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Review of Drought Stress on Yield, Seed Oil and Essential Oil Percentage in Medicinal Plants

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Abstract

Environmental stresses, including drought stress, are the most important factor reducing the yield of agricultural products worldwide. And have a significant negative impact on plant production areas. Drought stress is an important factor in reducing the dispersal of plants in most parts of the world. Given that most of Iran has an arid and semi-arid climate and a shortage of water resources, the control of these stresses to achieve real plant performance and increase the economic value of the product is inevitable. Since the effect of drought stress on the qualitative and quantitative characteristics of medicinal and aromatic plants has been less studied, in this study, by studying and reviewing valid articles, the results of stress studies have been inferred as follows. Medicinal plants have different sensitivity to drought stress at different stages of growth and the effect of drought stress on medicinal plants has caused different results in terms of quantitative and qualitative characteristics. In medicinal plants, application of different levels of drought stress has led to different results in yield, yield components, essential oil percentage, essential oil yield, essential oil quality, and seed oil percentage.

Keywords: Drought, proline, grain yield, percentage of essential oil, medicinal plants

Introduction

Drought stress is one of the most important environmental stresses in the climate of Iran is one of the factors limiting plant growth. Most of Iran consists of areas with limited water resources, which is the result of lack of rainfall and affects agricultural production. Drought stress is the most important non-viable factor limiting plant growth and it is estimated that it causes a 70% reduction in agricultural production worldwide (Wu et al, 2017). In Iran, drought stress is always one of the limiting factors for plant growth. In terms of plant physiology, drought stress can be defined as a period of drought and dehydration that causes physiological and morphological changes leading to reduced yield in plants (Anjum et al, 2011). Drought stress from pollination to physiological maturity, especially if accompanied by high temperatures, reduces grain filling period and grain filling rate, resulting in a decrease in mean grain weight (Royo et al, 2000).
Today, medicinal plants are considered as a rich and valuable source with high therapeutic effects. Due to the side effects of chemical drugs, the importance of herbal medicines is increasing worldwide. The unique properties of essential oils and active ingredients of medicinal plants are important in the treatment of diseases and have fewer side effects compared to chemical drugs. Due to water stress, different plants are different in terms of water productivity and

production of economic value compared to water consumption. Medicinal plants as a set of plants with high economic value can produce more capital than water for other products in the absence of water. Some medicinal plants are sensitive to drought stress and are especially damaged by increasing drought levels. Since water scarcity and consequent drought are important issues for future climate change, it is important to adopt and survive drought strategies. Therefore, drought tolerant cultivars and genotypes should be identified for exploitation and production of medicinal plants, which can achieve good grain yield and essential oil yield under drought stress conditions.

The purpose of analysis and collection of medicinal plants

The use of medicinal plants to treat diseases dates back centuries. Today, medicines made from the active ingredients of medicinal plants are considered as a valuable alternative to chemical drugs as bio-innovations in medicine. One of the important reasons for substitution is less side effects of herbal medicines compared to chemical medicines (Singh et al, 2015). Herbal compounds play a pivotal role in the food, cosmetics and health industries and have a wide variety of applications. Therefore, the economic importance of essential oils is undeniable (Gende et al, 2010). According to the World Health Organization (WHO), 80% of the world's population traditionally relies on herbs and natural products for primary health care (Chatterjee, 2002). The tendency to produce medicinal and aromatic plants and the demand for natural products are increasing, especially in the context of organic farming in the world (Carrubba et al, 2002). One of the important goals in medicinal plants is to study how to increase the amount of important active compounds in these plants. Today, many nutritionists recommend the consumption of plants, fruits and vegetables to provide the antioxidants needed by the body, because the use of herbal antioxidants, in addition to effective therapeutic effects, has fewer side effects. Plants that are rich in antioxidant compounds can protect the body's cells from oxidative damage and reduce the incidence of some diseases (prior and Cao, 2000). Therefore, due to the importance of using medicinal plants and the special effect of essential oils and their compounds in the treatment of diseases from the past to the present and very limited side effects with or without side effects of medicinal plants and the variety of essential oils in the food industry and Health, which has a very wide range and can be considered with the use of essential oils for the health and safety of consumers, Therefore, the industrial application of medicinal plants is of special importance and the motivation to expand and cultivate medicinal plants as much as possible has created a competitive market for these plants. Therefore, it is important to study the quantitative and qualitative characteristics of medicinal plants in order to reduce water consumption and increase plant yield.

