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Assessment of physiological attributes of safflower (*Carthamus tinctorious* L.) under drought

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Abstract

Safflower is one of the major oilseed crop enriched with various nourishing elements. It helps to full fill the food demand of present population. For the assessment of drought tolerant cultivars of safflower a completely randomized experiment was designed and performed at department of Botany, Government College University Faisalabad. Eighty accessions of safflower were selected for this purpose. Seeds were sown in plastic pots after pre-treatment of seeds with distilled water. After two weeks of germination, drought (60% field capacity) was applied to the plants. Their growth, shoot and root fresh and dry weights, shoot and root length were analyzed under well watered and water deficit condition. Data for growth had been collected manually, and by applying ANNOVA all the values were contrasted. Safflower due to its tape root system considered to be remain unaffected from drought but the present findings contradict this approach. Drought had significant ($P \leq 0.001$) effect on plant biomass. Due to drought plant shoot and root fresh weight was reduced. Dry weights of plant biomass were also reduced due to water deficit. Seedling length remained unaffected under water scarcity. All these effects were not same for all cultivars. Some of the accessions were remained drought tolerant. All these results had proven safflower to be cultivated at larger scale in dry and water deficit areas.

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Introduction

Family Asteraceae has an annual oilseed crop, Safflower (Carthamus tinctorius L. this is one of the widely cultivating crops all around the world (Rastogu *et al.,* 2013). Safflower is famous for its wide utilization in textile, food, and medicinal industry. This is one of those crops that can be grown under severe conditions whether warm or frost, well water or water deficit (Omidi *et al.,* 2012; Sampaio *et al.,* 2016). Its profound and rotating root framework enables it to investigate further soil layers, improving its capacity to concentrate water and supplements that are not accessible for most yields (Bagheri and SamDailiri, 2011). Then again, its enormous biomass creation and long developing season may bring about quick and serious decrease of ground water holds. Despite the fact that safflower is viewed as tolerant to dry spell, it might indicate decrease in photosynthesis and cell extension submerged pressure conditions, which prompts a reduction in plant tallness, leaf number and leaf territory. This essentially influences safflower grain yield and its monetary proficiency (Omidi *et al.,* 2012).

Dry spell named as a lack of water for a particular length that hold for a specific timeframe because of climatic changes, development, less precipitation, an unnatural weather change and biological zones (Qamar *et al.,* 2018). Numerous explores considered dry spell as a main consideration behind diminished harvest generation, yield decrease and monetary misfortune for any nation. Dry season happens when deficient water assets are given to a harvest to quite a while. Because of dry spell, soil become less fruitful as a result of increment in saltiness and de-oxygenation. Deficient water supply lead towards the poor development, cell lack of hydration, low pace of photosynthesis, receptive oxygen species (ROS) creation and in this way cell passing (Akram *et al.,* 2017). Water shortage is a principal factor behind the decrease of harvest yields and will turn into a risk, for nourishment creation and palatable oils, in coming years due to an Earth-wide temperature boost and expanding populace recurrence (Qamar *et al.,* 2018). In Pakistan dry season is known to be a developing danger for the horticultural land. Territories of Pakistan particularly Sindh and Baluchistan are experiencing dry spell because of less precipitation and low degree of stream water (Ashraf, 2009). It is evaluated that one fourth of rural place where there is Pakistan is experiencing extreme water lack (Khan *et al.,* 2011).

In this perspective, the present examination was intended to recognize the dry season tolerant cultivars of safflower to be developed in Pakistan.

Materials and methods

The first screening analysis was performed at Government College University Faisalabad. The test configuration was totally randomized comprising of four replicates. This analysis was included 80 cultivars of safflower. Dispensable plastic glass was taken to perform the analysis. Filled each pot with 500 g sandy-topsoil soil. The seeds of safflower were pretreated with refined water for one hour before planting. The soil, in which experiment was conducted, was chemically analyzed and data was recorded (pH, 8.2 ; EC, 1.8 dSm^{-1} ; P, 7.24 mg kg^{-1}; N, 0.08% ; K, 163 mg kg^{-1} ; Ca^{+2}, 129.4 mg kg^{-1}; Percentage of saturation, 40% ; organic matter, 1.28% ; clay,72% ; silt, 44% ; sand, 20%; Zn, 0.78 mg kg^{-1}; and Iron. In each pot 5 seeds were sown by hand. Germination of seeds was observed after one week. After two weeks of germination water stress (60% and 100% field capacity) treatment were applied. After one month of stress subsequent factors were examined.

