Iranian Journal of Forest
Vol. 13, No. 5, Winter 2022
pp. 57-69

DOI: 10.22034/ijf.2022.318436.1832
DOR: 20.1001.1.20086113.1400.13.5.5.2

Research Article

Effect of soil moisture content on survival, growth, and physiological characteristics of wild cherry (*Prunus avium* L.) seedlings

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(Received: 10 January 2022; Accepted: 16 March 2022)

Abstract
Wild cherry (*Prunus avium*) is one of the native and fast-growing broadleaves species of the Hyrcanian forests that can be used in mixed reforestations. Therefore, knowledge of the survival reaction and some morphological and physiological characteristics of seedlings of this species at different levels of soil moisture content (SMC) is crucial for the development of seedling production and afforestation programs, as well as habitat restoration. This experiment was conducted in a completely randomized block design with four irrigation levels (control or 100%, 75%, 50% and 25% of field capacity) in 3 replications and 5 seedlings per replication as subsamples. Thus, the seedlings were examined for five months (May to September) and a total of 60 potted seedlings were tested and sampled. Morphological characteristics of seedlings such as survival, height growth, diameter growth, root dry weight, stem dry weight, total dry weight, and root to stem ratio and physiological characteristics of plant pigment concentrations including chlorophyll (a, b and total), carotenoids, soluble sugars and proline were measured. The results showed that reducing SMC had different effects on morphological and physiological traits of wild cherry seedlings. With decreasing SMC, the amount of chlorophylls a and b, total chlorophyll, decreased. Proline levels were quadrupled and soluble sugars were doubled when extreme humidity decreased. An increase in the amount of proline and soluble sugars makes the plant more tolerant of drought. Therefore, at least 50% of the field moisture capacity in the rooting environment of seedlings is necessary.

Keywords: Soil moisture; Survival; Seedling; Drought tolerance; Wild cherry.

1. Introduction
Wild cherry (*Prunus avium* (L.) L.) is a multifunctional and valuable species that is naturally distributed in the beech and oak communities of the forests of Europe, North Africa and Anatolia, the Caucasus and the northern slopes of the Alborz Mountains. This species is a relatively fast growing mesophytic light demanding tree which due to its rapid juvenile growth and high colonization ability in the early stages of the stand development, it is a suitable species for pioneer rehabilitation and afforestation operations in the middle and highlands of northern Iran (maximum 2000 meters above sea level). Studies have shown that inadequate rainfall in summer as well as severe cold in winter limit the natural distribution of wild cherries. Beside climate changes, drought stress has become a serious limited factor for plant production and seedling growth (Sepahvand et al., 2021). On the other hand, due to climate change and the location of forests in northern Iran, it is possible that the planted wild cherry seedlings experience more environmental stresses in the

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planting area. Therefore, it is important to obtain scientific information on the response of wild cherry seedlings to drought stress. In general, the important role that water stress plays in the distribution of plants, has led to a lot of research on plant species in this field. Recently an attempt has been made to study and identify various mechanisms of plant tolerance to moisture stress, and to take a step towards maintaining plant yield in drought conditions as the effects of drought on plants become more widespread (Hashemi dezfuli et al., 1994; Kafi et al., 2009). Research has shown that plants respond differently to drought stress, including responses to changes in all aspects of plant growth. For example, in the study of Saeidi Abueshaghi et al. (2021), drought stress had a significant effect on the growth characteristics of *Cercis siliquastrum* L. seedlings (height, leaf area, root length and total dry weight). Nourozi Haroni et al. (2017) showed the effect of drought stress significantly reduced some morphological characteristics of *Cercis siliquastrum*. In addition, in a study conducted by Mirzaei & Yousefzadeh (2013) in greenhouse condition, wet and dry weight loss was observed in *Pistacia khinjuk* Stocks seedlings under drought stress. Researchers have reported that during drought stress, proline levels in *Ziziphus spina-christi* (L.) Desf. seedlings, *Abies fabri* (Mast.) Craib, *Albizzia lebbek* (Willd.) Benth., *Dalbergia sisso* Roxb., *Leucaena leucocephala* (Lam.) de Wit, *Shorea robusta* Gaertn., *Tectona grandis* L.f. and *P. khinjuk*, increased and several intracellular processes such as cell water status, osmolite content, protein status, plant hormone activity, transmission and photosynthesis, and ultimately growth were all affected by the stress (Jinying et al., 2007; Guo et al., 2010; Rao et al., 2008; Mirzaei & Yousefzadeh, 2013). The functional response of plants to drought, in addition to the species is affected by the length and duration of drought period, age and stage of plant development and structure. So, depending on the intensity and duration of stress, several changes are expected at different levels from the cell to the whole plant (Chaves et al., 2002; Jaleel et al., 2008).