The effect of drought stress on photosynthesis, respiration, material transport and chlorophyll in medicinal plants

Drought stress is one of the most important environmental stresses that affect plant growth and yield. It also reduces the water uptake by the plant root system, reduces transpiration, decreases stomatal conduction and photosynthesis, and also disturbs the hormonal balance in the plant (Khalafallah and Abo-Ghalia, 2008). One of the first signs of water deficiency is reduced inflammation and consequently reduced cell growth and development, especially in the stem and leaves (Omidbaigi et al, 2003). Accumulation of soluble sugars under drought stress may play a key role in osmotic regulation, but there are many factors involved in changing the amount of carbohydrates in plants, and the amount of sugars is directly related to processes such as photosynthesis, respiration and transport. . Therefore, the amount of carbohydrates cannot be easily interpreted (Watkinson et al, 2008). With reduced cell growth, organ size is limited and consequently light absorption is reduced and the total photosynthetic capacity of the plant is reduced. Obviously, with the restriction of photosynthetic products in conditions of water shortage, plant growth and finally yield It is defective (Omidbaigi et al, 2003). According to (Singh et al, 1997) drought stress stimulated the activity of PEP carboxylase and increased essential oil production in a species of lemongrass (*Cymbopogon flexousus*). They considered the increase in the activity of this enzyme as an adaptation mechanism to continue the assimilation of photosynthetic carbon and to maintain the water status of the plant. Drought stress reduces leaf biomass and leaf number in plants. This is probably the result of a disorder in the photosynthesis and metabolic processes of the plant. Due to drought stress, cell membranes and cell organs such as mitochondria and chloroplasts collapse. Chloroplast decay reduces chlorophyll concentration and photosynthesis (Anjum et al, 2011). Drought stress causes nutritional imbalance in plants. Closure of stomata due to drought reduces carbon dioxide exchange in leaves, resulting in reduced photosynthesis, leaf size, leaf area, biomass production, grain size and number (Grattan and Grieve, 1999). In the study of the effect of drought stress on physiological traits and essential oil content of (*Dracocephalum Moldavica* L), the highest yields of soluble sugar, chlorophyll a and total chlorophyll were reported in treatments of 60, 40, and 100% of field capacity, respectively. As the stress increases, the amount of chlorophyll a decreases and the amount of chlorophyll b increases (Safikhani, 2006). Drought stress reduces photosynthesis, degradation and reduction of chlorophyll concentration and decreases the leaf aperture of chamomile medicinal plants and also reduces the dry weight of flowers and shoots in chamomile (Farhoudi, 2012). Drought stress in Lemongrass (*Cichorium intybus*) causes chlorophyll depletion and reduces the photosynthetic ability of the plant leaves (Taheri, 2010).

Effect of drought stress on compatible metabolites (carbohydrates and proline)