Measurement of plant fresh and dry biomass

As a matter of first importance, the seed germination rate was determined. At that point, the roots and shoots were isolated and after that their new weights were determined physically by utilizing weight balance. Leaf territory per plant was then estimated by a scale. Shoot and root tests were oven dried at 60˚C for three days and their weights were calculated.

Measurement of plant length

By utilizing meter rule, the length of each plant per duplicate was estimated.

Statistical Analysis

A three-way analysis of variance of data (ANOVA) for all growth attributes was carried out to test the effects of water stress on safflower. To evaluate the significant change among the mean values, LSD at 5 % probability was employed (Snedecor, 1980). At the end interactions between growth and inhibiting factor were calculated.

Results and discussion

Mean squares from two-way analysis of variance of data (ANOVA) for shoot and root fresh weight had revealed that there is non-significant difference in safflower on shoot and root fresh weights, however Acc. 16171, 16183,161207 and 16246 had remarkable shoot fresh weights among all other accessions. Drought had significant ($P \leq 0.001$) reducing effect on shoot and root fresh weights.

Shoot dry weight was non-significantly affected by the variety of safflower but drought significantly ($P \leq 0.001$) decreased the shoot dry weights as shown in Fig. 1, 2, 3. Root dry weights were significantly ($P \leq 0.001$) varies with the variety of safflower under both well-water and water deficit conditions.

Table 1. Mean squares for shoot and root fresh and shoot dry weights of safflower (*Carthamus tinctorious* L.) plants under 100% field capacity and 60% field capacity (drought).

Source of variation	df	Shoot fresh wt.	Shoot dry wt.	Root fresh wt.
Cultivars (CVs)	79	87.254278ns	6.7235546ns	0.0138099 ns
Drought	1	13520***	142.96541***	0.1091503**
CVs × Drought	79	1.381e-26ns	0.240566 ns	7.693e-4 ns
Error	160			

** and *** = significant at 0.01 and 0.001 levels, respectively; ns = non-significant.

Table 2. Mean squares for root dry weights and shoot and root lengths of safflower (*Carthamus tinctorious* L.) plants under 100% field capacity and 60% field capacity (drought).

Source of variation	df	Root dry wt.	Shoot length	Root length
Cultivars (CVs)	79	0.0014309***	225.32582ns	36.55282**
Drought	1	0.0691782***	9680***	3774.3781***
CVs x Drought	79	9.8615e-5ns	2.22e-28ns	0.5679984ns
Error	160			

** and *** = significant at 0.01 and 0.001 levels, respectively; ns = non-significant.

During well water conditions, shoot lengths of all the accessions were non–significantly differentiate. But under water deficit stress, a significant ($P \leq 0.001$) decline was observed in almost all cultivars except in Acc. 16171, 16183, 161207 and 161246. Root lengths were significantly ($P \leq 0.001$) improved under both, well water and water deficit stress. Among all accessions this factor was greatly observed in Acc. 16171, 16183, 161207 and 161246 (Fig. 4, 5, 6).

Discussion

Dry season is the result of different human exercises, which is at last influencing the life of living beings present on earth (Javed *et al.,* 2014).

It legitimately meddle with the exercises of the makers of the biosphere. The opposite outcomes of water deficiency incorporates decrease in seed growing. For the improvement and better development of the plant, seed germination is an essential factor which is seriously misrepresented by the water shortage (Alonso *et al.,* 2014; Qamar *et al.,* 2018). As in the present study the growth of the plants in well water condition is remarkable.

