. Nitrogen metabolism and carbohydrate metabolism are interrelated, because carbon assimilation depends on N metabolism to provide the photosynthetic machinery, and N assimilation requires carbohydrate input for the carbon skeleton and energy supply (Cheng and Fuchigami, 2002). Because the reserve nutrients are necessary to support initial growth and development the following spring, the reserve of nursery plant nitrogen (N) and carbohydrates by the end of the growing is more important. This is supported by some investigates of Titus and Kang (1982), Tromp (1983), Oliveira and Priestley (1988), Loescher *et al.* (1990). In addition, Cheng and Fuchigami (2002), reported that an understanding of whether reserve N or reserve carbohydrate limits growth in the spring has important practical implications for managing reserve N and reserve carbohydrates to improve apple tree performance.

There was not a significant effect of interstock/rootstock combinations on P and K nutrients, and nearly the same effect were recorded in both treatments. While root P concentration of 1-yer-old-apple nursery tree at the end of the growing season was similar to laves, root K was evident low than those of leaves. Given that most cultivated deciduous fruit trees are complex genetic systems with rootstocks chosen in many cases for growth control, nutrient uptake characteristics, and, ultimately, such factors as fruit quality and yield efficiency (Westwood, 1993), there is surprisingly little information on root reserves in different rootstocks. Study of rootstock and scion interactions demonstrated that certain rootstocks resulted in greater dry weight of both roots and shoots, but scion effects on the rootstock were complex (Brown *et al*., 1985). Further work in this area may clarify the role of root reserves in rootstock and scion performance.

Table 3

Effects of rootstock/interstock combinations on mean (±s.d.) leaf and root macro element concentration of 'Red Chief' and 'Fuji' apple cultivars

Cultivar	Rootstock	N (%)		P(%)		K(%)	
		Root	Leaf	Root	Leaf	Root	Leaf
Red Chief	MM106/Seedling	0.84^{ns}	2.97	0.17	0.24	0.52	1.98
	M9/Seedling	0.81	3.00	0.21	0.26	0.46	1.96
	MM106/M9	1.10	2.52	0.12	0.28	0.43	2.04
	Seedling	1.06	3.05	017	0.26	0.50	2.31
	MM106	0.88	3.28	0.18	0.27	0.52	2.00
	M9	1.08	3.22	0.19	0.24	0.42	2.09
	Mean	*0.99±0.13*	*3.01±0.27*	*0.17±0.01*	*0.26±0.02*	*0.48±0.04*	*1.96±0.33*
Fuji	MM106/Seedling	0.68	3.31	0.19	0.28	0.45	1.98
	M9/Seedling	0.95	3.16	0.16	0.27	0.57	1.99
	Seedling	0.72	3.54	0.19	0.17	0.51	1.74
	MM106	0.65	3.20	0.18	0.21	0.49	1.80
	M9	0.94	3.47	0.15	0.23	0.46	2.26
	Mean	*0.79±0.15*	*3.34±0.17*	*0.17±0.02*	*0.23±0.04*	*0.50±0.05*	*1.95±0.20*

ns: nonsignificant p≤0.5

CONCLUSIONS

Some of the shortcomings of rootstocks can be (partly) eliminated by inserting a third cultivar between the rootstock and the scion. The rootstocks have different characteristics and may adapt to different ecological conditions. Therefore, it is necessary to thoroughly research their behavior in the adequate agro-ecological conditions related to characteristic of cultivar and growing technology. The scion-rootstock relationship is fundamental for optimal growth, water and nutrient uptake and transport. A deficiency in these physiological statuses might cause suppressed growth the scion cultivar. Therefore, rootstock and interstock selection for intended purpose (stress, etc.) must be made carefully. Based on our results interstock has no any unfavorable affect about C, C:N and some macro elements concentration of apple nursery trees. However, it has been determined that cultivars have significant effects on these parameters.

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