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Evaluation of competitive ability in Artemisia (*Artemisia aucheri*) with Bromus (*Bromus tomentellus*) and relationship with the amount and distribution of leaf canopy

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ABSTRACT

Coexistence of plants is regarded as important elements for the dynamics of plant communities. Knowing these relationships is useful for recognize various stages of dynamic cycle between the plants. In order to evaluate the competitive capability of Artemisia aucheri and Bromus tomentellus as well as their relationship with the amount and quality of leaf area distribution in the cover crown, an experiment was conducted in glasshouse condition using complete randomized design with 4 replications. The treatments were different proportions of A. aucheri and B. tomentellus seeds given as 0+100, 10+90, 20+80, 30+70, 40+60, 50+50, 60+40, 70+30, 80+20, 90+10, and 100+0, respectively. Seeds were sown in pots and the pots were placed in the greenhouse at the day and night temperature of 27±3 and 17±3°C, respectively. Data were collected for number of days till germination, vigor index, seedling leaf area index (LAI), leaf area duration (LAD), seedling fresh and dry weights, shoot/root length ratio, seedling length and root length were measured. Results of analysis variance showed that after the germination of B. tomentellus seeds, the mix cropping had had no considerable effects on the growth of stem, root, seedling and dry and wet weight of aerial organs, thus, it was concluded that higher portion of A. aucheri seeds had negatively significant allelopathic effect on the seed germination and seedling growth stage. Then, the germinated seeds of B. tomentellus species grew in comparison with A. aucheri species.

Key words: *Artemisia aucheri*, *Bromus tomentellus*, Leaf area index, Leaf area durability

INTRODUCTION

Mutual interactions of plants are considered as important elements for the dynamics of plant communities [1]. In recent decade, some studies demonstrated that in rainy regions and fertile soils with more suitable conditions for the plant growth, the competition interaction (a negative relationship) is more important. Whereas in dry regions, there is a probability of facilitation interaction (a positive relationship) between plants [2]. Competition may be regarded as a negative interference when it leads to the decreased growth in two adjacent plant species in order to reduce such necessary factors as water and mineral resources. In appropriate management circumstances along with suitable plant growth conditions, the most plant competition may be seen for light [3]. Often, the observed differences in the yield of competitive species with respect to the mixed cultivation are resulted from a difference between the amount of received light and its consumption efficiency [4]. Competition can occur among the individuals of one specific species (interspecies) or the individuals of different species (intra species) [5]. Interspecies competition usually has more negative effects on the plant since it is more likely to happen in a condition that the plants belonging to a species with similar morphological structure (leaf form, rooting pattern and height) and physiologic and ecologic requirements (nutrients and growth pattern) will be placed next to each other [6].

In dry areas, one of the valuable native species which is widely expanded in Iran is *Artemisia aucheri* Boiss which reproduces only by seeds [7]. *A. aucheri* is one of the most compatible bushes to hard conditions. In addition to its forage production in fall and winter seasons, it is highly resistant to drought and heat and avoids the erosion in these areas [8]. The *Bromus spp.* genus has a worldwide distribution as important range species. *Bromus tomentellus* is a winter Perennials herbaceous species, with a weak stem which has dense and fine fur at the nodes; the roots are alone or in a group. It has a height of 20 to 90 cm [9].

Goodall *et al.* [10] reported that the extract of *A. aucheri* was a mixture of flavonoid, glycoside, terpenes, saponins, artemisinin, santonian and tannins. For this reason, a lots of grass species in adjacent to *A. aucheri* not able to grow because the poisonous compounds of *A. aucheri* prevent from their growth [7]. Also, it was reported that seed germination percent and seedling growth of wheat and *Agropyron bulbosum* were significantly decreased due to the allelopathic effect of *A. sieberi*. Its flowers extract had higher allelopathic effect than that for stem and root extract on the germination percent [11]. Ghorbanli *et al*. [12] declared that the inhibitory effect of leaf aqueous extract of *A. aucheri* on the germination and growth of wild oat and *Amaranthus albus* seedlings was higher than its other vegetative organs. Also, the allopathic effect of leaf aqueous extract of *A. aucheri* on the germination percent of wild oat seedlings was higher than *Amaranthus albus* seedlings.