Drought stress also has effect on all physiological, morphological, and biochemical processes of the plant and reduces plant growth (Khalafallah & Abo-Ghalia, 2008). If the stress continues, it causes photosynthesis to stop, cell metabolism to be disrupted and eventually cell death (Amarjit et al., 2005). A study on *Pistacia vera* L. under drought stress showed that with increasing the intensity of drought stress, morphological characteristics of dry matter production, chlorophyll content and leaf photosynthesis rate decreased significantly (Bagheri et al., 2012). Several research has been done on the effect of irrigation regimes on seedlings of different species showing that proper irrigation regime increases the growth and viability of seedlings (Fotelli et al., 2000; Castro-Díez et al., 2008; Mclaren & McDonald, 2003).

On the other hand, moisture stress reduces the growth and viability of seedlings (Pesoli et al., 2003; Nagakura et al., 2004). Investigation of the effect of soil moisture on germination and survival of seedlings of four tree species in the dry forests of Jamaica showed that drought stresses have a significant effect on the survival and growth of seedlings (Mclaren & McDonald, 2003). A decrease in soil water potential also decreases cell division and the rate of leaf expansion, because the quality and quantity of plant growth can be affected by drought stress (Kusaka et al., 2005). When the plant is exposed to drought, even before any reduction in turpentine, the flexibility of the cell wall of growing leaves and stems generally decreases, leading to reduced plant organ growth, which can be a reason for reduced plant growth under water shortage stress.

The root cell wall also appears to be less sensitive to drought stress and may continue to grow when shoot growth has stopped (Abdel-Monaim, 2013). The content of photosynthetic pigments, including chlorophylls and carotenoids, which are important in converting light energy into chemical energy, changes under the influence of drought (Jaleel et al., 2008). These changes can somehow limit the performance of photosynthesis, complicating the direct effect of drought on pore closure, gas exchange, and photosynthesis. Decreased chlorophyll in drought-sensitive species can be the result of degradation of the delicate structure of chloroplasts, changes in the protein ratio of pigments, or increased chlorophyllaz activity. As the intensity of drought stress increases, the pigment content decreases, and a further decrease in chlorophyll b is more possible compared to chlorophyll (Sirousmehr et al., 2015). Reducing the amount of chlorophyll a and chlorophyll b pigments is used as a light protection mechanism to protect the plant photosynthetic chain by reducing light absorption. Among the most important substances that increase their accumulation in plant cells under drought stress, the free amino acid proline plays a role in maintaining the osmotic potential (Zafari et al., 2016) The higher accumulation capacity of proline in the plant under high stress allows the plant to continue to absorb water in harsh environmental conditions. Proline levels are greatly reduced if plants are subjected to severe stress. This may be due to destructive metabolic damage on land (Farshadfar & Mohammadi, 2003).

So far, few studies have been performed on wild cherry species, especially on its morphological, physiological and free proline content reactions to soil moisture changes. This study seeks to investigate the survival, growth, and physiological reactions of wild cherry seedlings to the different soil water level to provide basic information for managing irrigation operations in forest nurseries as well as the implementation of maintenance treatments in wild cherry planting projects in northern Iran.

2. Materials and methods

This experiment was performed to investigate the soil moisture content (SMC) on morphological and physiological characteristics of one-year wild cherry seedlings of *P. avium* in the greenhouse of the faculty of forest sciences, Gorgan University of agricultural sciences and natural resources in 2017. The experiment was conducted in a completely randomized block design with four irrigation levels (control or 100%, 75%, 50% and 25% of field capacity) in 3 replications and 5 seedlings per replication as subsamples. Thus, the seedlings were examined for five months (May to September) and a total of 60 potted seedlings were tested and sampled. The soil used in the pots was prepared from soil surface (depth 0 to 30 cm) of the natural site of this species in the Shast-Kalateh forest research station of Gorgan University. The physical and chemical properties of the soil are presented in Table 1.

Potential points of the soil including field capacity, permanent wilting point, bulk density and soil texture were measured and soil moisture curve (the relationship between soil water potential and moisture) irrigation rate were determined (Aliarab et al., 2020). Based on the field capacity, wilting point, seedling and pot weight, dry weight, and soil moisture in the mentioned points were determined and the reference weight of each treatment was determined.

