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The Evaluation of Three Commercial Pistachio Cultivars on UCB1-hybride Rootstock under Field Conditions

*M. Ahmadi Kouhbanani[*1], A. Tajabadipour[*2], D. Abadikhah Dehali[3]*

[1] Department of Horticulture, Jiroft Branch, Islamic Azad University, Jiroft, Iran

[2]Pistachio Research Center, Horticultural Sciences Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Rafsanjan, Iran

[3] Research and Development Department of Nazari Co., Kerman, Iran

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Abstract

Pistachio is the most important nut that is produced in Iran. Little research has been done to examine the effect of UCB1-hybride rootstock plants as tissue culture for pistachios (2011 in Toba company).This study aims to evaluate three pistachio varieties on UCB1 hybrid rootstock. The experiment was conducted as a randomized complete block design with three treatment groups (including Ohadi, Akbari and Ahmadaghaii) in three replications in Mahan, Kerman. The results showed that the three treatment groups were affecting in terms of diameter of the top part of the graft, the branch length, and graft height and leaf area. In addition, phosphorus, potassium, calcium and magnesium concentrations were measured. Akbari showed better result. The rootstock affected the amount of nutrients absorbed in the three treatment groups. The Ahmadaghai cultivar had the highest compatibility to rootstock because of high concentration of elements. The Akbari cultivar had the lowest compatibility to the UCB1 hybrid rootstock. Correlation analysis revealed that correlation coefficients between the traits were significant. The leaf calcium percentage was correlated to the branch diameter. I On the other hand; increasing the amount of leaf calcium caused an increase in the branch diameter. Stem diameter increased the number of branches and tree canopy.

Keywords: Compatibility, Cultivar, Growth characteristics, Pistachio, Rootstocks.

Introduction

Almost all pistachio rootstocks are produced from seeds. UCB-1 hybrid rootstock is propagated from the seed of a controlled cross between a P. *atlantica* female and a P. *integerrima* male. Clonal propagation of this rootstock is also necessary since it produces identical genotypes. Recently, UCB1 has introduced in Iran. However, little research has been done on this subject. Pistachio seedling rootstocks from different species or hybrids have been reported to significantly affect the vigor and nutrient status of the tree, early nut production, alternate bearing, soil-borne diseases, cold and salt tolerance and, to some extent, blank-nut production and the degree of shell splitting (Crane and Forde, 1976; Crane and Iwakiri, 1986; Ashworth, 1985; Walker *et al*., 1987). Ferguson *et al*. (2002) reported that the growth of 'Kerman' was evaluated based on an increase in the total leaf area, increase in trunk diameter and total above-ground biomass production. All growth parameters decreased as salinity increased, but were

