

Effect of Weed Competition, Planting Time and Depth on *Pistacia atlantica* Seedlings in a Mediterranean Nursery in Iran

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Abstract. The effect of weed competition, Planting time and Depth on growth and survival of *Pistacia atlantica* seedlings was evaluated in nursery conditions. *Pistacia atlantica* is a deciduous tree species that belongs to the *Anacardiaceae* family. It is valuable for soil conservation and therefore suitable for plantation in dry lands. Regeneration of *Pistacia atlantica* in western part of Iran presents problems due to much destruction of its natural habitats. Two levels of weed treatment (weed competition was removed several times by hand or the weeds permitted to grow) and three levels of sowing date (9 January, 29 January, 18 February) were used. In addition, seeds were sown at three different depths (0.4 and 8 cm) but no seedlings emerged when seeds were sown at 0 cm sowing depth. At the end of the first growing season on September 2004, survival, height above the soil surface, collar diameter, shoot/root length ratio and shoot/root dry weight ratio were measured. Survival was significantly affected by sowing depth but not by sowing date and weed treatment. Survival was greater at 4 cm than at 8 cm sowing depth. Collar diameter was significantly greater at 4 cm than at 8 cm sowing depth and in 9 January and 29 January than in 18 February sowing date but was not different between weed treatments. Shoot/root length ratio and height was not affected by sowing date, sowing depth and weed treatment. Shoot/root dry weight ratio was significantly lower at 4 cm sowing depth but not affected by sowing date. This ratio was greater in weed competition condition. In general weed treatment, sowing date and sowing depth are factors that can influence physical and morphological traits of seedlings.

Key words: seedling; sowing depth; sowing date; weed competition; survival; growth; nursery

Efeito da Competição de Ervas Daninhas, da Época e Profundidade da Sementeira sobre Plantas Jovens de *Pistacia atlantica* num Viveiro Mediterrânico no Irão

Sumário. Avaliaram-se, em viveiro, os efeitos da competição de ervas daninhas, época e profundidade de sementeira, sobre o desenvolvimento e sobrevivência de plântulas de *Pistacia*

atlantica. A *Pistacia atlantica* é uma árvore de folha caduca que pertence à família *Anacardiaceae*. É uma espécie muito importante, valiosa para a conservação do solo, e portanto apropriada para a plantação em regiões secas. A regeneração da *Pistacia atlantica* na zona oeste do Irão é problemática, devido à destruição dos seus habitats naturais. Foram estudados dois níveis de tratamento de infestantes (removidas manualmente várias vezes ou deixadas crescer) e três datas de sementeira (9 e 29 de Janeiro, e 18 de Fevereiro). Além disso, as sementes foram semeadas a três profundidades diferentes (0, 4 e 8 cm). A 0 cm não houve germinação. No final da primeira estação de crescimento em Setembro de 2004, contabilizou-se a sobrevivência e mediu-se a altura, diâmetro do colo, relação altura/comprimento da raiz e altura/peso seco da raiz. A sobrevivência foi significativamente afectada pela profundidade da sementeira, mas não pela data de sementeira e controle de infestantes. A sobrevivência foi maior com a sementeira a 4cm de profundidade do que a 8 cm. O diâmetro do colo foi significativamente maior com a sementeira a 4cm de profundidade do que a 8 cm, e para 9 e 29 de Janeiro por comparação com a da data de 18 de Fevereiro, mas sem diferença relativamente aos tratamentos das ervas. A razão altura/peso seco da raiz foi significativamente menor na sementeira a 4 cm, mas não foi afectada pela data da mesma. Esta relação aumentou no caso de competição com as infestantes. Em geral a concorrência das infestantes, data e profundidade de sementeira são factores que podem influenciar os caracteres físicos e morfológicos das plântulas.