The growth and development of medicinal plants, like other plants, is reduced by drought stress, but these stressful conditions usually intensify the synthesis of secondary metabolites, including active ingredients of medicinal plants. It is noteworthy that the occurrence of mild and controlled drought stress can increase the quality of medicinal plants, because most of the essential oils and medicinal effects of these plants are due to the accumulation of secondary metabolites (Petropoulos et al., 2008). In response to dehydration, plants accumulate or synthesize substances such as enzymes, proteins, secondary metabolites, and minerals (Barsa, 1997). Researchers have shown that environmental stresses increase the levels of secondary metabolites of medicinal plants (Zobayed et al, 2007). In an experiment, the effect of drought stress was to increase the concentration of soluble carbohydrates and leaf proline of the medicinal plant (*Nigella Sativa* L) Proline is an amino acid in the cytoplasm of the cell that plays a positive role in the uptake of water molecules into the cell environment. Helps maintain leaf inflammation and water uptake by roots (Rezapor et al, 2011). There have been numerous reports of a correlation between proline accumulation and soluble sugars in plants exposed to dehydration. In general, osmotic regulation is better in plants where soluble sugars accumulate in response to dehydration stress (Salama et al, 2007).
(Rezaei Chiyaneh et al, 2012) An experiment has shown that the medicinal plant Fennel (*Foeniculum vulgare* L) increases both its soluble sugars and its proline content in response to dehydration to maintain its water status. ¬ Gives to cope with drought to some extent through osmotic regulation mechanism. Increasing the amount of carbohydrates under stress conditions (especially severe stress conditions) can be due to increased decomposition of insoluble carbohydrates and consequently rising levels of soluble sugars, synthesis of osmotic substances from non-photosynthetic pathways, growth in

hibition , Reducing the rate of material transfer and increasing the rate of sucrose synthesis due to the activation of the enzyme sucrose phosphate synthase (Arndt et al, 2001). Usually the amount of free proline in plants that are irrigated optimally is very low and is about 0.6 to 0.2 mg / g dry matter. This amount increases to 40-50 mg per gram of dry matter after reducing tissue water. In some plants, several amino acids increase in the early stages of dehydration stress, but as dehydration continues, only the amino acid proline accumulates and stores more (Rajinder, 1987). (Aliabadi et al, 2008) observed accumulation of proline in drought stress conditions in coriander (*Coriandrum sativum* L). Also (Bandurska and Jozwiak, 2010) have studied the effect of drought stress on the plant (*Lolium perenne*) and concluded that as the relative water content decreases, the amount of proline increases.

As a result, the effect of moisture stress (100, 90, 80, 70, 60, 50% of field capacity) on morphological and biochemical characteristics of purple basil (*Ocimum basillicum* L) was determined that plant height, stem thickness, number and leaf area, leaf area index (LAI) and plant chlorophyll content decreases, but its levels of anthocyanins and proline increase sharply (Alishah et al, 2006). (Ghanbari and Ariafar, 2013) Studying the effect of drought stress on peppermint (*Mentha piperita* L) have stated that the application of stress will produce more secondary metabolites to prevent the oxidation process in cells. The function of a medicinal plant is cost-effective when its primary and secondary metabolites are optimal. Therefore, by managing environmental factors, maximum product performance can be achieved (Kusano et al, 2008). Drought tolerant species are able to reduce the effect of drought stress to some extent by reducing the transpiration level, increasing root length and volume, and producing compatible osmolality. At the cellular level, some genotypes regulate cell torque stress by accumulating osmolytes such as sugars, amino acids, quaternary amines, organic acids, and ions, and prevent cell damage and leaf surface development to some extent (Movahhedy Dehnavy et al, 2002).

The effect of drought stress on vegetative and reproductive growth of medicinal plants

The first sign of drought stress in the plant is inhibition of rapid shoot growth and low root growth (Neumann, 2008). Decreased single plant weight during increasing drought stress level can be related to reduced plant height, decreased leaf area and increased photosynthetic material allocation to the root relative to the aerial part of the plant (Sreevalii et al, 2001). Height difference in most plants is due to genetic characteristics and changes in environmental conditions, and since cell division and increase in size are very sensitive to drought stress, it seems that in plants under dehydration, cell size increase is affected. Located, by inhibiting the longitudinal growth of the stem, reduces plant height (Patel et al, 1996).