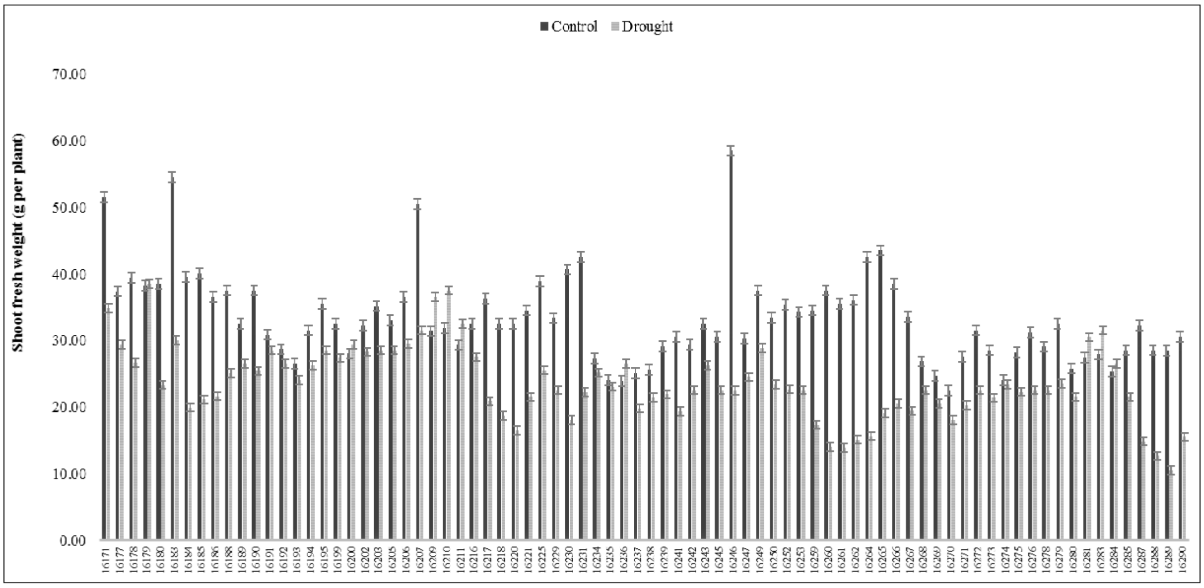

Fig. 1. Shoot fresh weights of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

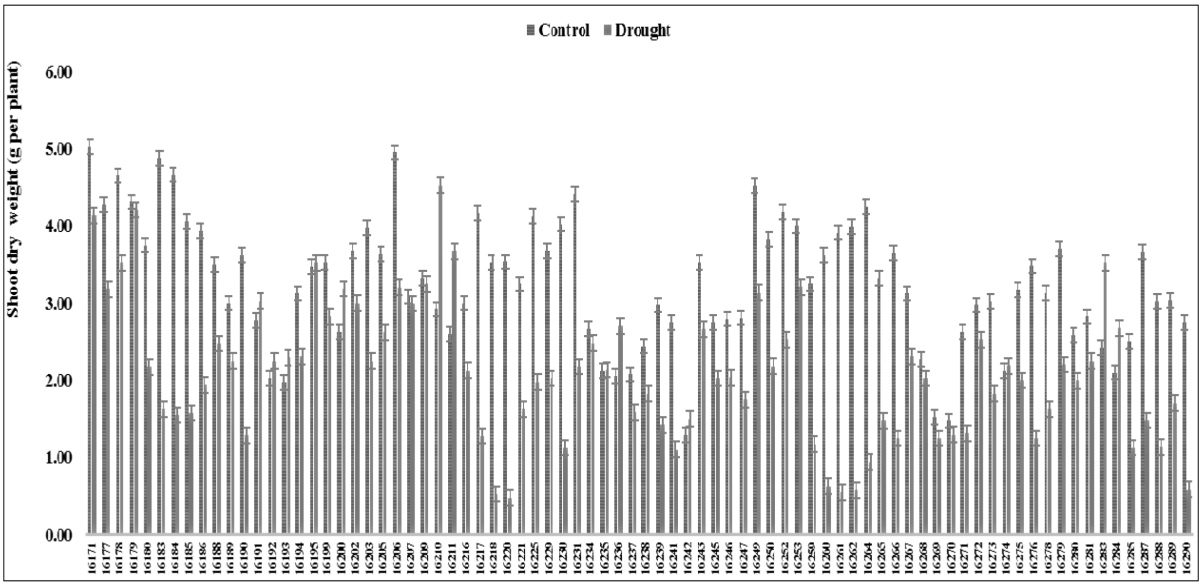

Fig. 2. Shoot dry weights of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