Palavras-chave: plantas jovens; Profundidade da sementeira; época da Sementeira; Competição de ervas daninhas; sobrevivência; crescimento; viveiro

Effet de la Concurrence de l'Herbe, du Temps et de la Profondeur d'Ensemencement sur des jeunes Plantes de *Pistacia atlantica* Dans une Pépinière Méditerranéenne en Iran

Résumé. Les effets de la concurrence de l'herbe, du période et de la profondeur de la plantation ont été évalués sur la croissance et la survie des jeunes plantes de *Pistacia atlantica* dans une pépinière. *Pistacia atlantica* est un arbre feuillu qui appartient à la famille des *Anacardiaceae*. Cette espèce est très importante, car elle conserve le sol et est ainsi appropriée à la plantation dans les régions sèches. La régénération de *Pistacia atlantica* à l'ouest de l'Iran a des problèmes dus aux destructions de ses habitats naturels. Deux niveaux de traitement d'herbe (les herbes ont été enlevées plusieurs fois à la main ou laissé se développer) et trois niveaux de date d'ensemencement (le 9, le 29 janvier, le 18 février) ont été étudiés. En plus, des graines ont été semées à trois profondeurs différentes (0, 4 et 8 cm). Aucune plantes n'ont émergé à la profondeur d'ensemencement 0 cm. À la fin de la première saison de croissance en septembre 2004, la survie, la taille au-dessus de la surface du sol, le diamètre de collier, le rapport de longueur et poids sec de pousse/racine ont été mesurés. La survie a été significativement affectée par la profondeur d'ensemencement mais rien par la date d'ensemencement ni le traitement de l'herbe. La survie était plus importante pour la profondeur d'ensemencement à 4 centimètres qu'à 8 centimètres. Le diamètre de collier était considérablement plus important à 4 centimètres de profondeur d'ensemencement qu'à 8 et plus important pour l'ensemencement aux 9 et 29 janvier qu'au 18 février, mais elle n'était pas différente entre les traitements d'herbe. Le rapport de longueur de pousse/racine et la taille n'ont pas été affectés par la date ni par la profondeur d'ensemencement ni par le traitement d'herbe. Le rapport de poids sec de pousse/racine à 4 centimètres de profondeur d'ensemencement était significativement inférieur aux autres profondeurs mais n'a pas été affectée par la date d'ensemencement. Ce rapport était plus important dans les conditions de traitement d'herbe. En général, la concurrence d'herbe, la date et la profondeur d'ensemencement sont des paramètres qui peuvent influencer les caractères physiques et morphologiques des jeunes plantes.

Mots clés: jeune plante; profondeur d'ensemencement; date d'ensemencement; concurrence d'herbe; survie; croissance; pépinière

Introduction

The forest areas of the Zagros Mountain in Iran range have a semi-arid temperate climate, with annual precipitation ranging from 400 mm to 600 mm, falling mostly in winter and spring and extreme summer aridity also prevails (ANDERSON, 1999; FREY and PROBST, 1986). This forest consists mainly of deciduous, broad-leaved trees or shrubs that dominant species are pistachio (*Pistacia* spp.), oak (*Quercus* spp.), and a few others (ZOHARY, 1973). Zagros is the original source of some species that are also now found in some eastern Mediterranean mountains, such as *Pistacia* species (ZOHARY, 1973). Advanced degradation is visible even in densely forested areas of the Zagros Mountains (FREY and PROBST, 1986) and rehabilitation of some areas of this forest is a must. *Pistacia atlantica* Zohary is an important alternative for plantation in this ecosystem.

Pistacia atlantica Zohary is a deciduous tree species that belongs to the *Anacardiaceae* family. In the genus of *Pistacia* there are about 11 species which some of them used as ornamentals and some valued as fruit tree (ATLI *et al.*, 2000; OZBEK, 1978). The height of this tree reaches to 2 to 7 meters (JAZIREI and EBRAHIMI ROSTAGHI, 2003). The seedlings of this species are slow growing (ATLI *et al.*, 2000; JAZIREI and EBRAHIMI ROSTAGHI, 2003; TABATABAII and GHASRIANI, 1993). It is possible to plant one year old seedlings but as a result of their slow growth and low height they need to be protected from shading by neighbouring herbs. For this reason, commonly 2 years old seedlings are used for planting in open field

condition. Different species of *Pistacia*, especially *Pistacia atlantica*, as a result of their vigorous root growing ability can adopt with difficult environmental conditions (JAZIREI and EBRAHIMI ROSTAGHI, 2003; VARGAS *et al.*, 1998), such as dry and hot summer, low moisture of soil, poor soil and cold winter (TABATABAII and GHASRIANI, 1993; BARZEGAR GHAZI *et al.*, 2001). *Pistacia atlantica* is a multipurpose tree that valued as fuel, fruit and therapy properties. It is valuable in soil conservation (RAHEMI and BANINASAB, 2001) and so suitable for plantation in dry lands (JAZIREI, 2001). BARZEGAR GHAZI *et al.* (2001) found this species have most survival and highest growth in comparison with other trees in semi-arid environment.