Jankju [13] stated that, there was a dynamic cycle between perennial semi-shrub *Artemisia aucheri* Boiss and annual grass *Bromus tectorum*. It is started by the establishment of *A. aucheri* seedling, continued by the facilitation process and a competition between two species and ended by the dead of *Artemisia aucheri*. The most important effective factor in the mutual interactions of *A. aucheri* and *B. tomentellus* species can be introduced as soil moisture. Therefore, it may be predicted that during the droughts, the competition between these two species will be increased for the soil moisture leading to the intensified damping off of *A. aucheri* species in the area.

Hassani [14] investigated the effects of mixed cultivation and pure stand on the yield of grasses and legumes and confirmed that the highest yield could be related to the individual cultivation of the plants. In addition, Foroughi *et al*. [15] proposed that the increased cultivation density for sesame could enhance the competitive capability of it with cocklebur.

Usually, in the plant communities of *A. aucheri*, a specific growth pattern is seen so that in the *A. aucheri* stands, the dominant vegetation is consisted of *A. aucheri* bushes since the poisonous compounds of this species avoid the growth of grass species. Given that the growth of early season and cover crown formation in the shortest period are always highly important, the presence of allelopathic materials may result in lack of seed germination and primary growth reduction. Thus, it is essential to evaluate the seedlings of *A. aucheri* and *B. tomentellus* due to the allelopathic effects of this species and competition impact between these two plant species for consuming natural resources as well as their facilitation effects in order to present such ecologic models as present and transfer and natural vegetation management. The paper aims to evaluate the competitive capability of *A. aucheri* and *B. tomentellus* seedlings and its relation to the amount and quality of leaf area distribution in cover crown.

MATERIALS AND METHODS

This research was conducted in greenhouse condition in Islamic Azad University of Baft, Iran in spring 2015. The treatments were different proportions of *A. aucheri* and *B. tomentellus* seeds given as 0+100, 10+90, 20+80, 30+70, 40+60, 50+50, 60+40, 70+30, 80+20, 90+10, and 100+0, respectively. These treatments were then considered as T_1, T_2 … to T_{11}, respectively. Seeds were sown in pots and pots were arranged using complete randomized design with 11 treatments in 4 replications. Seeds were sown in pots, then they were placed in the greenhouse at the day and night temperature of 27±3 and 17±3 °C, respectively. Weeds of pots were daily removed by hand.

Prior to seed sowing, the amount of seeds for applying the treatments with respect to two desired species were weighted. Afterwards, seeds were sown in 44 pots with the size of 20 x 20 cm. The pots were daily irrigated due to heat stress for 90 days. The germinated seeds were observed in third day and the number of germinated seeds was counted and recorded for 10 days when no seeds were germinated. Seeds with the 2mm roots were considerde as the germinated ones.

Data were collected for germination percentage, seed vigor index, seedling length, root length, leaf area index (LAI), dry and fresh weight of seedlings and aerial parts to root ratio were measured
Germination percent=seeds germinated/total seeds x 100
Seed vigor index (VI) = seedling length average (mm) × (Germination percent)
Leaf area index of seedling (LAI) = leaf area /ground area(m2 / m2) [16]
Seedling length, root length and seedling height were measured by a caliper (cm)
Seedling Fresh weight was determined. To calculate the dry weight, the plant was placed in 75 °C oven for 72 h, then, was weighted by the scale.

Data were analysis of variance (ANOVA) using SAS 9.0) software and the means comparisons were made using Duncan test. Before analysis of variance, normality test was evaluated for data and if they were not normal, data transformation was used.