Drought stress causes a significant reduction in the height of the black seed plant, because under drought stress conditions, plant photosynthesis is reduced and not enough photosynthetic material is provided for plant growth. Also, due to the decrease in relative leaf moisture, cell division and growth in the meristematic region are affected, which results in a decrease in plant height (Rezaei Chiyaneh and Pirzad, 2014). The study on the effect of dehydration stress in (*Thymus vulgaris* L) showed that the effect of soil moisture levels on the length of branches was significant and the reduction of soil water content in the irrigation cycle of 10 days compared to Control treatment (irrigation period of 3 days) led to a reduction of this trait by 25.7% (Aziz et al, 2008).

(Khalil et al, 2010) in the study of the effect of dehydration stress on basil (*Ocimum basilicum* L) have stated that reducing soil moisture has a significant effect on the number of leaves, so that in the treatment of 30% of field capacity Leaves are 15% less than 50% of field capacity. It is believed that reducing the amount of water available to the plant by affecting the torsion pressure of plant cells reduces the growth and expansion of leaf cells, so the number of leaves in this condition is reduced (Alishah et al, 2006). Reduction of stem length with increasing drought stress, which was due to 2, 4, 6, 8, 10 day irrigation periods on chamomile medicinal plant and it was found that by reducing irrigation periods to once every 10-days, plant height, The number of branches, number and diameter of flowers, fresh and dry weight of flowers and the amount of essential oil of the plant are reduced. Also in thyme, under drought and 10-day irrigation periods, plant height, weight Drought and freshness of the plant decreases compared to the period of less or no stress irrigation (Aziz et al, 2008).

In one study, the effect of drought stress on five medicinal plant species was investigated and factors such as dry matter, root weight, root length, aerial body weight and plant height were measured. At the end of the experiment, (*Salvia officinalis*) and (*Achillea millefolium*) were introduced as medicinal plants resistant to drought or dehydration (Lebaschy and sharifi Ashoorabadi, 2004). The study of the effect of soil moisture levels on the medicinal plant Lemongrass shows that reducing the amount of water available to the plant leads to a reduction in the number of branches, so that the number of branches in the most severe dehydration treatment (50% reduction in root water availability) 25 Percentage is less than the optimal irrigation treatment (12.5% reduction in root water availability) (Ozturk et al, 2004). In another experiment on (*Satureja hortensis* L), vegetative characteristics such as stem height, number and area of leaf area, root length, leaf dry weight, stem and root decreased significantly with increasing drought (Esmaielpour et al , 2013).

(Rizopoulou and Diamantoglon, 1991) with an experiment on marjoram (*Origanum majorana*) have stated that drought stress has increased the amount of essential oil in this plant and the number of internodes, biomass and plant height in conditions of low water stress with Has been declining. In a study, it was reported that increasing the number of irrigation cycles had a positive effect on increasing the plant height of (*Plantago ovata* L) (Patel et al, 1996). The results of research conducted in some medicinal plants showed that the lack of water in the vegetative growth stages (before the flowering stage) causes the creation of plants with short height and also the shrinkage of leaf leaf surface, for example in yarrow medicinal plant (Sharifi Ashoorabadi et al, 2005). Due to the limited growth of black seed, drought stress increases the rate of transition from vegetative to reproductive stage, reduces the number of sub-branches, reduces the number of capsules and seeds per capsule (Mozzafari et al, 2000).

(Jahanara and Haerizadah, 2001) have observed the negative effects of drought stress on plant height, biomass, number of umbrellas, number of umbrellas per umbrella, 1000-seed weight and grain yield in two native fennel stands. Flowering status in flowering plant (*Dracocephalum Moldavica* L) shows that application of intense moisture stress reduces flowering and flowering branch yield in severe moisture stress treatments compared to non-stress treatments (Lebaschy and sharifi Ashoorabadi, 2004). (Heidari et al, 2012) In the study of the effect of water shortage stress on (*Pimpinella anisum* L) reduction of grain yield, 1000-seed weight, biomass, number of umbrellas per plant, number of umbrellas per umbrella, number of seeds per umbrella, The index of harvest and yield of essential oil under drought stress conditions have been reported. Drought stress reduces plant growth and delays germination by reducing turbulence and cell growth, reducing light absorption and total photosynthetic capacity of the plant, especially in stems and leaves (Hasani, 2006).