*** Corresponding author**: Email: iamfallandautumn@gmail.com; atajabadi@yahoo.com

not significant until ECiw exceeded 12 $dS \cdot m^{-1}$. However, the growth of 'Kerman' on P. atlantica and 'UCB-1' was considerably better than on P. integerrima at 16 dS·m–1. The onset and severity of foliar injury differed among scions and treatments and was attributed primarily to B toxicity rather than the effects of salinity. Concentrations of B in injured leaf tissue ranged from 1000 to 2500 $mg \cdot kg^{-1}$. Leaf injury decreased with increasing salinity, although leaf B was not significantly reduced, suggesting an internal synergistic interaction between B and other mineral nutrients. However, for P. *vera* on P. *integerrima*, the highest level of salinity produced the greatest injury, possibly as a combination of B plus Cl^- and/or Na^+ toxicity. Leaf transpiration, stomata conductance, and chlorophyll concentration of P. *vera*, determined by steady-state porometry, were also reduced to a greater degree by combined salinity and B when budded on P. *integerrima* than on the other two rootstocks. Few studies have shown the salinity growth response in pistachios and have involved salts other than NaCl. In California, as in many arid parts of the world, irrigation water supplies, particularly ground water sources, contain a mixture of Na^+, SO_4^{2-}, Cl^-, Mg^{2+} and Ca^{2+} salts in addition to high B. A companion field study in the western SJV has been underway since 1994, where the performance of 'Kerman'pistachio on several popular rootstocks ('UCB-1', P. *atlantica*, 'Pioneer Gold I', and 'Pioneer Gold II') is being evaluated at five salinity + B levels. Results through 2000 indicated that irrigation with 8 $dS \cdot m^{-1}$ water containing B at $8 mg \cdot L^{-1}$ produced no significant effect on marketable yield of trees (Ferguson *et al*., 2001). The EC of the sand solution resulting in 50% biomass reductions (C50) relative to nonsaline controls was similar to that reported in studies where B was not elevated (Sepashkah and Maftoun, 1988). If one assumes that EC of soil water is twice that of ECe (Ayers and Westcot, 1985), then the C50 values reported by Sepashkah and Maftoun (1988) were between 15.8 and 20 $dS \cdot m^{-1}$. Earlier Sepashkah *et al*., (1985) observed C50 values that were close to those reported for trees on P. atlantica and 'UCB-1'(15.4 dS·m–1) but greater than that observed for trees on P. *integerrima* (12.9 $dS \cdot m^{-1}$). Fotouhi *et al*. (2007) indicated that the rate of photosynthesis, stomata conductance and transpiration increased until the second stage of nut growth and development and then decreased until harvesting stage. Negative correlation was found between photosynthesis and leaves internal CO_2 pressure. The highest rate of photosynthesis (16.59 µmol m-2s-1), stomatal conductance (0.456 mol m-2s-1) and transpiration rate (6.357 mmol m-2s-1) were found in Sarakhs rootstock, and the lowest ($P < 0.01$) was measured in Mutica. In addition, three indexes (Pn, gs, E) decreased within Sarakhs, Atlantica, Badami riz and Mutica rootstocks, respectively.

Pistachio rootstocks vary significantly in their ability to take up nutrients from the soil. Scion grafted on 'Atlantica' rootstock is less likely to show B, Ca or Zn deficiency than other rootstocks with P. *integerrima* parentage (Ferguson, 1995.). Ferguson *et al*. (2002) showed that all growth parameters decreased as salinity increased but were not significant until ECiw exceeded 12 $dS \cdot m^{-1}$. However, the growth of `Kerman' on P. atlantica and `UCB-1' was considerably better than on P. *integerrima* at 16 $dS \cdot m^{-1}$. The onset and severity of foliar injury differed among scions and treatments and was attributed primarily to B toxicity rather than the effects of salinity. Concentrations of B in injured leaf tissue ranged from 1000 to 2500 $mg \cdot kg^{-1}$. Leaf injury decreased with increasing salinity, although leaf B was not significantly reduced, suggesting an internal synergistic interaction between B and other mineral nutrients. However, for P. *vera* on P. *integerrima*, the highest level of salinity produced the greatest injury, possibly as a combination of B plus Cl^- and/or Na^+ toxicity. Leaf transpiration, stomatal conductance, and chlorophyll concentration

of P. *vera*, determined by steady-state porometry, were also reduced to a greater degree by combined salinity and B when budded on P. integerrima than on the other two rootstocks. In addition, Kandemir and Sakar (2013) reported that the lowest bud take rate was obtained from 'P. *khinjuk* × Ohadi' in combination with 40%. On the other hand, in previous work in 2003, the bud sticks were kept in the refrigerator for three days and then used. The first day budding success was 80%, second day's was 68% and third day's was 30%. Chip budding was generally not successful. In this experiment, T-budding was successful. The best scion development was obtained from P. *vera* and P. *khinjuk*. The use of daily harvested bud sticks were observed as an important factor of successfulness. The variability in crop production among scions budded on different rootstocks could be related to genetic and edaphic conditions (Johnson *et al*., 1987). Moreno *et al*. (2011) observed that P. *cerasus* and hybrids of this species had the highest number of root suckers. Suckers are growth units that are initiated and developed in the current season and removing them around the crown of pistachio trees is beneficial effect to yield (Spann *et al*., 2005).

Tavallali and Rahemi (2007) reported that Zn content of leaves of cultivars of 'Ahamd-aghaii' and 'Owhadi' growing on 'Beneh' rootstock was significantly higher than other rootstocks. Leaves of cultivars grafted on 'Badami' rootstock had lower Zn concentration than other rootstocks. Trees on UCB1 rootstock are more tolerant to cold condition than that of PG1 rootstock. An evaluation of young tree mortality and freeze damage after the December 1989 freeze clearly demonstrated that trees on UCB-1 are significantly colder to colder weather (Ferguson, 1991).