In the roots, there is water potential inclination present between the roots and soil which is liable for the development of the water among soil and plants. (Chen *et al.,* 2011). Water insufficiency causes root cells to be solidify, which results in the denied development of plant (Kano *et al.,* 2011; Zhu and Gong, 2014). The same thing was observed in the present study that the root fresh and dry weights were reduced in most of the safflower accessions. These results are similar to those which were reported by Shafiq *et al*., 2014. Plants having tape root framework are more tolerant instead of the shallow root framework. Like in tubers (potatoes) less resilience is accounted for dry spell when contrasted with the safflower and different plants having tape root framework (Fitters *et al.,* 2018). In the present study, drought (60% field capacity) significantly ($P \leq 0.001$) reduced the plant shoot and root fresh and dry biomass of almost all cultivars. Age of abscisic acid in the roots happens when there is shortage of water, bringing about the end of air and water pores to limit the vanishing of water (Chaves *et al.,* 2009).

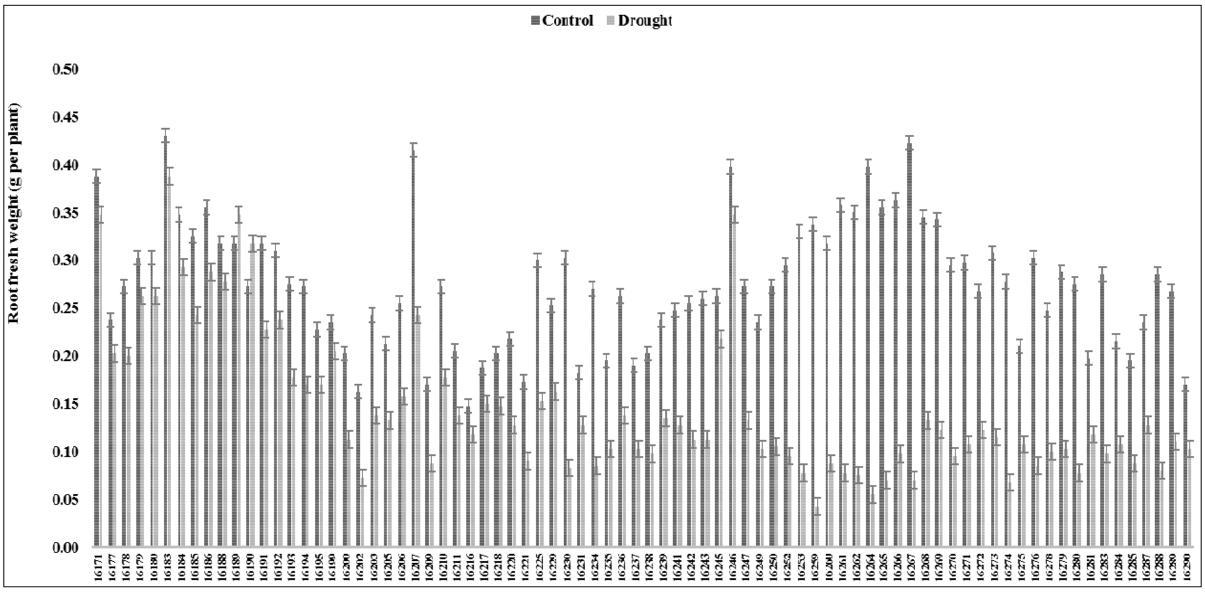

Fig. 3. Root fresh weight of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

