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THE EFFECT OF DEFICIT IRRIGATION ON THE GROWTH OF SOME APPLE SEEDLINGS ROOTSTOCKS

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Abstract

The present investigation has done at the Agricultural Scientific Research Center in Sweida, Syria to study the effect of deficit irrigationon the growth of five apple seedlings rootstocks genotypes in the nursery, to estimate their ability to drought tolerancein the lack of water resources and the hold of rain, by applying two irrigation levels: 100% of water requirement (control), the second 75% of water requirement (deficit irrigation treatment). Many parameters were measured: shoot length, leaves number, leaflength and width, main and secondary root lengths and dry matter partitioning in leaves, shoots, stem and roots at each level. The results showed the effect of deficit irrigation treatment on studied genotypes by the reduction of shoots length, leaves number and leaf length and width at deficit irrigation treatment comparing with the control. On the other hand, the main root length was insignificantly higher at the deficit irrigation treatment in the genotypes A, B and H than the control, and the secondary roots length were significantly higher in the genotypes A, C and S2 at the deficit irrigation treatment than the control. The dry matter partitioning decreased in leaves, shoots and stem and increased in the fine and coarse roots at the deficit irrigation treatment as a response to drought condition. However, there was a difference between studied genotypes due to the difference of their vigor. Consequently, all studied genotypes responded to deficit irrigation treatment, so it is necessary to test these genotypes under 50% of water requirement to select the most tolerance genotype.

Key words: *apple, deficit irrigation, seedling rootstock*

Introduction

The Mediterranean region is the most vulnerable to climate change because of its sensitivity to drought, rising temperatures and water scarcity. Drought is the major problem for agriculture and leads to the reduction of crop yield (Farooq *et al*., 2009) especially in fruit trees. Apple is one of the main trees in Syria and play an important role in commodities balance. As in most of plants, water relations are critical to the function of the apple tree, as water is the greatest component of the tree by mass, and even essential processes can be limited by inappropriate water status (Lakso, 2003), so the current production systems should be modified to preserve fruit trees and conserve the limited water resources (Sun *et al*., 2012), in addition to improve water use efficiency (Bassett *et al*., 2011). Irrigation management strategies shift from emphasizing production per unit area towards maximizing the production per unit of water consumed (Fereres and Soriano, 2007). Deficit irrigation is one of the new irrigation techniques that applied by adding water below the full crop requirements, and considered as an important strategy to increase the efficiency of using available irrigation water (Kirda, 2002; Marsal *et al*., 2002) Many researchers applied deficit irrigation on apple trees to study its effects on different growth indicators like trunk diameter, vegetative growth, fruit traits and productivity (Lancu, 1985; Mpelasoka*et al*., 2001; Caspari*etal*., 2004; Einhorn and Caspari, 2004; Connell and Goodwin, 2007).

Recently, deficit irrigation researches on apple trees are concerned with the role of the rootstock and its response to deficit irrigation which lead to increase the efficiency of water use.Vegetative and seedling apple rootstocks grafted with commercial cultivars were subjected to determine the effect of deficit irrigation on fruit quality and quantity by applying three irrigation levels ;100%, 75%, and 50% of water requirement (Sakalauskaite *et al*., 2006; Hasani *et al*., 2009). Likewise, apple rootstocks showed different responses to drought tolerance when exposed to gradually reducing water irrigation until natural soil drought conditions at the early stage of vegetative growth (Atkinson *et al*., 1999). On the other hand, apple seedling rootstocks derived from different apple species showed an important traits to improve the ability to drought conditions due to the root architecture system (Wertheim and Webster, 2003;. Webster and Wertheim, 2003). According to the main role of apple rootstocks breeding program in Syria to produce drought tolerant rootstocks, the present investigation was carried out to evaluate the response of apple seedling rootstocks to deficit irrigation at early stage of growth under limited water resources.

Materials and methods

The present investigation was carried out at the agricultural scientific research center – GCSAR- in Sweida province, which is located 1525m altitude at the south of Syria.

Plant Material

One year old apple seedlings from five apple genotypes were introduced into apple rootstock breeding program in Syria: A, B and C genotypes produced by open pollination, S2 is local apple cultivar (Sukari), and H is a hybrid genotype between the rootstock MM106 and the local apple cultivar Sk (Skarji).