The regeneration of *Pistacia atlantica* in western part of Iran due to much destruction to its natural habitats has problems. In order to restoration of this important species, planting and direct seeding are used. Within this scope, producing vigorous seedlings in nursery and having information about suitable factors related to seed sowing are essential (TABATABAII and GHASRIANI, 1993). Successful sowing depends on sowing date and depth which are important factors in producing successful seedlings (THOMPSON, 1984).

Buried seeds are more likely to establish new plants than unburied seeds. Shallow burial, particularly improves the germination of seeds and the subsequent emergence and survival of seedlings. Seeds beneath a prospective layer of soil, sand or litter experience a much more moderate environment (e.g. temperature, moisture), because it prevents them from drying, freezing or

ejecting due to frost heave (SEIWA *et al.*, 2002). Seeds buried deeply, on the other hand usually establish very few seedlings, because pre emergence mortality results from a cessation of seedling growth before it reaches the soil surface or the seeds are unable to germinate due to lack of oxygen, light and/or temperature fluctuation (VAN ASSCHE and VANLERBERGHE, 1989; VLEESHOUWERS, 1997). These traits suggest that there is an optimal range of burial depth to maximize the seedling emergence and subsequent seedling growth (SEIWA *et al.*, 2002). Sowing date can greatly impact field performance. Finding the suitable sowing date for each species could help seedling become established during favourable growing conditions (McCREARY, 1990). Nursery cultural practices have been shown to greatly influence the morphological and physiological condition of the seedlings and ultimately their field performance potential. One practice is weeds control in the nursery bed and thus reduce competition (McCARTHY and O REILLY, 2001). A weed is a plant growing out of place, competing with more desirable plants for soil water, nutrients, sunlight and space (ZOLLINGER and QUAM, 1997) which are all important factors for the establishment of the seedlings (GEMMEL *et al.*, 1996). They reduce available moisture and nutrient levels in the soil. Weed compete with seedlings by quickly developing a root system in the top several inches of the soil that reduce water and nutrient availability to tree roots (ZOLLINGER and QUAM, 1997). Low water availability may impair photosynthesis and affect the regeneration of roots (LARSON and WHITMORE, 1970) resulting in slow growth or death of the seedling

(BURDETT, 1990). The study presented here is a nursery study to evaluate the effects of sowing date, sowing depth and weed competition on *Pistacia atlantica* survival and growth.

Material and method

Experimental design

The study was conducted in a nursery (35°16'N, 47°1'E, approximately 1450m above sea level) located at Sanandaj in western part of Iran (Figure 1). Mean annual temperature is 13.3°C and mean annual precipitation is 480 mm. According to Ombrothermic diagram, the dry season begin from last May to September.

The seeds were floated in water for 24 h to eliminate the empty ones. Then after putting the seeds in the hot water by using coarse gloves the hard shell of them were removed. The study design was a $3 \times 3 \times 2$ factorial (with 5 seedling in 3 replicate arranged in a completely randomized design).

Common sowing depth and sowing date in nursery condition are 4 cm and last January. But there are not reliable knowledge about suitable sowing depth and sowing date. Therefore we choose the first factor as sowing date with three different dates (9 January, 29 January, 18 February) and the second factor as sowing depth with three different depths (0, 4 and 8 cm). The third factor was weed treatment (weed competition was removed several times by hand or the weeds permitted to grow). Two seeds were sown in poly bags (15 cm in diameter \times 20 cm in height). All seedlings were irrigated between one and three times a week (during dry season that is about 4 months and begins from June).