Rahemi and Tavallali (2007) showed that genetic variability among pistachio rootstocks may influence scion vigour, yield, extent of shell splitting, blankness and nut weight. Gijón *et al*. (2010) showed different responses of cv. Kerman depending on the rootstock onto which it had been grafted. The hybrid rootstock was associated with a higher degree of stomatal control and reduced leaf senescence compared to *P. atlantica* and *P. terebinthus*, despite being associated with the most vigorous shoot growth. *P. terebinthus* enabled very effective stomata control but was also associated with the most rapid leaf senescence. *P. atlantica* was associated with less vigorous shoot growth and similar levels of water stress as occurred with the others rootstocks under conditions of high evaporative demand, which was associated with lower stomatal control. Although P. *integerrima* was comparatively unaffected by Verticillium wilt, the rootstock was sensitive to frost. In the mid-1980s, two interspecific hybrid pistachio rootstocks were introduced into California: 'Pioneer Gold II' PGII) (P. *atlantica* ×P. *integerrima*) and 'UCBI' (P. *atlantica'KAC'* × P. *integerrima*). Based on a combination of results from a 1-year field trial in 1990 and laboratory assays, Morgan *et al*. (1992) reported that P. *integerrima* and P. *atlantica* were resistant and susceptible, respectively. UCBI was moderately resistant and PGII was susceptible to Verticillium wilt. Epstein *et al*. (2003) reported that trees on the (P. *atlantica* 'KAC' × P. *integerrima*) hybrid UCBI rootstock grew and yielded as well as those on P. *integerrima*. Trees on the hybrid PGII yielded the least. Analysis of variance and log-linear models indicated that in soil infested with V. *dahliae*, three associations significantly affected pistachio nut yield. Rootstock affected scion vigor and extent of infection. The extent of infection and scion vigor were inversely associated. Although trees on the P. *integerrima* rootstock had the highest ratings in a visual assessment of vigor, 65% were infected with V. dahlia in the trunk in the graft region compared with 73% in P. *atlantica* and 25% in UCBI. Thus, P. *integerrima* and UCBI have at least one different mechanism for resistance to V.

dahliae. Sherafati *et al*. (2011) showed that there were significant differences ($p<0.01$) in the amount of potassium, phosphorus and iron content among treatments. The interaction between Akbari scion budded on Badami Rootstock was the most effective on the amount potassium and zinc acquisition (1.56% and 11.05 ppm, respectively). The least amount of potassium and zinc was obtained from the interaction between Akbari scion budded on Daneshmandi rootstock (0.80% and 7.33 ppm, respectively). Barg-seyah scion budded on Kalle-ghouchi rootstock resulted in the most amount of iron (241 ppm) and copper (12.15 ppm).

Tajabadipour *et al*. (2006) reported that the number of fruits per cluster was the highest in Ohadi. The percentages of early splitted pistachios with either soft and smooth hulls or shrivelled and dry hulls were higher in *Pistacia atlantica* subsp. Mutica and *P. atlantica* Subsp. Atlantica rootstocks than in *P. vera* . The percentage of early splitting in *P. vera* rootstock was lower than *P. atlantica* Subsp. Atlantica rootstocks. The percentage of cracks on pistachio hull in grafted scions on *P. vera* rootstock was the lowest but showed no significant differences with other rootstocks. Kalleh-Ghuchi scion showed the lowest percentage of cracks on pistachio hull. Hence, the present work was undertaken to evaluate three pistachio cultivars on UCB1 hybrid rootstock.

Materials and Methods

Plant

UCB1 was first introduced commercially in 1989. The rootstock planted in 2011 and has grafted in 2013, with Ahmadaghai, Akbari and Ohadi cultivars scion. This evaluation was performed in 2014 and 2015. So, the treatment was comparison of three commercial cultivars: Ahmadaghai, Akbari and Ohadi on UCB1 rootstock. The trees were irrigated in two-week intervals. The diameter of the top part of the graft was measured. The branch length in current year was measured. The graft height and leaf area were measured by using leaf area meter. Phosphorus, potassium, calcium and magnesium concentration were measured as well. The data was statistically analyzed by using Mstat-c. The significant differences among means were carried out by using Duncan test at $P < 0.05$.