RESULTS

The result of ANOVA regarding the measured traits of two species is presented in Table 1. Results indicated significant difference for all the studied traits except fresh weight of *B. tomentellus* (P<0.01).

Table 1. Variance analysis for studied traits in *Artemisi aucheri* and *Bromus tomentellus*

Species	SOV	DF	MS								
			Germination percentage	Germination rate	Leaf area index	Seed vigor index	Dry weight	Stem length	Fresh weight	Root length	plant height
A.aucheri	Treat	10	2703.9**	0.583**	12.18**	376.83**	3.61**	182.2**	177.2**	124.6**	605.7**
	Error	33	17.74	0.0046	0.061	2.709	0.023	1.43	1.123	0.944	4.712
B.tomentellus	Treat	10	3433.1**	0.524**	2.33**	0.637**	2.331**	216.4**	15.8ns	113.5**	503.9**
	Error	33	71.75	0.029	0.096	0.027	0.096	5.03	0.69	5.03	20.76

**, ** and ns= significant at 5% and 1% probability levels and non significant*

Effect of treatments

Seed germination percent: Considering the increased seed mixture of *Bromus tomentellus*, the germination percentage of *A. aucheri* was decreased so that, in a mix ratio of 90% *B. tomentellus* the germination percentage of *A. aucheri* was reached to 50.37%. The highest germination percentage of *A. aucheri was* obtained in its pure seed (100%). Also, the highest germination percentage of *B. tomentellus* was achieved in its pure seed (100%) with germination percentage of 81.25% (Fig 1a).

Vigor index: Means comparisons demonstrated that the lowest seed vigor of *B. tomentellus* was obtained when the portion in mix ratio was 10%. As well, the increased *B. tomentellus* percentage in the mixture ratio led to the increased seed vigor index of *B. tomentellus.* On the other hand, the highest seed vigor index of *B. tomentellus was* obtained in its pure stand (100%) with average values of 41.35 (Fig 1).

Rate of Germination: the highest germination rate of *A. aucheri* was obtained when its ratio were 100 and 90% in mix cropping. In addition, the means comparison of data displayed that the *A. aucheri* seed amounts of 10, 20, 30, 40, 50, 60 and 70% in the mix ratio had no significant difference pure stand for rate of germination. Furthermore, the increased *B. tomentellus* percent in mix ratio resulted in the increased in its germination percent (Fig 1c).

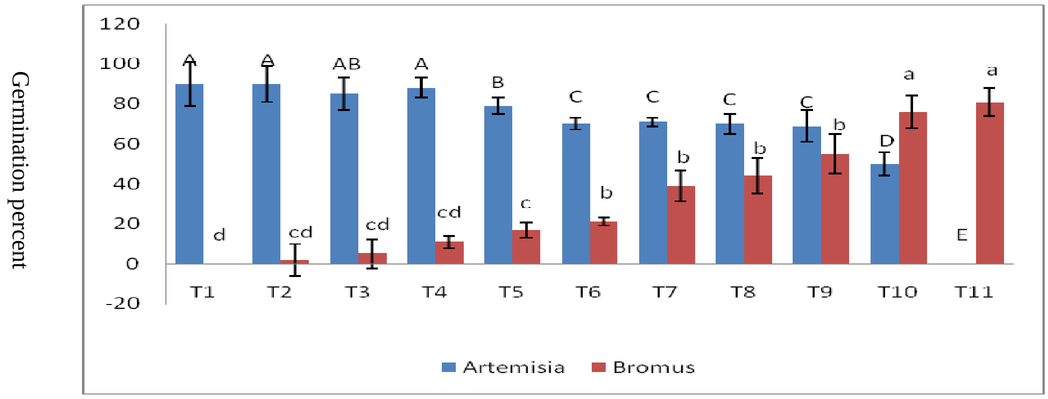
Stem length When the seed percentage of *A. aucheri* in the ratio was lower than 60%, no significant difference concerning the stem length was observed among the treatments. The lowest stem length of *A. aucheri* was observed when the seed percent of *A. aucheri* was 90 and 100% in the mix ratio. Also, the means comparison of stem length of *B. tomentellus* showed that the increased *B. tomentellus* in the ratio has caused the increase in its stem length. The lowest and highest stem lengths were obtained in the 10% and 100% mix ratio, respectively. The highest stem length as 25.53 cm was related to the 100% *B. tomentellus* treatment (Fig 2a).