The effect of drought stress on grain yield and yield components in medicinal plants

Decreased yield as a result of stress (Sreevalli et al, 2001) may be related to the increased allocation of photosynthetic material to the roots relative to the aerial part of the plant. Research on the medicinal plant of coriander shows that increasing drought stress reduces yield and its components and the highest percentage of essential oil and its main components (linalool, alphapinene, gamma terpinin, geranium acetate, camphor) are treated with mild stress treatment. (Ahmadian and Nourzad, 2014). The results of a study (Barnabas et al, 2007) on coriander and a study (Mohamed et al., 2002) on parsley (*Tagetes Minuta*) show that the reduction in grain yield, either by reducing the number of seeds or reducing their weight Or both. Drought stress also reduces the duration of the vegetative period to the flowering period. (Afsharmanesh et al, 2008) The grain yield of asfarzeh medicinal plant under severe stress conditions (irrigation after 25% of field capacity) was reported to be 88.1 kg / ha compared to mild stress (irrigation after 75% of field capacity) 43 Had a percentage. (Bazazi et al, 2013) By studying the effect of drought stress on fenugreek (*Trigoneella Foenum-graecum* L) have shown that biological yield and grain yield are significantly reduced under the influence of drought stress. (Baghalian et al, 2011) By examining drought stress on chamomile flower yield, they have observed that dry stress reduces chamomile flower yield.

(Razavizadeh et al, 2017) have reported an 18% decrease in the number of umbrellas per plant and a 33% decrease in seed yield of the medicinal plant (*Carum copticum* L) in reducing the irrigation rate to 70% of the field capacity and also stated that in the capacity 50% of the field capacity, the plant did not reach the seed stage. Decreased plant dry matter yield in response to drought stress, on the other hand, may lead to a decrease in the active ingredient yield of the medicinal plant. (Pouryousef, 2015) In an experiment on the fennel plant, it was reported that the yield of fennel seeds and essential oil decreased significantly under the influence of drought stress. Drought stress with a negative effect on the number of capsules per plant and seed in the capsule has caused a significant reduction in black seed grain yield. (Rezaei Chiyaneh and Pirzad, 2014) Also in another study on plant Drought stress causes wet and dry weight loss (Bettaieb et al, 2011). (Patel et al, 1996) have stated that with increasing irrigation frequency, the number of seeds per umbel in (*Plantago psyllium* L) increases. According to experimental results on asparagus, it is reported that under low water stress due to closed pores, reduced leaf area and reduced photosynthetic activity as well as shortening the period of seed filling, premature aging And 1000-seed weight of asparagus is significantly reduced (Kocheki and Teimori, 2011).

(Ganpat et al, 1992) have studied the response of asparagus to the number of irrigations and have concluded that by increasing the number of irrigations to 5 times, straw yield and up to 4 irrigations, seed yield increases. (Surendra et al, (1994) In response of coriander to different amounts of irrigation, have shown that using 3 irrigations in the stages of branching, flowering, and grain filling, grain yield and straw are higher Shows in comparison with 1 and 2 irrigations. (Noroozi Shahri et al, 2015) In an experiment to investigate the effect of drought stress on yield and yield components of some native cultivars of fennel have shown that drought stress reduces grain yield, percentage and yield of biomass essential oil. (Lebaschy and Sharifi Ashoorabadi, 2004) have stated that the medicinal plants of asparagus, yarrow, sage, marigold and chamomile reduce shoot weight, plant height and grain yield by intensifying drought stress.