Results

Diameter in top part of the graft

The result of variance analysis showed that there were significant differences among the three pistachio cultivars ($P<0.05$) in various time frames ($P<0.05$) and year ($P<0.01$) in regards to the diameter of the top part of the graft. However, the others factors were not significantly affected. The maximum diameter of the top part of the graft was observed in the Akbari cultivar on UCB1-hybride rootstock, which had a significant difference. The Ohadi cultivar had the lowest diameter (Fig. 1).

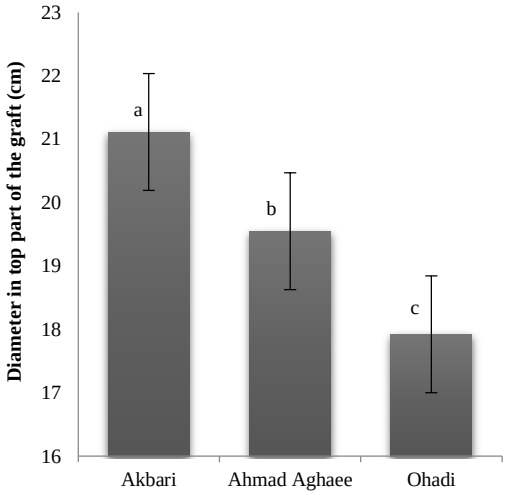

Fig. 1. Diameter in top part of the graft in different cultivars on tissue culture UCB1

The results showed that the diameter of the top part of the graft in the Akbari, Ahmadaghai and Ohadi cultivars were significantly different in the first and second years. The Ohadi cultivar had the lowest diameter in the second year, which had a significant difference with the other varieties in the two years. The maximum of diameter was observed in Akbari cultivar in the first year (Fig. 2).

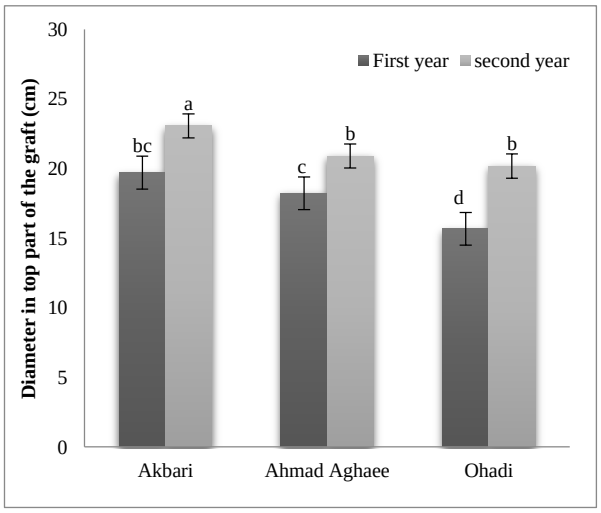

Fig. 2. Diameter in top part of the graft (cm) in different pistachio cultivars on tissue culture UCB1 in different years

Branch length that growth in current year

The results showed that there was not a significant different in the branch length among the varieties. The maximum of branch length was observed in the Ohadi cultivar in the USB1-hybrid rootstock. The branch length was different depending on the time of the growing season The longest branch length was obtained in October. The lowest branch length in the current season was seen

in the Akbari cultivar in the first year. The Akbari cultivar was significantly different from the others varieties in the second year (Fig. 3).

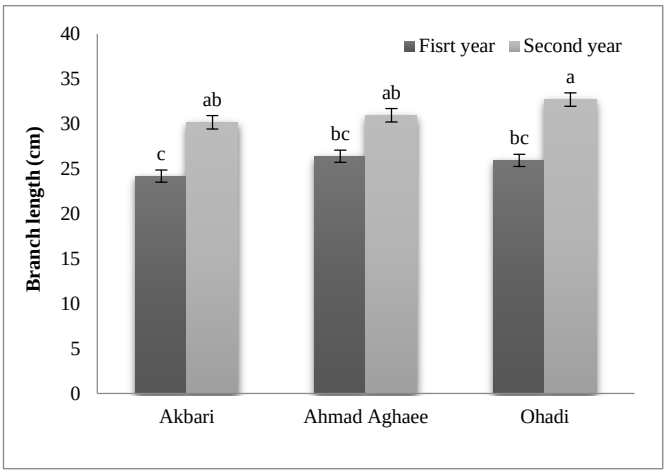

Fig. 3. Branch length in different pistachio cultivars on tissue culture UCB1 in different years

Leaf area

The mean comparison revealed that theh Akbari cultivar had the maximum amount of leaf area Ohadi cultivar leaf area had the lowest (Fig. 4).