Root length: Results indicated that there was no significant difference concerning the root length among various treatments when the seed percent of *A. aucheri* was lower than 70%. The lowest root length was observed in the mix ratio of 90 and 100% *A. aucheri*. Also, results of means comparison showed that by increased *B. tomentellus* percent in the ratio has caused the increase in the root length. The lowest root length was obtained in the 10% ratio. In contrast, the highest one with average value of 18.53 cm was related to the 100% *B. tomentellus* treatment (Fig 2b).
Plant height: When the seed percent of *A. aucheri* in the ratio was 90 and 100%, the lowest plant height was observed. As the seed percent of *A. aucheri* was lower than 80% in the ratio, no significant difference was observed among the treatments for plant height. By increasing *B. tomentellus,* its plant height was increased. The lowest plant height of *B. tomentellus* species was observed in the 10% *B. tomentellus* ratio. The highest value of B. tomentellus with average values of 44.07 cm was observed in 100% treatment (Fig 2c).

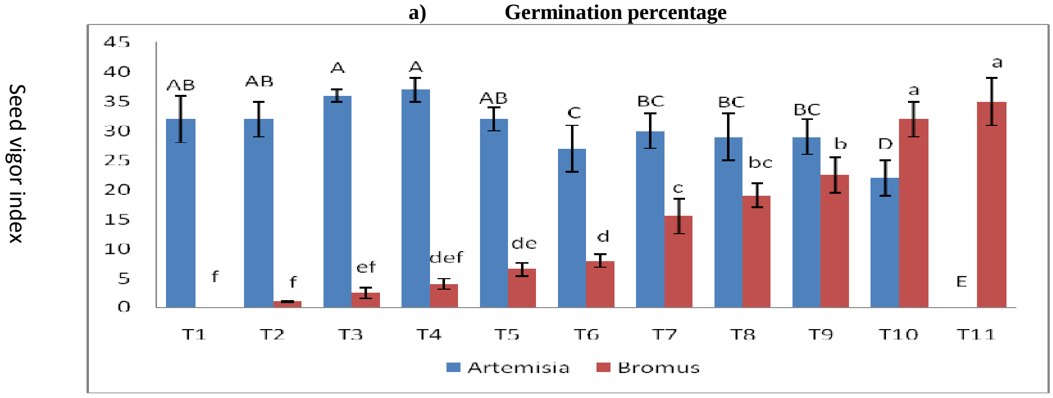
Leaf area index (LAI): The means comparison showed that the most leaf area was obtained for *A. aucheri* as the 90 and 100% in the mix ratio. The least LAI was observed when the seed percent of *A. aucheri* was 10, 20 and 30% in the ratio. In *B. tomentellus,* the result indicated that by increasing *B. tomentellus* in the ratio the LAI values were increased. The lowest LAI was related to the 10 and 20% *B. tomentellus* ratios and result demonstrated that 90, 80, 70, 60, 50, 40 and 100% *B. tomentellus* in the ratio had no significant difference concerning the LAI in these two species (Fig 3a).

Seedling fresh weight: When the *A. aucheri* was 90, 80, 70 and 100% in the mix ratio, the highest fresh weight was attributed to this species. Means comparison indicated that the 10, 20, 30 and 40% ratios of *A. aucheri* showed no significant difference leading to the lowest fresh weight of desired plant in these treatments. In *B. tomentellus* result demonstrated that the fresh weight of this species had no significant difference as the *B. tomentellus* ratio was increased higher than 30% (Fig 3).