Table 1. Physical and chemical properties of the soil in pots.

Texture	Sand (%)	Silt (%)	Clay (%)	pH	Organic matter (%)	Bulky density (gr/cm3)
Loam	37.64	46.84	15.52	7.3	6.7	1.56

2.1. Measurement of morphological characteristics of seedlings

In this study, at the beginning (May 10) and the end of the growing season (October 8), morphological characteristics of seedlings, including collar diameter using digital caliper (accuracy 0.01 mm), and height using line Calibrated strain (with an accuracy of 1 mm) were measured. Diameter and height growths were calculated from the difference between the growth rate at the end and the beginning of the period. Survival rate was calculated through dividing the number of live seedlings per replication into the total number of seedlings per replication.

Also, for each treatment, seedlings were taken out of the potting soil and the root length was measured after washing the soil around the roots. Then, each seedling was divided into root and stem (shoot). After drying stems and roots in the oven (temperature of 70 ° C for 48 hours), they were weighed with a digital scale (0.001 g) (Yin et al., 2005). Then the root, shoot, and total biomass (total stem and shoot biomass) were determined and the root-to-shoot length ratio was calculated.

2.2. Measurement of seedling physiological characteristics

Leaf samples of different treatments were taken from the upper third of the seedlings crown and some physiological characteristics of seedlings (concentration of plant pigments including chlorophyll a, b and total, carotenoids, soluble sugars and Proline) was measured. Arnon (1949) method was used to extract and measure the amount of chlorophyll a, b, and total. To measure the chlorophyll a and b, 100 mg of leaf sample was suspended in 10 mL of 80% acetone, mixed well and kept at 4°C overnight in dark. Supernatant was withdrawn after centrifugation (5000 rmp) and absorbance was recorded at 470, 648, and 664 nm in Spectrophotometer. Equations (1), (2), (3) and (4) were then used to measure chlorophyll a, chlorophyll b, total chlorophyll and carotenoids:

$$\text{Chlorophyll a} = 13.36(A664)-5.19(A648), \quad (1)$$

$$\text{Chlorophyll b} = 27.43(A664)-8.12(A664), \quad (2)$$

$$\text{Total chlorophyll} = \text{chlorophyll a} + \text{chlorophyll b}, \quad (3)$$

$$\text{Carotenoid} = \{1000(A470)-2.13(\text{chlorophyll a}) - 97.64(\text{chlorophyll b})\}/209, \quad (4)$$

2.3. Proline measurement

100 mg of leaves were weighed and placed in a microtube (1.5 ml) and liquid nitrogen was poured into the microtube and completely pulverized with a homogenizer. Then 500 µl of 3% sulfosalicylic acid was added to the sample. The sample was then centrifuged for 3 min at 3000 rpm and transferred to a new microtubule at a rate of 200 µl of high clear solution. Then 200 µl of ninhydrin reagent and 200 µl of glycolic acetic acid were added to the microtubule. It was kept at 100 degrees for half an hour in Ben Marie. The sample changed color based on the proline content. This discoloration was in the form of cherries, which increased with increasing the amount of proline. The samples were then spectra at 520 nm (Bates et al., 1973).

2.4. Data analysis

Statistical analysis of the data obtained from the measured treatments as well as the means was performed by Duncan's multi-domain test using SPSS software.

3. Results

3.1. Morphological characteristics

Survival: In this study, the results of analysis of variance showed that the reduction of soil moisture significantly reduced the viability of seedlings. The results also showed that the lack of SMC had a negative effect on Morphological parameters such as diameter and height, which is consistent with the results of other researchers on different tree species (Zolfaghari et al., 2013). The results of the effect of SMC on seedling survival showed that 100 and 75% treatments had the highest survival and demonstrated a significant difference with 50 and 25% treatment (Table 2).

Table 2. One-way ANOVA of growth characteristics of wild cherry seedlings at different levels of soil moisture content.

Characteristics	F-value	p-value	Soil moisture content (%)			
			100%	75%	50%	25%
Survival (%)	7.212 *	0.015	100 a	100 a	86.67 b	80.00 b
Height growth (cm)	10.319 *	0.014	13.1 a	8.27 b	8.40 b	5.70 b
Diameter growth (mm)	5.673 *	0.046	0.62 a	0.65 a	0.44 ab	0.27 b
Root biomass (gr)	8.264 *	0.022	14.43 ab	12.98 a	10.89 bc	10.69 c
Shoot biomass (gr)	18.927 **	0.002	19.04 a	13.30 b	11.17 bc	10.00 c
Total biomass (gr)	5.864 *	0.025	32.57 a	25.12 b	22.79 b	21.71 b
Root to Shoot ratio	5.785 *	0.044	0.748 b	1.018 a	1.127 a	1.165 a

ns: Non significant, ** : Significant at 99% probability level , * Significant at 95% probability level.