Study area



Figure 1 - Map of Iran and location of study area

Measurements

At the end of first growing season on September 2004 all the seedlings were measured of their height above the soil surface and collar diameter. For each replicate, seedlings survival percent was calculated. In order to measuring shoot/root ratio, roots were cleaned with water then each seedling was separated into roots and shoots and the lengths of the shoots and roots were measured to nearest mm. The different parts of each seedling were then oven- dried at 80°C during 48h for measuring shoot/root dry weight.

Statistical analysis

The effects of sowing date, sowing depth and weed competition on survival, height, collar diameter, shoot/root ratio and shoot/root dry weight ratio were analyzed using three-way ANOVAs. Since no seedlings emerged from 0 sowing depth in all of the replicates, this treatment was not included in any analysis because it could not be validly analyzed with ANOVA. Duncan multiple comparison test was used to determine differences in sowing date.

Results

No significant difference was found in survival among sowing date (Figure 2A, $p = 0.343$). Seedling survival was significantly affected by sowing depth (Figure 2A, $p = 0.039$). It was higher at 4 cm sowing depth. There was no significant difference in survival between weed treatment (Figure 2A, $p = 0.852$).

Seeds sown in 9 January and 29 January, whereas they did not have significant difference with each other, reached greater collar diameter than those in 18 February (Figure 2B, $p = 0.032$). Sowing depth affected significantly the seedlings collar diameter (Figure 2B, $p = 0.035$). It was higher at 4 cm sowing depth.

Collar diameter (Figure 2B, $p = 0.292$), height (Figure 2C, $p = 0.402$), and shoot/root length ratio (Figure 3A, $p = 0.73$) was not significantly affected by weed treatment. Sowing date had not significant effect on height (Figure 2C, $p = 0.219$) and shoot/root length ratio (Figure 3A, $p = 0.942$). Also there was not significant difference in height (Figure 2C, $p = 0.79$) and shoot/root length ratio (Figure 3A, $p = 0.600$) between seed sowing depth.

No significant difference was found in Shoot/root dry weight ratio among sowing date (Figure 3B, $p = 0.107$). Shoot/root dry weight ratio was significantly differed between seed sowing depth (Figure 3B, $p = 0.005$). It was greater at 8 cm sowing depth. Weed treatment had significant effect on Shoot/root dry weight ratio (Figure 3B, $p = 0.031$). It was greater in weed competition condition.

Discussion

There was no significant difference in survival among sowing date but it was significantly affected by sowing depth. Seedlings survival was lower at 8 cm sowing depth, mainly due to greater fraction of seed reserves were exhausted by the time of the seedling emergence (SEIWA *et al.*, 2002). There was no significant difference in survival between weed treatments. Because greater soil moisture and favourable growing conditions, can help seedlings to have greater survival (McCREARY, 1990). It seems that weed competition might not influence on these two factors.

Seedlings collar diameter differed among sowing date. It was greater in 9 January and 29 January than those in 18 February. Probably, early sowing date should help seedlings become established during favourable growing conditions, before soil moisture becomes limiting (McCREARY, 1990). Rainfall is gradually reduced from first sowing date. So seeds sown in early sowing date used favourable soil moisture and germinate earlier. Earlier germination provides earlier establishment and growth before beginning dry season. It seems that irrigation during dry season have the same influence on seedlings that grew in different sowing dates, so the seedlings that germinated and established earlier (seeds sown in early sowing date) grew better. Thompson in 1984 expressed that early sowing can increase seedling size.