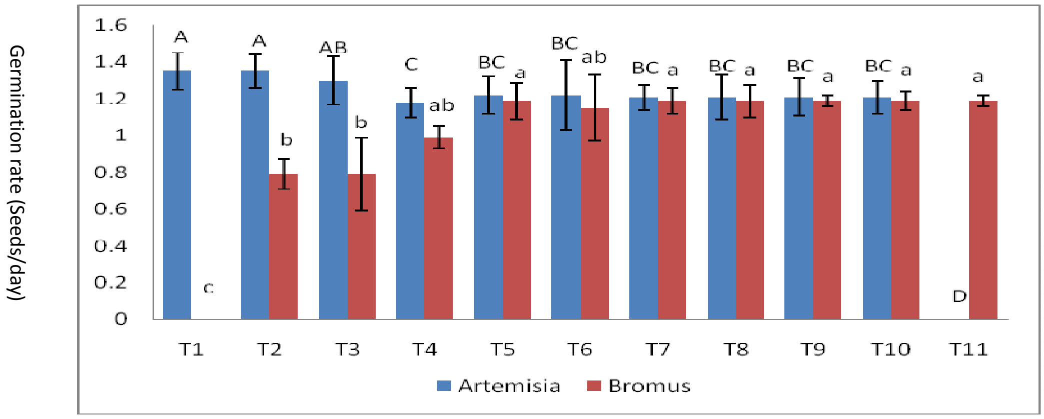
Seedling dry weight: Similarly, result indicated that when the seed percent of *A. aucheri* was 90, 80, 70 and 100% in the ratio, the highest dry weight was attributed to *A. aucheri* species. Means comparison of data displayed that the 10, 20, 30 and 40% ratios of *A. aucheri* seeds showed no significant difference leading to the lowest dry weight of desired plant in these treatments. For dry weight of *B. tomentellus* there was no significant difference between treatments (Fig 3c).