Height growth and collar diameter: In relation to the height growth, analysis of variance showed that there is a significant difference between different moisture treatments (p-value = 0.014, F-value = 10.319). The height growth were measured 13.1, 8.27, 8.40, and 5.70 cm for 100%, 70%, 50%, and 25% of field capacity, respectively. The results of the study on the effect of different moisture treatments on the average collar diameter of seedlings also showed that there was no significant difference between 100%, 75% and 50%, but there was a difference between 25% and 50% treatments (Table 2). Based on the results of comparing the mean of Duncan test, the decrease in soil moisture led to a decrease in the diameter of seedlings. There were significant differences between 50 and 25% treatments which were 0.44 and 0.27, respectively (p-value = 0.046, F-value = 5.673).

Root and shoot dry weight: Comparing the mean data of root dry weight showed that the highest value belonged to 75% treatment while the lowest with 24% decrease belonged to 25% treatment, which did not differ significantly with 100% of field capacity. There was also a significant difference with 25 and 75% of field capacity (p-value = 0.022, F-value = 8.264).The results of comparing the mean dry weight of shoots showed that drought stress reduced this trait.

Stem dry weight were measured 19.04, 13.30, 11.17 and 10.00 g for 100%, 70%, 50%, and 25% of field capacity treatments, , respectively (p-value = 0.002, F-value = 18.927). The highest shoot dry matter was related to the treatment of 100% of field capacity, however, the lowest amount was obtained in the treatment of 25% of field capacity, which was significantly different from the other three treatments (Table 2).

Root to shoot ratio: The results of studies on the ratio of root to shoot showed that this ratio increased with decreasing soil moisture so that the least value was observed in the control treatment. The highest value of root to stem ratio was related to 25% treatment and the lowest value was related to 100% treatment, which was not significantly different from 50% and 75% treatment, but was significantly different from 100% treatment (p-value = 0.044, F-value = 5.785).

3.2. Physiological characteristics

Chlorophyll a, b, and total: The results of analysis of variance showed that the effect of drought stress on chlorophyll a and total chlorophyll was significant at the level of probability of 1%. This effect was also significant for chlorophyll b at the level of probability of 5% (Figure 1- a).

Comparison of means showed that the amount of chlorophyll a, b, and total in 100% of field capacity with 1.013, 0.527 and 1.540 mg / g of fresh leaves had the highest amount respectively and in 25% of field capacity, chlorophyll a, b, and total with 0.294, 0.153 and 0.446 mg / g of fresh leaves had the lowest values. The amount of carotenoids in the treatment of 100% of field capacity was the highest (0.491 mg / g of fresh leaves) while the treatment of 25% (with 0.081 mg / g of fresh leaves) was the lowest (Figure 1- d, c, b).

Proline and total soluble carbohydrates: Leaf proline amount increased with decreasing soil moisture. The highest amount of proline belonged to 25% treatment whereas the lowest amount observed for 100% treatment. There was a significant difference between 25% treatment with 75% and 100% treatment, whilst no significant difference was observed with 50% treatment (Figure 1- e).

4. Discussion

We found out that the decrease in soil moisture had a significant effect on the amount of soluble sugars in the leaves (Table 1), so that the lowest amount of soluble sugars was observed in the control treatment and the highest amount was observed in the treatment of 50% of field capacity. Comparison of means showed that the level of 50% of field capacity was the highest amount of soluble sugar and the levels of 25%, 75% and control were in the subsequent orders (Figure 1- f).

Survival, longitudinal growth and diameter and dry weight of shoots: In general, the decrease in seedling viability due to the decrease in soil moisture can be related to the decrease in the uptake of primary growth elements, which has weakened the establishment of seedlings (Kusaka et al., 2005). Nourozi Haroni et al. (2017) reported that reducing soil moisture by limiting the uptake of primary growth elements can lead to poor establishment and reduced plant viability. It can also be stated that the ability of a plant to survive in drought conditions and tolerate a decrease in water intake is directly related to the osmotic regulation of the plant (Jarrett, 1991).