Cultivation and Water Treatments

Three seedlings from each genotypes were planted in each replicate, in an average 3 replicates in each treatment, the planting distance was 25 cm between plants, 1 m between lines and 3 m between treatments. Seedlings were pruned after a period of growing with keeping 3 shoots on each seedling. Two levels of water treatment were attained by applying two irrigation regimes: 100% of water requirement (control), and 75% of water requirement (deficit irrigation treatment).

After irrigation was stopped, the following measurements were applied:

- shoot length, leaf number, leaf length and width and main and secondary root length were calculated for each genotype and its seedlings in the two treatments**.**- Dry matter partitioning: plants were divided into leaves, roots, stem and shoots then dried at 80º C to constant weight (except root). Roots were washed gently and then separated by hand into fine roots (< 2 mmin diameter) and coarse roots (> 2 mm in diameter) according to Atkinson *et al.*, (1999), then roots were dried at 80º C to constant weight and the amount of dry matter in both size classes was determined.

Experimental Design and Statistical Analysis

Factorial experiment in a simple randomized block design to compare the five genotypes at two levels of irrigation. The analysis of variance was done using two way ANOVA to compare means of measured parameters by LSD test ($p < 0.05$).

Results and discussion

Shoot length

Data showed that the shoot length was higher in control than deficit irrigation treatment except genotype H which reflected the response of seedlings to drought conditions by decreasing the vegetative growth then reduction water lose throw transpiration (Atkinson *et* *al*., 1999). The studied genotypes revealed different responses against the two irrigation treatments (Figure 1), The genotypes C and S2 revealed high significant shoot length (74,7 and 70.7 cm at the control, then 60 and55 cm at the deficit irrigation treatment, respectively) than genotypes A (59 cm and 45 cm, respectively), B (52 cm and 37.3 cm, respectively), and H that showed low variance of shoot length between the two treatments (44 cm at the control and 47 cm at the deficit irrigation treatment) which related to its parentage as a hybrid between semi vigor (MM 106) rootstock and vigor parents (Skarji) cultivar.

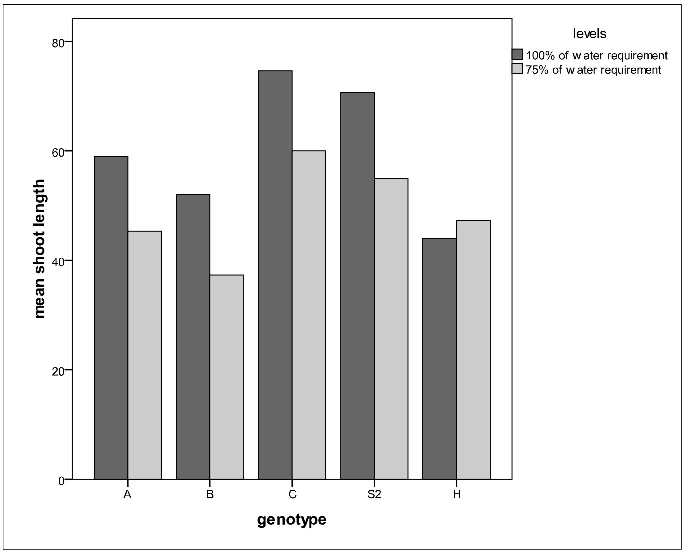

Figure 1: Shoot length at the two irrigation treatment within studied genotypes.
LSD5% = 6.8 between the two treatments, LSD5% = 15 among genotypes.

Leaves number

The number of leaves was higher at the control than at the deficit irrigation treatment for all seedlings of studied genotypes except H genotype (112 at the control and 150 leaves at the deficit irrigation treatment) as a response of plants to deficit irrigation. All genotypes revealed noticeable decreasing of leaves number at the deficit irrigation treatment in the comparison with the control except H genotype which related to the architecture system of each genotype, number of leaves related to internodes length and differ in compact growth system than standard growth system (Figure 2), seedlings of genotype C gave the highest number of leaves (220 and 175 at the control and at the deficit irrigation treatment, respectively). On the other hand, except genotype H, all other genotypes showed different responses to the reduction of leaves number; Genotype A showed limited reduction of leaves number at the deficit irrigation treatment, followed by genotypes S2, C, and B respectively. The reduction of leaves number considered as an indicator to the response to drought conditions (Atkinson et al.,1999).