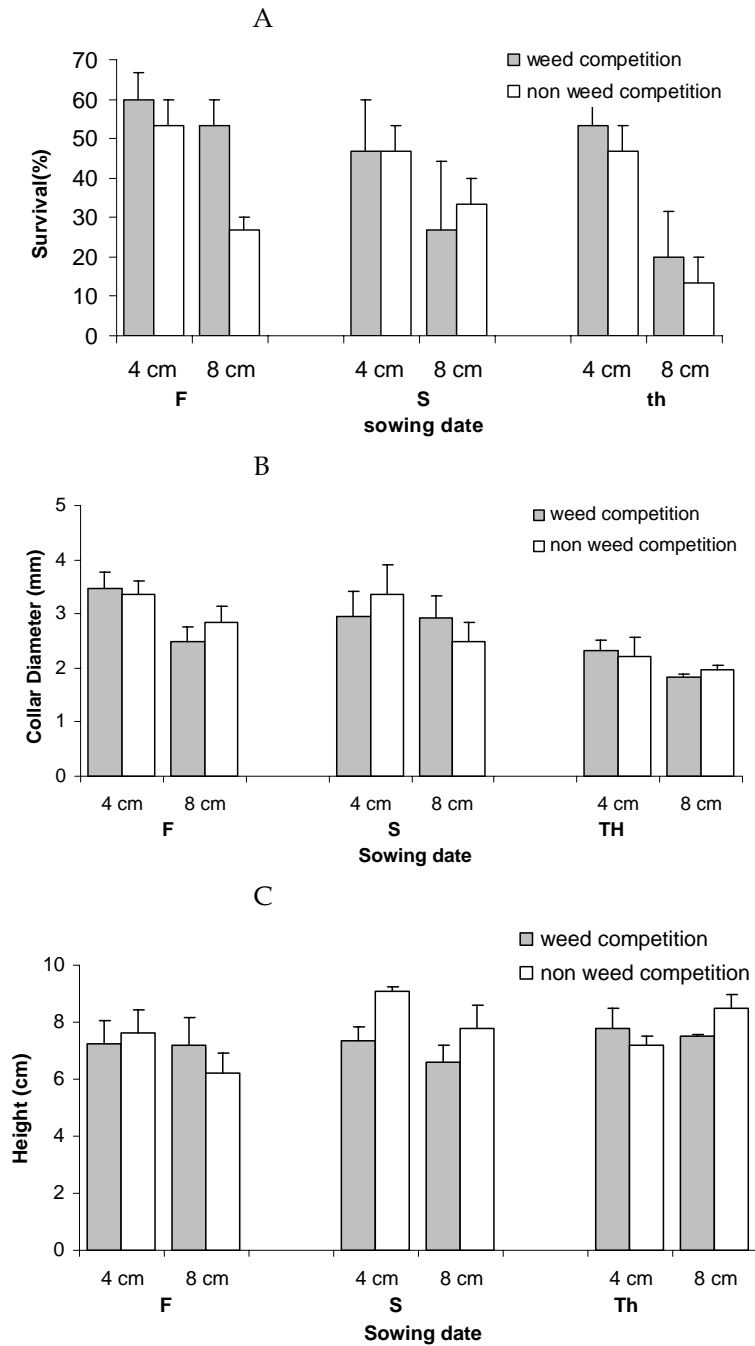


Figure 2 - (A) Mean (\pm S.E.) survival percent of seedlings, (B) mean (\pm S.E.) Collar diameters of seedlings, (C) mean (\pm S.E.) Height of seedlings, F: 9 January sowing date, S: 29 January sowing date, TH: 18 February sowing date