The decrease in soil moisture led to a decrease in the diameter of seedlings. There were significant differences between treatments of 50 and 25% of field capacity which were 0.44 and 0.27, respectively. Jinying et al. (2007) studied the effect of drought stress on the diameter and height of hawthorn (*Crataegus*) seedlings. As well, Wu & Xia (2006) studied the effect of drought stress on the height and diameter of citrus (*Citrus aurantium*) seedlings. Decreased height and diameter of *Sophora davidii* (Franch.) Pavol., *Eucalyptus microtheca* F.Muell. and *Pistacia khinjuk* seedlings due to drought stress have also been reported (Wu et al., 2006; Wang et al., 1992; Li & Wang, 2003; Mirzaei et al., 2013). According to the results of Lee et al. (2006), the morphological response of seedlings to the reduction of soil moisture is the most important mechanism to cope with drought and adaptation to stress conditions, which reduces the height, diameter, and total vegetation (Lei et al., 2006).

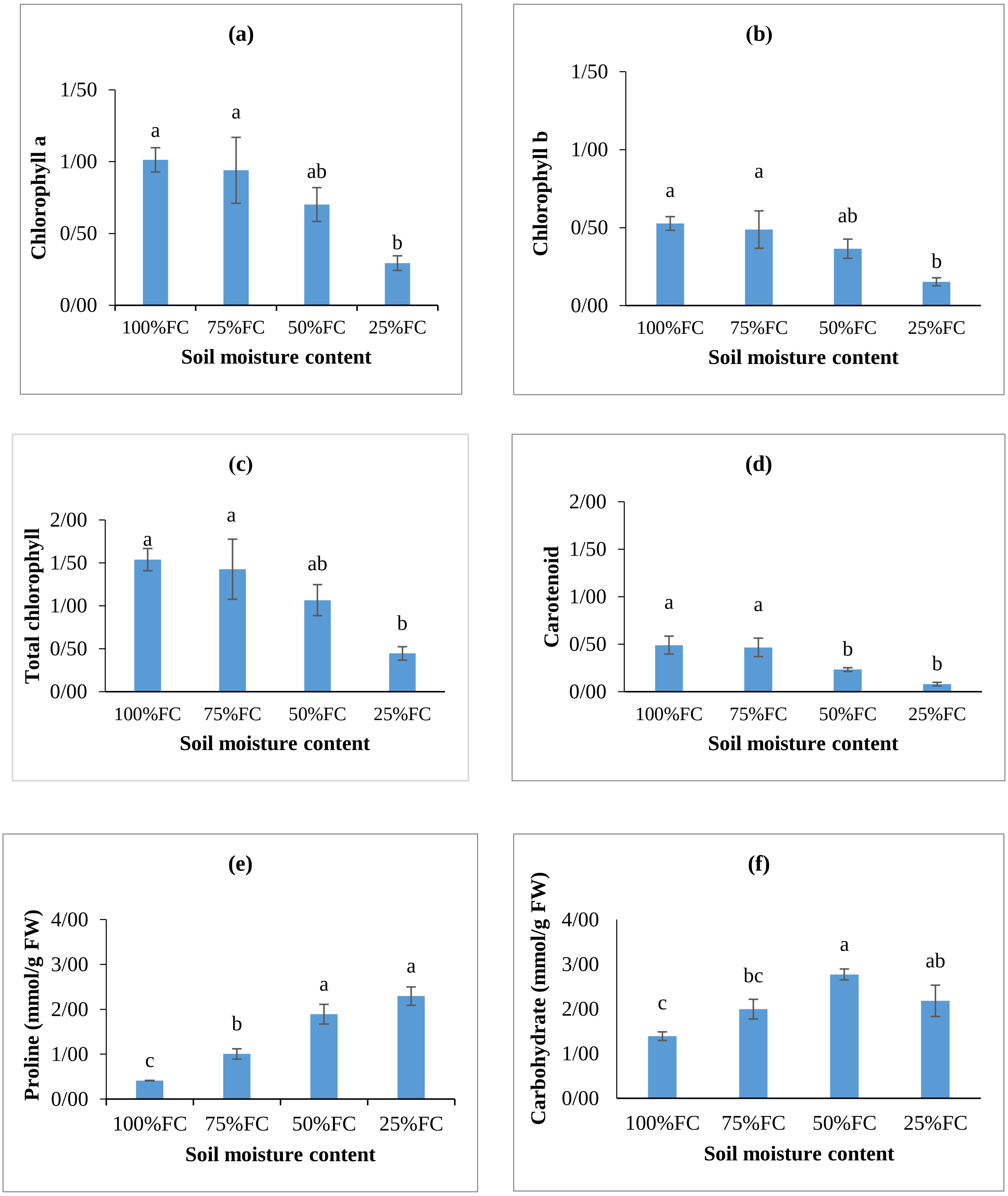

Figure 1. The effect of different soil moisture contents on physiological traits of wild cherry seedlings. a) chlorophyll a; b) chlorophyll b; c) total chlorophyll; d) carotenoid content; e) proline content; f) soluble sugar content (Means that have at least one same letter do not differ significantly at the 5% level of Duncan test).

In addition, Singh & Singh (2006) showed that different water treatments caused significant changes in reducing the collar diameter and height of seedlings (Singh & Singh, 2006). Significant reduction of dry matter due to reduction of soil moisture indicates that the roots as one of the most important components of the plant are affected by soil moisture due to this environmental phenomenon. In fact, as soil moisture decreases, the leaf photosynthesis declines, and the sugar requirements for osmotic regulation in plants increases and consequently root growth inevitably ceases.

The results obtained from the dry weight of the plant are similar to the findings of other researchers such as Tsuchida et al. (2011) and Lei et al. (2006) who showed the reduction of shoot dry weight was due to drought stress. The amount of wet and dry plant production has a strong correlation with the amount of leaf area and light absorbed by the seedlings crown (branches and leaves). Reducing any of these indicators can reduce the fresh and dry weight of the plant. The constant decrease of water in the soil leads to a decrease in leaf size and leaf area, and as a result, the dry matter of the aerial parts.