a) Germination percentage



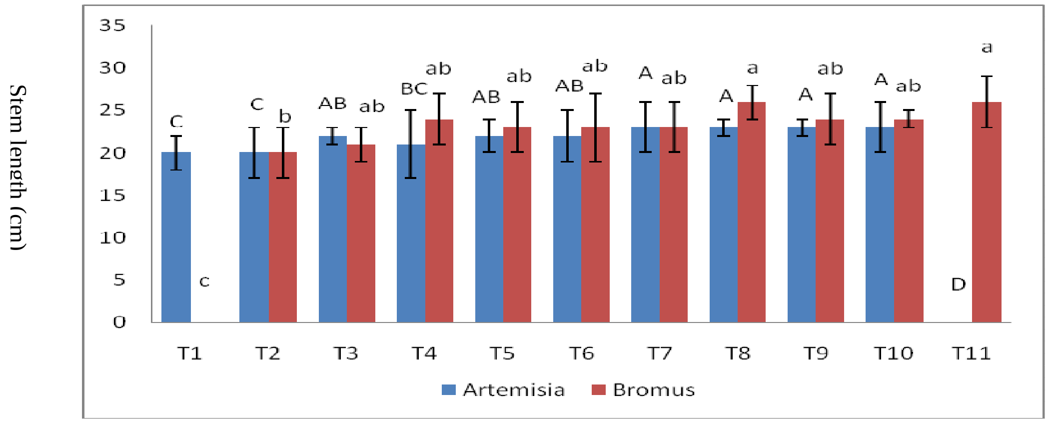
b) Seed vigor index



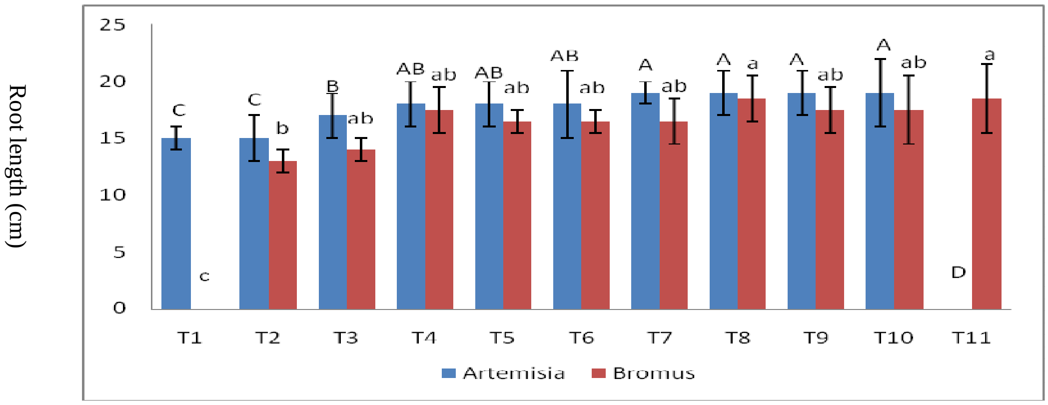
c) germination rate

Fig. 1. Effect of different ratios of mix cropping of *A. aucheri* and *B. tomentellus* as 0+100, 10+90, 20+80, 30+70, 40+60, 50+50, 60+40, 70+30, 80+20, 90+10, and 100+0, equal to T_1, T_2 … to T_{11}, respectively, on germination percentage (a), seed vigor index (b) and germination rate (c)

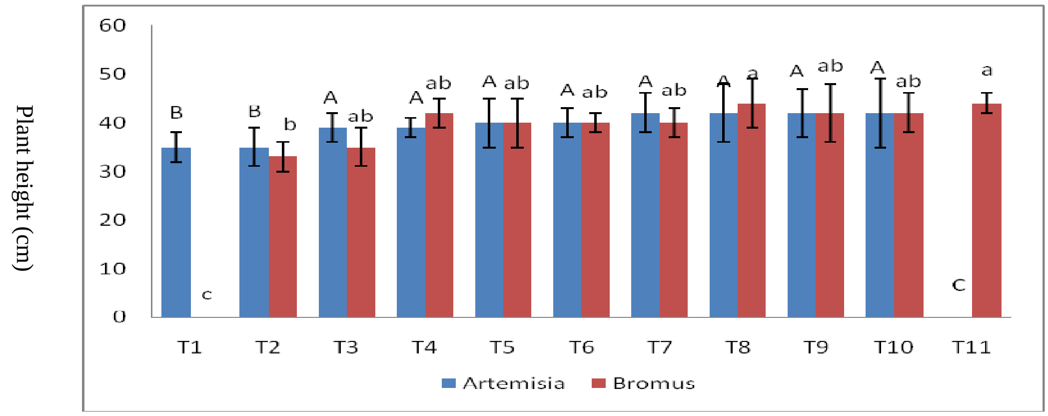
Means followed with the similar uppercase and lowercase letters had no significant differences between treatments for *A .aucheri* and *B. tomentellus*, respectively.