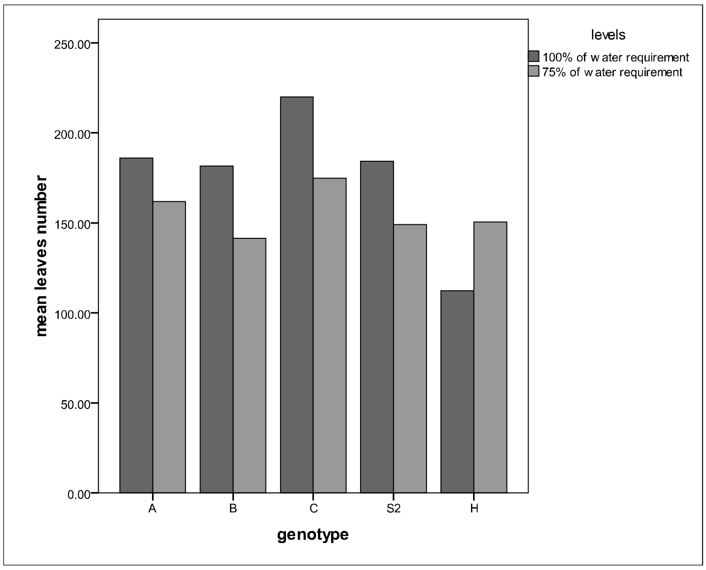

Figure 2: Leaves number at the two irrigation treatment within studied genotypes.
LSD5%= 22.7 between the two treatments, LSD5%= 35.2 among genotypes.

Leaf length and width

Data showed that the control significantly revealed higher leaf length and width for all studied genotypes than the deficit irrigation treatment except S2 genotype due to the response of plants to drought conditions (Atkinson *et al*., 1999; Sakalauskaite *et al*., 2006). The studied genotypes were varied in their response to deficit irrigation (Figure 3), genotypes C, S2 and H significantly revealed high leaf length and width than A and B genotypes which related to the growth habit for each genotype (Al-Halabi *et al.*, 2012).

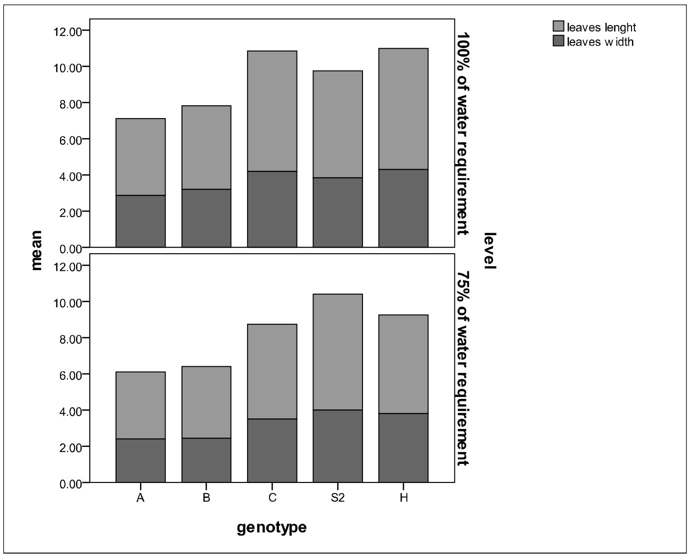

Figure 3: Leaves length and width at the two irrigation treatment within studied genotypes.
LSD5% = 0.5 and 0.4 for leaf length and width respectively between the two treatments,
LSD5% = 0.8 and 0.6 among genotypes for leaf length and width respectively.

Main and secondary root length

The main root length was higher at the deficit irrigation treatment in the genotypes A, B and H than the control, but these differences were insignificant, while the main root length in the genotype S2 and C was insignificantly shorter in deficit irrigation treatment than the control.