When the plant is under drought stress, leaf area, number of leaves, plant height, stem diameter, and finally plant growth decreases, resulting in a decrease in the total dry weight of the plant. Decreased leaf area due to reduced soil moisture reduced the plant's ability to absorb light. This ended to produce photosynthetic material and ultimately reduced organ weight due to reduced materialization. The dry weight loss of plant organs under drought stress observed in this study is consistent with studies conducted on apricot seedlings and some crops such as strawberries (Tsuchida et al., 2011; Grant et al., 2010)

Root-to-shoot ratio: Infiltration of roots into the lower layers of the soil in low water conditions can be considered as the ability of the plant to maintain its internal moisture content and counteract drought stress (Heidari et al., 2015, Pedrol et al., 2000). This result was also obtained through a study on medicinal plants such as Shirazi thyme, cockatiel, garden thyme and flowerpot (Lorenz et al., 1997). Although water deficiency reduces the growth of shoots and roots, the reduction of shoot growth is more than the roots (Hashemi dezfuli et al., 1994). It seems that in case of water shortage, the plant allocates more photosynthetic materials to its roots and thus, by maintaining the relative growth of roots and increasing the ratio of roots to shoots, the the plant is able to continue absorbing water (Lorenz et al., 1997).

Under drought stress conditions, nutrients from photosynthesis are more available to the roots and increase the ratio of root dry weight to shoot, which is due to a greater reduction in shoot growth compared to the root (Krishnamurthy et al., 2003). Yin et al. (2005) showed that in poplar seedlings with soil moisture content of 25%, the volume of roots per shoot was higher than the control (soil moisture 100%). Seedlings under drought stress had longer root-to-stem length than other seedlings. In other words, with decreasing soil moisture, the length of root to stem in seedlings increased. Klose et al. (2005) showed that such behavior increases water absorption that the plant shows in conditions of reduced moisture. In other words, high root-to-stem ratio creates a better balance between water uptake by the root and its excretion by the shoot (Close et al., 2005). Wu et al. (2008) by studying *Sophora davidii* seedlings showed that drought stress reduces root length, but on the other hand, increases root to stem of seedlings, which is consistent with the present results (Wu et al., 2008). In addition, increase in root-to-stem length has been observed in drought-tolerant seedlings of *Abies fabri*, *Arbutus unedo* L., *Jatropha curcas* L. (Guo et al., 2010; Achten et al., 2010).