a) Stem length



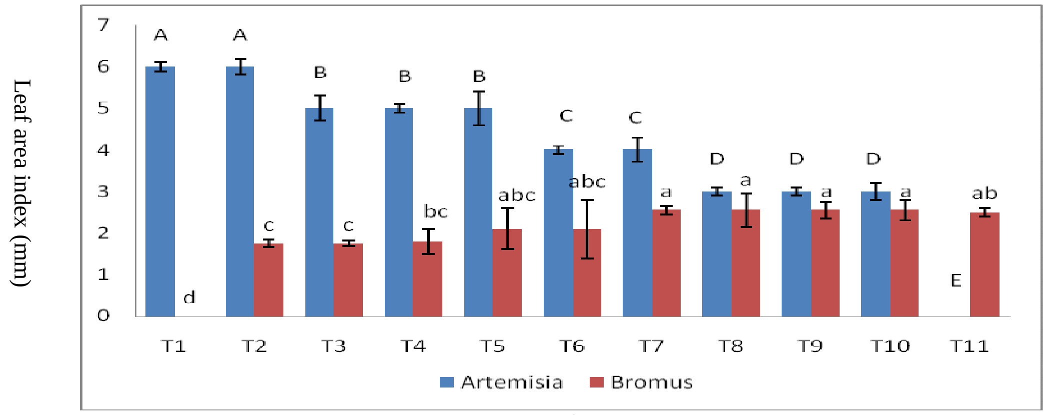
b) Root length



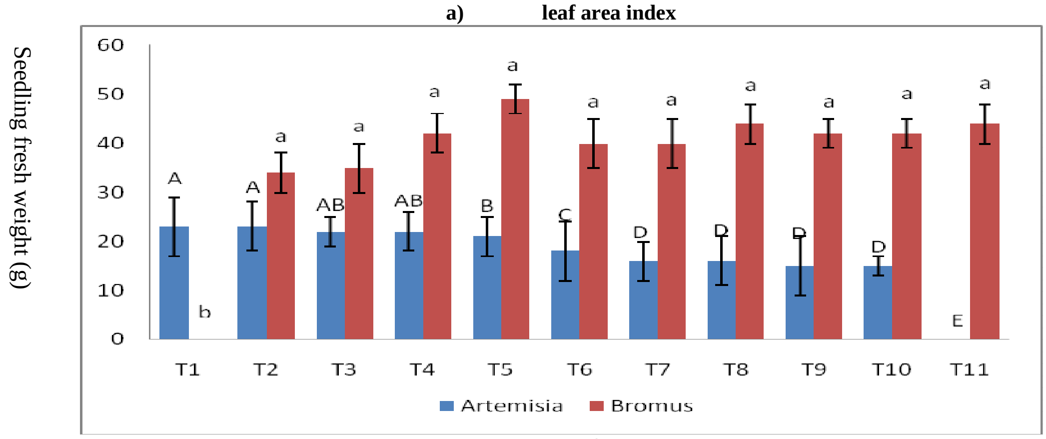
c) Plant height

Fig. 2. Effect of different ratios of mix cropping of *A. aucheri* and *B. tomentellus* as 0+100, 10+90, 20+80, 30+70, 40+60, 50+50, 60+40, 70+30, 80+20, 90+10, and 100+0, equal to T_1, T_2 … to T_{11}, respectively, on a) stem length, b) root length and c) plant height

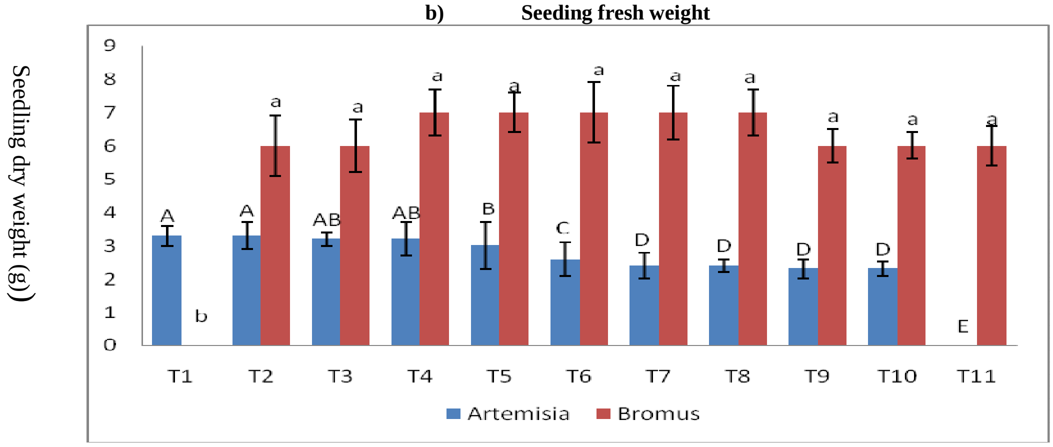
Means followed with the similar uppercase and lowercase letters had no significant differences between treatments for *A .aucheri* and *B. tomentellus*, respectively.