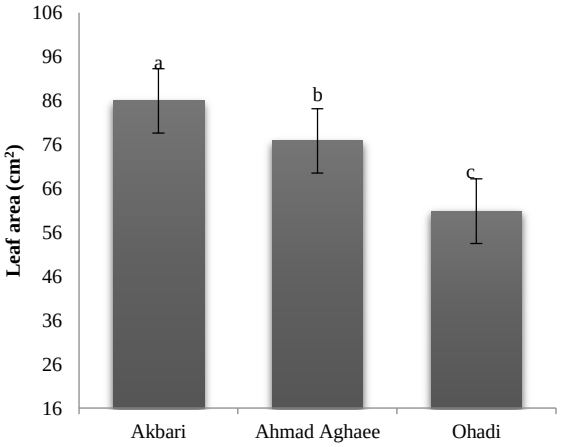

Fig. 4. Leaf area in different pistachio cultivars on tissue culture rootstock UCB1.

As seen in Fig. 2, the leaf phosphorus, calcium and magnesium concentrations were not significantly different among the three treatment groups. The minimum leaf boron and Fe was seen in the Ohadi cultivar. The lowest leaf copper was observed in the Ahmadaghai cultivar, which was statistically different, compared to the Ohadi and Akbari cultivars. However, it was not a significant

difference among varieties in term of Zn and Mn on UCB1-hybride rootstock. The result showed that the interaction between varieties and rootstock had a significant difference and resulted in different absorption of nutrient with rootstock (Table 1).

Table 1. Mean comparison of leaf concentration between 3 pistachio cultivars on UCB1-hybride rootstock

Variety	Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)	B (ppm)	Mg (%)	Ca (%)	K (%)	P (%)
Akbari	12.1 a	42 a	79 ab	8.4 a	89 a	0.5 a	1.7 a	1.3 ab	0.1 a
Ahmadaghai	11.4 a	42 a	85 a	5.6 b	88 a	0.6 a	1.5 a	1.8 a	0.09 a
Ohadi	10.1 a	42 a	68 b	9.4 a	58 b	0.6 a	1.6 a	1 a	0.1 a

Discussion

The result showed that the Ahmadaghaii and Ohadi cultivars had more growth than the Akbari cultivar. The maximum branch length was observed in the Ohadi cultivar in the second year; however it was not significantly different in the first year. However, there was a significant difference in two years (Fig. 4). The highest diameter of the top part of the graft was obtained in October and the lowest was in June. Since June is the start of the growing season, there was not enough time to improve their growing. Johnson *et al*. (1987) reported that the variability in crop production among scions budded on different rootstocks could be related to genetic and edaphic conditions. Among the scions, the number of fruits per cluster was the highest in the Ohadi cultivar. The percentages of early splitted pistachios with either soft and smooth hulls or shrivelled and dry hulls were higher in the Baneh and Atlantica rootstocks than in the Ahli. The percentage of early splitting in the Ahli scion was lower than the Kalleh-Ghuchi scion. The percentage of cracks on pistachio hull in grafted scions on Ahli rootstock was the lowest but showed no significant differences with other rootstocks. Kalleh-Ghuchi scion showed the lowest percentage of cracks on pistachio hull (Tajabadipour *et al*., 2006).