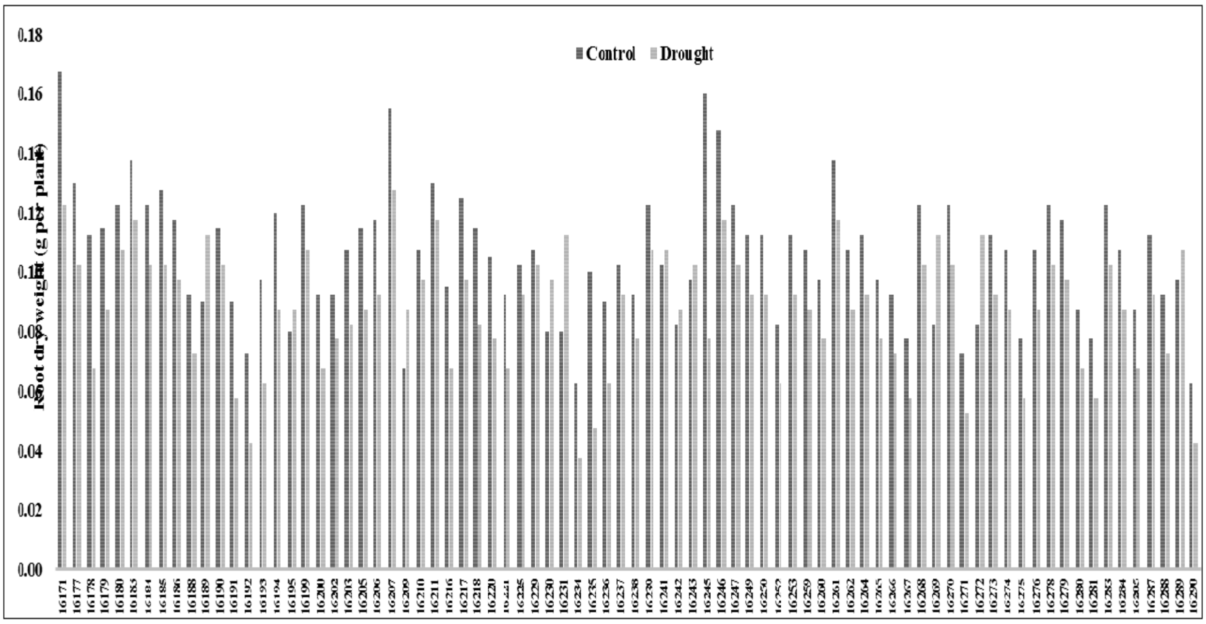

Fig. 4. Root dry weight of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

Root length diminishes in the wetter part however the roots in the dried part stay unaffected (Chimungu *et al.,* 2014; Chimungu *et al.,* 2015).

In any case, from such discussion and from the results of the exploration work, it is cleared that the plant crisp and dry biomass in any kind of root framework is influenced by dry season. In corn (Wang *et al.,* 2017), wheat (Djanaguiraman *et al.,* 2018), rice (Larkunthod *et al.,* 2018), chickpea (Sofi *et al.,* 2018), canola (Shafiq *et al.,* 2014), safflower (Khosrowshahi *et al.,* 2018), adequately declined plant new and dry biomass have been accounted for which are similar to the results of the present study.

Dry season negatively affects development of the plant shoot in this manner driving towards the lack of the feed stock for the creatures (Scasta *et al.,* 2016; Indrasumunar *et al.,* 2017).

As in the present examination a noticeable impact of dry season has been seen on root and shoot lengths which results the less yield. A similar pattern was seen in maize (Chimungu *et al.,* 2015), wheat (Djanaguiraman *et al.,* 2018), rice (Larkunthod *et al.,* 2018), chickpea (Sofi *et al.,* 2018), canola (Shafiq *et al.,* 2014), safflower (Khosrowshahi *et al.,* 2018).