Chlorophyll a, b, and total: The results of this study showed that chlorophyll content decreases with increasing drought stress. The decrease in chlorophyll concentration is due to the action of chlorophyll and peroxidase as a result of chlorophyll decomposition, which can also affect the amount of dry matter produced by the plant. On the other hand, drought stress disrupts enzymatic systems that reduce the activity of reactive oxygen species and increases lipid peroxidation, resulting in damage to cell membranes and pigment degradation. In other words, a decrease in chlorophyll content is likely. Due to the increased catabolism of chlorophylls and the destruction of photosynthetic pigments, this process is the result of the lack of necessary factors for the chlorophyll synthesis and the destruction of its structure under stress (Ahmadi et al., 2005). Due to drought, the formation of new plastids of chlorophyll a, b, and carotene is reduced and the ratio of chlorophyll a to chlorophyll b is changed (Ahmadi et al., 2005).

Therefore, the amount of chlorophyll decreased as observed in this experiment (Figure 1- c). This is similar to the results of experiments performed on two species of Brant`s oak (*Quercus brantii* Lindl.) and olive *(Olea europaea L*) (Zolfaghari et al., 2013).

Proline and total soluble carbohydrates: Proline and total soluble carbohydrates are often increased in leaves under drought stress and are involved in osmotic regulation (Pinheiro et al., 2004). Increases in soluble carbohydrates and proline under drought stress indicates that an increase in these properties may be a mechanism for increasing osmotic pressure and continued water uptake. Under environmental stresses, amino acids often act as osmolites for the plant and help the plant to retain water. The increase in proline in this study has probably the same reason. Soluble sugars are important osmolites that have been reported to increase in response to drought stress. Sucrose, as an osmotic regulator, maintains cell turbidity (Kerepesi et al., 1998). Drought stress increases cell-soluble carbohydrates by breaking down polysaccharides such as starch (Mohammadkhani & Heidari, 2008).

Proline is the most stable amino acid, and even more compatible with the optimal cell conditions. It accumulates in unfavorable conditions (Bates et al., 1973). Proline is one of the active amino acids in the phenomenon of osmotic regulation playing an important role in creating and maintaining osmotic pressure inside the plant. Any factor that reduces the water potential will cause proline accumulation. Proline accumulation under drought conditions has several biological effects. When the aqueous potential of the soil solution decreases, the production of free proline increases, which increases the osmotic pressure of the cell sap (Levitt, 1980; Bagheri et al., 2012). Proline accumulation in plants under drought stress is related to its oxidation to glutamate and reduced proline consumption in the production of proteins, due to stunted plant growth (Stewart, 1980). The results of various research showed that proline accumulation is effective in tolerating drought conditions. Drought-tolerant plants increase the amount of proline to cope with this stress. Increasing the amount of proline by osmotic regulation and elimination of free radicals prevents damage to the thylakoid membrane and chloroplast membrane. High levels of proline enable the plant to maintain its water potential (Valliyodan & Nguyen, 2006). Proline levels also increased in this experiment and showed a significant difference compared to the control treatment.

Proline is an osmotic regulator compound that plays a major role in osmotic resistance. The role of proline in drought resistance is complex. Some researchers believe that the increase in proline concentration during drought is simply due to a stress injury (Paleg & Aspinall, 1981). In fact, proline accumulation in drought stress conditions is a general reaction that occurs due to the production of proline in the tissue, inhibition of proline oxidation and inhibition of proline participation in protein production (Levitt, 1980). Deligoz & Baylar (2018) indicated that oak (*Quercus cerris* L., *Quercus robur* L.) showed an increase in proline in response to to a decrease in soil moisture.

In this study, it was found that the amount of soluble sugars in the leaves of seedlings increased due to lack of soil moisture. Under drought stress, starch decomposition as well as reduced transfer of sucrose out of the leaves leads to an increase in soluble carbohydrates (Pereira & Chaves, 1993).

Under drought stress, the accumulation of soluble sugars which have important physiological roles for providing energy and preventing certain death, reduces the osmotic potential of the cell.

Osmotic regulation leads to higher amount of relative water in the seedling genotype and that can be play an important role in the drought tolerance mechanism.

With this respect, the obtained results are consistent with the results of other research (Jinying et al., 2007). Increasing the concentration of carbohydrates (soluble sugars) is one of the reactions that plants show in the face of lack of soil moisture (Bohnert et al., 1995). Drought stress increases the concentration of soluble sugars by degrading and reducing starch due to increased amylase activity (Anderson & Kohorn, 2001). The results are along with the presented results based on the increase of soluble sugars under non-biological stress conditions (Kishor et al., 1995; Li &Wang, 2003). The accumulation of soluble sugars in the cell plays an important role in osmotic regulation and helps to reduce the cell water potential, thus leaving more water from the cell to maintain the torsional pressure at low water stress (Sato et al., 2004).