The effect of drought stress on oil quality and percentage in medicinal plants

Although drought stress increases the percentage of essential oils of the rosemary (*Rosmarinus officinalis* L); However, the essential oil content decreases under drought stress conditions, which is the case for most medicinal plants (Manieval et al, 2001). (Rahmani et al, 2008) have shown that drought stress has a significant effect on oil yield and essential oil content of(*calendula officinalis*). In another study, drought stress reduced grain yield, dry weight, root weight and the amount of coriander oil produced (Patra et al, 1999). The effect of drought stress on fatty acids, yield and medicinal composition of sage has been shown that drought stress significantly reduces the fatty acid content of this plant (Bettaieb et al, 2008). (Demir kaya et al, (2006) have shown in their research that salinity stress reduces the essential oil yield in plants of the mint family and on the other hand drought stress can increase the percentage of essential oils of most medicinal plants, because In this case, more metabolites are produced and these substances prevent the action of oxidation in the cell. (Wahbi et al, 2005) by studying the effect of deficient root irrigation on olive plant (*Olea europaea* L) have reported that the percentage of oil, fruit weight and water use efficiency have increased as a result of poor root irrigation.

The effect of drought stress on essential oil compounds in medicinal plants

Research (Schwars et al, 2001) has shown that cell membranes and organs are the first site of damage to cells under drought stress by reactive oxygen species. Plants have processes in place to counteract these compounds. They have developed what are generally known as the antioxidant defense process. Active substances are made primarily by genetic processes, but their quantity and quality are significantly influenced by environmental factors such as water, climate, light and soil (Omidbeigi, 1995). Drought is one of the most important environmental factors affecting the quantity and quality of essential oils, so that with increasing drought, the total amount of essential oil of lemongrass decreases (Ozturk et al, 2004). Drought stress on (*Padron pepper*) also increases phenolic compounds and increases its intensity (Estrada et al, 1999). The study of the effect of water stress on the change of essential oil composition of basil has shown that with the application of drought stress, the potential of the plant leaf water is greatly reduced, but in contrast to the amount of basil essential oil to 6.2 μl / g dry weight of the plant increase. Drought stress has also been shown to increase linalool and methylcavicol in basil, although the relative components of sesquiterpenes decrease (Simon et al, 1992). (Okwany et al, 2011) have studied the effect of low irrigation on yield and quality of peppermint essential oil (*Mentha Spicata* L) and reported that the highest essential oil yield in the treatment of 73% of complete water requirement and 60.4 Kg per hectare has been observed. The highest percentages of limonene, carvone and myrrh as the main constituents of essential oil were observed in treatments 73, 82, 94% of complete water requirement and the rates of 18.9, 66.67 and 6.14%, respectively. The highest essential oil harvest index and water consumption efficiency of essential oil were observed at the highest stress levels of 0.006 and 0.027 kg / m3, respectively.

It is noteworthy about the amount and composition of essential oils of lavender (*Lavandula angustifolia*) and the difference in these amounts in different reports, so that in a report on the amount and composition of components of lavender essential oil grown in northern Iran, There is a large difference between the amount of leaf essential oil (0.64%) and flowers (6.25%), which are different in other studies where the most important components of leaf essential oil include borneol, cinnabar and camphor. There is also a big difference between the type of composition of essential oil components and the amount of those components in flowers and leaves (Kara and Baydar, 2013). The highest thymol content was obtained in thyme at 70% of field capacity (Letchamo et al, 1994). In the medicinal plant rosemary, the production of essential oils and phenolic compounds decreases in water-deficient conditions compared to non-stress conditions (Solinas et al, 1996).