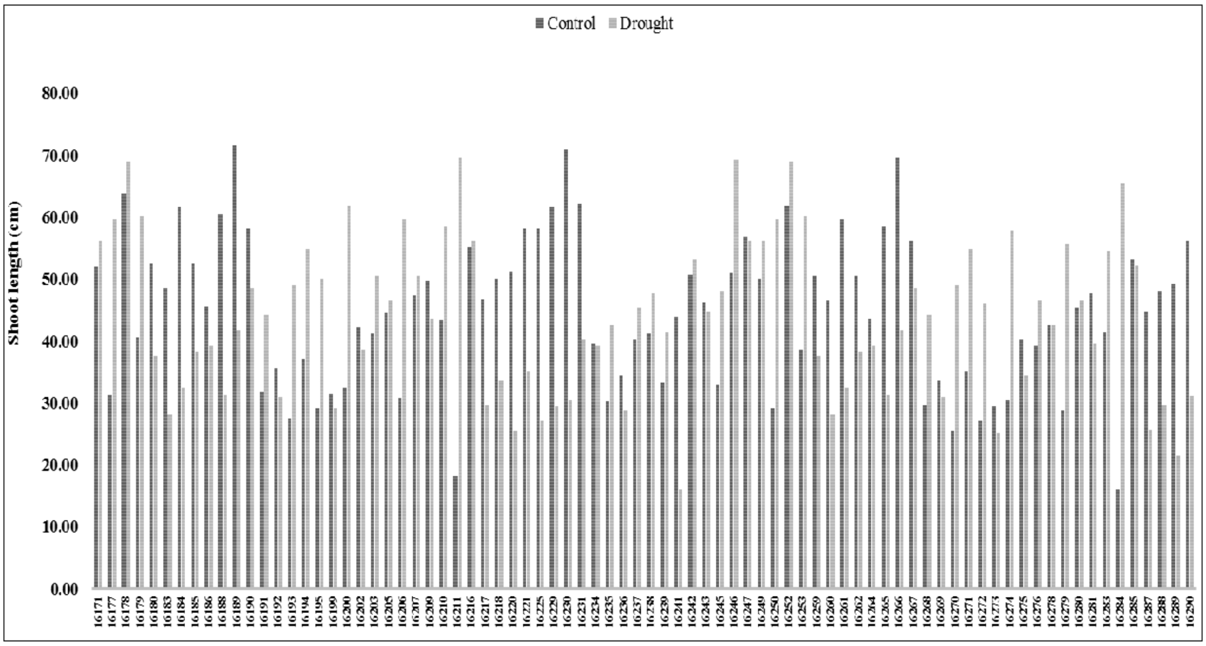

Fig. 5. Shoot length of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

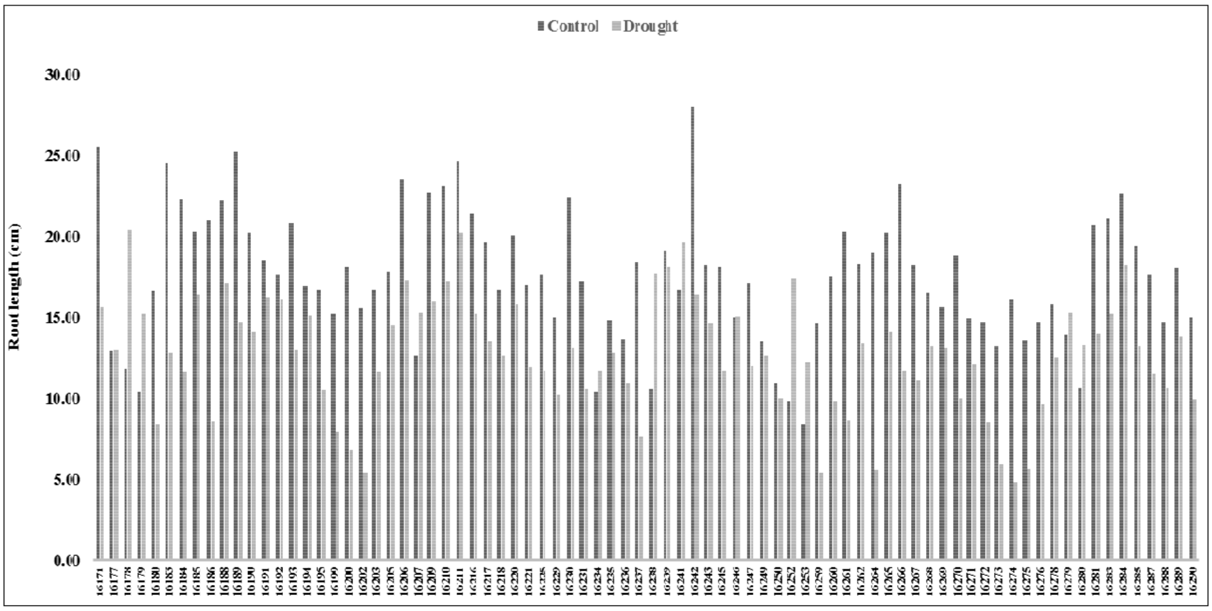

Fig. 6. Root lengths of 80 accessions of safflower under control and drought (60 % Field capacity) conditions.

Conclusion

According to the results, it was concluded that various varieties of safflower are resistant to drought. Also pretreatment of the seeds with water can also help the plant to survive in dry conditions. Increase of lengths of the root frame work of safflower confirms the efficacy of its tape root system to explore layer of soil to fulfill water deficiency.

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