Ahmadaghaei had the maximum amount of leaf potassium and Ohadi had the lowest amount of leaf potassium, which was seen in the experiment done by Tavallali and Rahemi (2007). Their experiment showed that cultivars grafted on ‘Beneh’ rootstock had higher K concentration in their leaves than other rootstocks such as Kalleh-ghouch, Badami, and sarakhs. The Akbari cultivar had the highest compatibility with tissue culture rootstock, causing more absorption with rootstock. It also had more amount of leaf nutrient. It is interesting that this variety had the highest growth parameters, which it showed the relationship between leaf nutrient and growth parameters. Tavallali and Rahemi (2007) reported that the leaves of cultivars grafted on ‘Beneh’rootstock had higher K, P, Zn and lower Mg and Na content than other rootstocks. Pistachio cultivars growing on ‘Badami’ rootstock had higher Ca and lower Zn content than the other rootstocks. ‘Ahmad-aghaii’ cultivar grafted on ‘Sarakhs’ rootstock had higher Cu content than those on other rootstocks. Cultivars growing on ‘Sarakhs’ rootstock had higher Fe and Cu content than the other rootstocks. The kernels of cultivars grafted on ‘Sarakhs’ rootstock had higher K, P, Mg, Cu, Fe and Zn than the other rootstocks. The ‘Sarakhs’ rootstock had the highest protein content in the kernels and ‘Beneh’ rootstock had the lowest.

Genetic studies have been done on the pistacia diversity in the world (Hormoza *et al*. 1998; Parfitt-Dan *et al*. 1997; Caruso *et al*. 1998; Kafkas *et al*. 2001; Kafkas *et al*. 2002; Golan-Goldhirsh *et al*. 2004). Amongst the edible nuts, pistachio is very popular but less known than others. Nevertheless,

pistachios are rich source of energy and contain many health benefiting nutrients, minerals, antioxidants and vitamins that are essential for optimum health (Ferguson, 1995). Chemical composition of pistachio nuts may vary depending upon cultivar, rootstock and maturity at harvest and moisture content. The composition of pistachio kernels of various Iranian cultivars was studied by Kamangar and Farsam, 1997. According to their results, the amount of constituent in 100 g kernel were within the following ranges: oil 55.2-60.5%, protein 15.0- 21.2%, carbohydrate 14.9-17.7%, Na 4.0 mg, K 1048-1142 mg, Ca 120-150 mg, P 494-514.5 mg, Fe 5.8-11.4 mg, Cu 1.0-1.4 mg, Mg 157.5-165.0 mg (Kamangar and Farsam, 1997) and 100 g pistachio has 600 calories (Kizilgoz *et al*., 2010).

Phosphorus in the examined pistachio cultivars had values that ranged from 350-550 mg 100 g^{-1}. Therefore, pistachios seem to be an excellent source of phosphorus in human nutrition. Our results confirmed previous findings that pistachios are rich in phosphorus, which helps the body break down meat and other proteins into amino acids. Phosphorus is necessary for hormone production and to help the body use B vitamins (Davarynejad *et al*., 2012). Low phosphorus can cause glucose intolerance and abnormally low serum phosphate level (hypophosphatemia). The effects of hypophosphatemia may include loss of appetite, anemia, muscle weakness, bone pain, rickets (in children), osteomalacia (in adults) and increased susceptibility to infection (Knochel, 2006).

The results showed that the average potassium content of examined cultivars is 8000 $mg.kg^{-1}$. Significant differences in potassium content of kernel were observed. The highest amount of potassium belongs to "Non-grafted 2" by 11000 mg. kg^{-1}, and the lowest amount belongs to Pistacia atlantica Deaf. With 5000 $mg.kg^{-1}$ (Davarynejad *et al*., 2012).

Calcium has an important function in the human body as a structural element and affects cell signalling, cofactor for enzymes and proteins. Calcium plays a role in mediating the constriction and relaxation of blood vessels (vasoconstruction and vasodilation), nerve impulse transmission, muscle contraction and the secretion of hormones like insulin (FNB, 1997b). The results showed that the maximum calcium levels in the nut of examined pistachio cultivars were about 1350 mg kg^{-1} in "Daneshmandi" and minimum level in "Nongrafted 2" (400 mg kg^{-1}). "Kallehghuchi 3", "Ohadi 3", "Ahmedaghaii", "Akbary 1" and "Akbary 2" cultivars have medium amount of calcium which significantly differ with the other cultivars including "Kallehghuchi 1", "Ohadi 2", "Kallehghuchi 2", "Badami zarand", "Momtaz", "Ohadi 1", "Garmeh", P. vera variety "Sarakhs", "Non-grafted 1", "Non-grafted 3" and "Sefid" (Davarynejad *et al*., 2012).

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