The effect of drought stress on the percentage and yield of essential oils of medicinal plants

In most medicinal plants, drought stress increases the percentage of their active ingredients, such as in calendula (*Cymbopogon winterianus Juwit*) (Fatima et al, 1999), (*calendula officinalis* L) (Taherkhani et al ., 2011), German chamomile (*Matricaria chamomilla* L) and martigale (*Silybum marianum* L) (Vazque, 2010) have been reported. (Rahmani et al, 2008) have reported that drought stress has a significant effect on the percentage of essential oil of (*calendula officinalis*). Their results show that the highest percentage of essential oil is obtained in dry conditions. The results of research on Mexican oregano have shown that the percentage of essential oil of this medicinal plant has increased significantly with the application of drought stress (Dunford and Vazquez, 2005). In the study of the effect of moisture regimes on thyme, the highest percentage of essential oil yield was obtained under 70% of field capacity and there was no significant difference between 90% and 50% moisture regimes. (Letchamo and Gosselin, 1996). The effect of drought stress on growth indices of Lemongrass has shown that drought stress is effective on leaf area index, dry matter, plant growth rate and relative growth rate and percentage and yield of plant essential oil (Ardekani et al, 2010). Research on the medicinal plant Cumin (*Cuminum Cyminum* L) has shown that the highest amount of essential oil is obtained at moderate stress (Bettaieb et al, 2012). (Safikhani et al, 2007) By studying the effect of drought stress on the percentage and yield of essential oil and physiological characteristics of (*Dracocephalum moldavica*) have shown that the highest percentage of essential oil in the treatment of moisture stress is 40% of usable plant moisture. (Misra and Srivastava, 2000) have observed that water stress significantly reduces fresh and dry weight and essential oil yield of peppermint plants.

Estrada et al, (1999) reported that drought stress increases the percentage and yield of essential oil in black pepper (*Padron piper*). (Zehtab-Salmasi et al, 2001) By examining the effect of drought stress on the essential oil yield of some medicinal plants, they have observed that drought stress increases the percentage of some essential oil compositions of rosemary, but on the percentage and yield of anise essential oil. It had no significant effect. Increased essential oil yield of chamomile under the influence of mild drought stress and severe reduction in essential oil yield under the influence of severe drought stress have been reported in research (Farhoudi, 2012). In medicinal plants such as wormwood (*Artemisia absinthium* L) and rosemary (*Rosmarinus officinalis* L), no change in the yield of active ingredients under drought stress conditions has been observed (Fransworth et al., 2011). (Ghanbari and Ariafar, 2013) have studied the effect of low irrigation at three levels of 70, 50, 30% of field capacity and application of zeolite on the growth traits and yield of essential oil in peppermint. They reported that the highest percentage of essential oil in low irrigation treatments was related to the treatment of 30% of field capacity and the highest essential oil yield was observed in the treatment of 50% of field capacity at the rate of 17.5 mg / m2. Drought stress has affected wet and dry yield, chlorophyll a and b, soluble sugars, proline, relative leaf water content and percentage and yield of peppermint essential oil (Izadi et al, 2009). In other studies, the effect of drought stress on the yield of basil, thyme and rosemary essential oils has been reported (Solinas and Deiana, 1996).

Experiments with German chamomile (*Matricaria chamomilla* L) have shown that the essential oil content of this plant was higher in mild stress than in severe stress and full irrigation (Ahmadian et al, 2011). (Khorasaninedjad et al, 2016) The highest percentage of essential oil in the treatment of 26% of usable plant moisture in lavender has been reported. They have stated that the amount of essential oil does not always increase with increasing stress intensity, because at more intense stresses, the plant spends most of its photosynthetic material on the production of osmotic regulatory compounds such as proline, glycine, betaine and Sugars such as sucrose, fructose and fructans to provide the necessary conditions for its survival. In the study of the effect of water stress on a species of basil (*Ocimum gratissimum*), it was found that plant height, total chlorophyll content and relative leaf water content decreased in response to stress; While the levels of total phenol in the leaves and roots of stressed plants have increased by 104% and 97%, respectively, compared to non-stressed conditions. Also, despite the increase in the percentage of essential oil due to stress, the difference between stressed and non-stressed plants was not significant (Hazzoumi et al, 2015). The results of research conducted on the Mexican oregano plant have shown that a significant increase in the essential oil content of this medicinal plant has been reported due to drought stress. Therefore, it can be stated that in order to prevent the decline in essential oil yield, irrigation should be stopped as much as possible (Dunford and Vazquez, 2005). In two separate studies, the effect of different levels of drought stress (55, 70, 85, percentage of field capacity) by (Omidbaigi et al, 2003) in basil (*Ocimum basilicum*) and (Hassani, 2006) in Badershbo (*Dracocephalum moldavica*) was investigated and the results It has been shown that in both plants with increasing drought stress, the percentage of essential oil increases to 70% of field capacity, while the yield of essential oil at all levels of stress decreases compared to the control treatment. (Petropoulos et al, 2008) Research has shown that drought stress increases the quality and yield of essential oil in parsley.