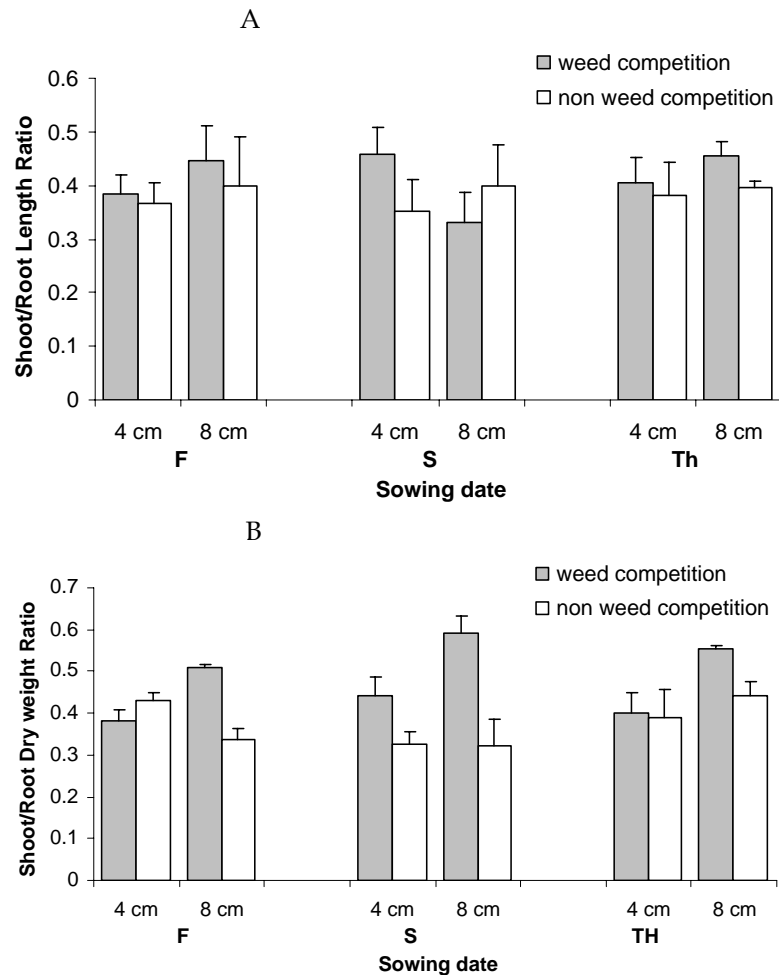


Figure 3 - (A) Mean (\pm S.E.) Shoot/Root length ratio of seedlings, (B) mean (\pm S.E.) Shoot/Root Dry Weight ratio of seedlings, F: 9 January sowing date, S: 29 January sowing date, TH: 18 February sowing date

Seedling collar diameter was greater at 4 cm seed sowing depth. It seems a greater fraction of seed reserves was exhausted by the time of the seedling emergence because seedling that emerged from deeper sowing depth showed smaller size. These seedlings would have less initial investment to future growth (SEIWA *et al.*, 2002).

Weed treatment had not significant difference on collar diameter, height and Shoot/ root length ratio. Probably due to seedlings try to strength their stems against competitive weed by allocation more biomass to their stem not by more height and collar diameter. Also should be considered that this species is slow growing. There was no significant

difference in height and Shoot/root length ratio between sowing depth and sowing date. It could be a result of slowing growth of this species.

Seedlings Shoot/root dry weight ratio was not differed among sowing date. This is a reasonable result because different sowing dates influence on seedling growing condition such as moisture and temperature but not on factors that dealing with allocating of biomass and carbon allocation to seedlings shoot and root (CERVANTES *et al.*, 1998).

Shoot/root dry weight ratio was higher at 8 cm sowing depth. The seedlings from deeper sowing depth showed greater dry weight allocation to stem, instead of the roots. Such plastic response in dry weight allocation suggests that the seedlings allocates lower carbon reserves to the roots and diverts the rest to the stem to facilitate emergence from a deep location (SEWIA *et al.*, 2002). Seedlings from a deeper location had a longer first internode or subcoleoptile internode but shorter roots than those in a shallow depth (MAUN and RICH, 1981; REDMANN and QI, 1992).

Weed competition tended to wards significant increase in Shoot/root dry weight ratio. Tall weeds interference with growth of small seedlings by blocking sunlight (ZOLLINGER and QUAM, 1997) and light is important limiting factor (MADSEN, 1995). Probably seedlings of *Pistacia* try to strength their stems against competitive weed by allocation more biomass to their stem because greater allocation of biomass to foliage and stem growth makes a species a better competitor for light (LANDSBERG and GOWER, 1997).

Longer and powerful roots enhance the capacity of seedlings to compete for water and nutrients (VILELA and RAVETTA, 2001). Also seedlings with large diameters often survive and grow better (MEXAL *et al.*, 2002). The results of this study indicate that early sowing date was better because leads to greater collar diameter, as compared to delayed sowing.

Also 4 cm sowing depth showed better results such as greater survival, greater collar diameter and lower Shoot/root dry weight ratio than those at 8 cm sowing depth.

Weed treatments had not effect on survival, collar diameter, height and Shoot/root length ratio but Shoot/root dry weight ratio was significantly higher in weed competition condition. Since JAZIREI and EBRAHIMI ROSTAGHI (2003) reported that the seedling of this species had better growth in future when they be shaded in the first stage of growing and root length was not differed between weed treatments (Data was not shown) it seems that removing weed was unuseful.

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