5. Conclusion

In general, the seedlings which are under serious stress drought (soil moisture content 25% of capacity) viability and biomasses were severely reduced. The results showed that under deficiency of soil moisture the amount of chlorophylls a and b, total chlorophyll, in wild cherries seedlings decreases, however, the amount of proline during severe stress up to four times and soluble sugars up to two times increased. . An increase in the amount of proline and soluble sugars makes the plant more tolerant of drought. Accumulation of proline helps the plant to survive shortly after drought stress and the plant can regain its growth after stress relief, so it will have a positive effect on plant growth. Moreover, for seedling survival or for afforestation initiatives with this species, planting areas should be selected through the minimum soil capacity which is 50%. Under this condition seedling survival is guaranteed.

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مجلۀ جنگل ایران، انجمن جنگلبانی ایران
سال سیزدهم، شمارۀ ۵، زمستان ۱۴۰۰
ص ۶۹-۵۷
مقاله پژوهشی

شناسه دیجیتال (DOI): 10.22034/ijf.2022.318436.1832
شناسه دیجیتال (DOR):20.1001.1.20086113.1400.13.5.5.2

تأثیر محتوی رطوبت خاک بر زنده‌مانی، رشد و برخی صفات فیزیولوژیک نهال‌های گیلاس وحشی

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(تاریخ دریافت: ۱۴۰۰/۱۰/۲۰؛ تاریخ پذیرش: ۱۴۰۰/۱۲/۲۵)

چکیده
گیلاس وحشی یا آلوکک، یکی از پهن‌برگان بومی و سریع‌الرشد جنگل‌های هیرکانی است که در جنگل‌کاری‌های آمیخته احیـایی قابـل استفاده است. بنابراین کسب آگاهی در مورد نحوه عکس‌العمل زنده‌مانی و برخی ویژگی‌های رویشی و فیزیولوژیکی نهال‌های ایـن گونـه در سطوح مختلف رطوبت خاک می‌تواند در تدوین برنامه‌های تولید نهال و جنگل‌کاری و همچنین احیای رویشگاه‌های تخریب‌یافته این گونه مورد استفاده قرار گیرد. آزمایش در قالب طرح بلوک کاملاً تصادفی با چهـار سـطح آبیـاری (شـاهد یـا ۱۰۰٪، ۷۵٪، ۵۰٪ و ۲۵٪ ظرفیت زراعی) و سه تکرار انجام شد که در هر تکرار ۵ نهال و در مجموع با ۶۰ نهال گلدانی اجرا گردید. بدین ترتیـب نهـال‌هـا بعـد از انتقال به گلدان ها به مدت پنج ماه (اردیبهشت تا شهریور) مـورد بررسـی قـرار گرفتنـد. پـس از اعمـال تیمارهـا برخـی از خصوصـیات مورفولوژیکی نهال‌ها از جمله زنده‌مانی، رشد ارتفاعی، رشد قطری، وزن خشک ریشه، وزن خشک ساقه، وزن خشک کل و نسبت ریشـه به ساقه و برخی از ویژگی‌های فیزیولوژیکی نهال‌ها از جمله غلظت رنگیزه‌های گیاهی شامل کلروفیل (a، b و کل)، کاروتنوئید، قنـدهای محلول و پرولین اندازه‌گیری شد. نتایج مشخص کرد که کاهش میزان رطوبت خاک بر زنده‌مانی و خصوصیات رویشی نهال‌هـا از جملـه رشد ارتفاعی، رشد قطری، وزن خشک ریشه، وزن خشک ساقه و نسبت ریشه به ساقه معنی‌دار بود. کاهش میزان رطوبت خـاک اثـرات متفاوتی بر صفات مورفولوژی و فیزیولوژی نهال گیلاس وحشی داشت. با کمبود رطوبت خاک میزان کلروفیل‌های a و b، کلروفیل کـل، در نهال کاهش یافت میزان پرولین در هنگام تنش شدید تا چهار برابر و میزان قندهای محلول تا دو برابر افزایش یافت. که افـزایش در میزان پرولین و قندهای محلول سبب می‌شود گیاه تحمل بیشتری در برابر خشکی داشته باشد. بنابراین حـداقل ۵۰٪ ظرفیـت زراعـی رطوبت در محیط ریشه‌دوانی نهال‌ها ضروری به نظر می‌رسد.

واژه‌های کلیدی: محتوی رطوبت خاک، زنده‌مانی، نهال، گیلاس وحشی.

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