Other research has shown that in essential oil of marjoram due to lack of water, the amount of essential oil increases and due to reduced cell division, leaf length decreases (Rizopoulou and Diamantoglon, 1991). According to experimental results on lemongrass, mild stress treatment had the highest essential oil yield, which was higher than control and severe stress treatment (Ardakani et al, 2007). (Munne et al, 1999) stated that drought stress reduced the relative water (RWC) of rosemary by 40% and lemongrass by 30% and increased the amount of tocopherol, the percentage of essential oil and the amount of soluble sugars. . Also, the yield of both plants has been significantly reduced compared to the non-stress treatment, but the yield of essential oil has been different from the results of dry matter yield and the highest amount of essential oil is obtained in one-post irrigation after harvest.

Discussion and conclusion

Environmental stresses are the most important factor reducing the yield of agricultural products worldwide. And have a significant negative impact on plant production areas. Given that most of Iran has an arid and semi-arid climate and a shortage of water resources, controlling these stresses to achieve real plant performance and increase the economic value of the product is inevitable. Since the effect of drought stress on the qualitative and quantitative characteristics of medicinal and aromatic plants has been less studied, in this study, by studying and reviewing valid articles, the results of studies in this field have been inferred. Drought stress on medicinal plants has different results in terms of quantitative and qualitative characteristics, which in most medicinal plants leads to an increase in the percentage of essential oil, essential oil yield and increased essential oil quality, as well as reduced dry matter, grain yield and oil percentage has been. In other words, in this study, due to the application of drought stress on medicinal plants, it is generally inferred that the amount of drought stress has different results in vegetative and reproductive growth stages in medicinal plants, leading to different yield results in these plants. The effect of drought stress significantly increases the secondary metabolites, especially phenolic compounds in plants and the highest accumulation of proline and carbohydrates is obtained at the level of severe drought stress. Drought stress causes changes in medicinal and aromatic compounds of medicinal plants. The effect of dehydration stress is not limited to the function of essential oil but also affects the quality of essential oil. Drought stress increases the percentage of essential oil and the major constituents of essential oil in medicinal and aromatic plants. . On the other hand, mild drought stress increases the yield of essential oil and severe drought stress increases the quality of the essential oil. Also, severe drought stress reduces the vegetative and reproductive growth of the plant and plant height, number of lateral branches and total dry weight of medicinal plants are reduced. With increasing intensity of drought stress, the number of seeds obtained from the plant, 1000-seed weight, and grain yield decrease. Reducing the concentration of chlorophyll and consequently reducing photosynthesis has a great effect on reducing the weight of the economic organs of plants.

Therefore, considering that water has a major effect on the growth and development of active ingredients of medicinal plants, and drought stress is one of the main obstacles in reducing the production of medicinal plants, conducting effective research to reduce the adverse effects of stress. To achieve economic thresholds, the yield of medicinal plants seems to be important and recognizing the different reactions of medicinal plants to water scarcity and water resources management in order to increase productivity and efficiency of water consumption is of particular importance, since drought. An important issue for future climate change is the application of a drought tolerance strategy. Therefore, the important issue is the use of drought tolerant species that it is suggested to identify drought tolerant cultivars and genotypes for exploitation and production of medicinal plants, which can have good grain yield and essential oil yield. Have under drought stress conditions.

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