The main root length of genotype C was the highest one of all studied genotypes in the control, while the genotype H showed the highest main root length of all studied genotypes in deficit irrigation treatment (Table 1). On the other hand, the secondary roots length were significantly higher in the genotypes A, C and S2 at the deficit irrigation treatment than the control. Table 1 showed that the genotype S2 distinguished by the highest secondary root length (29.8 cm) of all studied genotypes at the deficit irrigation treatment. These results indicated the response of studied genotypes to deficit irrigation condition through deepening their root system into the soil (Dudley, 1996).

Table 1: The main and secondary root length at the two irrigation treatment within studied genotypes

Genotype	Main root length (cm)		Secondary roots length (cm)	
	Control treatment	Deficit irrigation treatment	Control treatment	Deficit irrigation treatment
A	43	53	21.3	28.5*
B	42.2	53.2	18.5	17
C	63	53.5	18.5	28.4*
S2	56.8	54	21.7	29.8*
H	37.3	58.7	25.8	28
LSD5%			4.4	

*indicated to significant difference between treatment

Dry matter partitioning

Figure 4, showed that the dry matter significantly decreased in leaves in A, C and H genotypes at the deficit irrigation treatment than the control, while genotypes B and S2 showed insignificant differences between two treatments. In addition, the dry matter of shoots and stem significantly decreased in all genotypes at the deficit irrigation treatment than the control, except genotype B. These results were in agreement with Atkinson *et al*. (1999) and Sakalauskaite*et al.* (2006) that the response to drought condition occurred through decreasing dry matter in leaves, shoots and stem. In contrast, the differences in dry matter partitioning in fine and coarse roots were insignificant between the two treatments. This indicated that the dry matter partitioning decreased in leaves, shoots and stem and increased in the roots at the deficit irrigation treatment as a response to drought condition according to Wilson (1988). On the other hand, the studied genotypes were differed in dry matter mass due tothe ability of rootstocks to decrease the dry matter partitioning in leaves, shoots and stem according to their growth vigor (Atkinson *et al*., 1999).

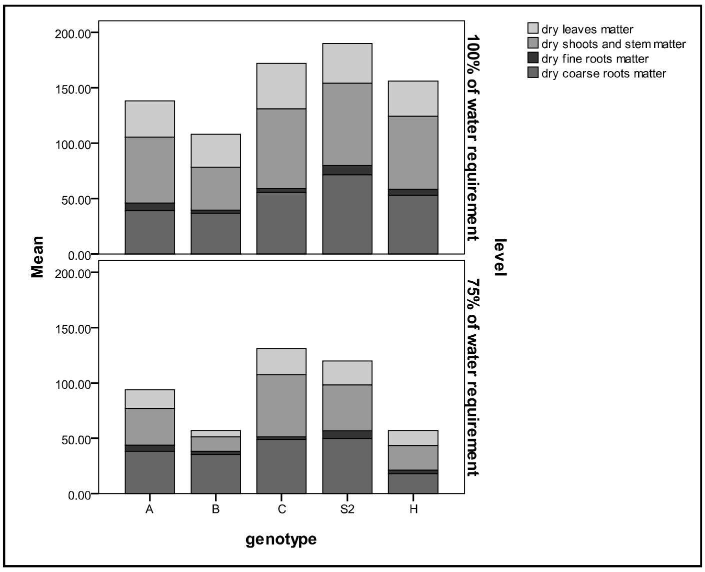

Figure 4: Dry matter partitioning at the two irrigation treatment within studied genotypes LSD5% = 14.1 and 16.3 for leaves dry matter and shoots and stem dry matter respectively between the two treatments, LSD5%= 25.8 among genotypes for shoots and stem dry matter, LSD5%= 2.3 and 11.5 among genotypes for fine roots and coarse roots respectively.

Conclusion

As a result the studied genotypes showed the ability to tolerate the deficit irrigation conditions in early stage through deepening their root system, on the other hand, shortening shoots length, reducing leaves number and leaf length and width. In addition to decrease dry matter partitioning in leaves, shoots and stem, in contrast, to increase dry matter partitioning in fine and coarse roots in comparison with the control. Although, genotypes behaved in the same way under deficit irrigation treatment but they showed differences among each other due to the different in growth vigor. Therefore, it is necessary to test these genotypes under 50% of water requirement level to select the most tolerance genotypes.

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