a) leaf area index



b) Seeding fresh weight



c) Seeding dry weight

Fig. 2. Effect of different ratios of mix cropping of *A. aucheri* and *B. tomentellus* as 0+100, 10+90, 20+80, 30+70, 40+60, 50+50, 60+40, 70+30, 80+20, 90+10, and 100+0, equal to T_1, T_2 … to T_{11}, respectively, on a) leaf area index, b), seeding fresh weight c) seeding dry weight

Means followed with the similar uppercase and lowercase letters had no significant differences between treatments for *A.aucheri* and *B. tomentellus*, respectively.

DISCUSSION

In the current research, since the two species had accessed to the adequate moisture, the allelopathic effect of *A. aucheri* on *B. tomentellus* species was not observed. Whereas, various studies have shown this impact. The effect of *A. aucheri* facilitation on *B. tomentellus* species could be realized through the increase of moisture under *A. aucheri* floor leading to the increased number of *B. tomentellus* stands [13, 17]. Also, due to the existence of enough moisture in the pots, the competitive effects between two species could not been interpreted as the consequence of moisture reduction. Reduction of almost all the traits was seen because of the increased density of another species in this research; this competition can be also observed in nature. Competition in the plant communities will happen when two or more plants looking for the shared resources of minerals, water and light are put in a limited space [5].

In addition, this competitive impact can relatively interpreted as the result of seed allelopathic effects of two different species.

In this study, *B. tomentellus* could take part in the light competition due to the early germination (during almost 3 days) although it is a narrow-leaved plant. Gupta [18] stated that the seeds with the early germination and seedling in the primary stages are more likely to be of faster growth while allocating more shares of total mixed canopy and acting more successful roles in the light competition. Amount of light absorption in the broad-leaved and tall plants is more than the narrow-leaved and dwarf ones because of high leaf area and high shadow.

Previous studies have displayed that the inhibitory impact of *A. aucheri* on the other species is resulted from the extract of leaves, stem and [19, 20]. Thus, as it has been observed in this study, the increased seeds density has enhanced the germination percent and seed vigor for both species and the allelopathic effect of *A. aucheri* on *B. tomentellus* was not seen. Results indicated that considering the stem length of *A. aucheri*, the increased competition caused the increased height of it, but it was reversed for *B. tomentellus* species. As a result, it can be stated that the interaction of height is related to the plant density (competition intensity) and plant type and as well, it can be positive or negative [21]. Some report believed that the competition among plants during the primary growth stages or their weak competition might lead to the increase in the plant height [22]. It is due to the changes in the light quality reaching the cultivar and the reduction of red light to red ultra-light as well as the increased cell size regarded as the ways in order to escape the shadow [23]. In addition, the results on the root length and plant length are in conformity with those obtained for the stem length. There is a difference in the positive or negative sign of seed mixture values in relation to the stem length, root length, and plant length resulting from various reactions of plants in circumstances which the limited resources are available [24, 25]. Plants having the increased leaf area in primary vegetative stages are able to absorb the resources and occupy more space in competition with the adjacent plants; in general, the leaf area index is an indicative of crown cover ability in the light absorption and dry matter production. Every factor which reduces this index can affect the plant significantly [15]. In this paper, the increased seed ratio for each plant led to the enhanced leaf area value and this effect is more evident for *A. aucheri* species because of increased competition ability as compared to *B. tomentellus* species.

According to the ultimate yield stability, the increased density will increase the biomass, but as the environmental resources are limited, its value may be constant. Currently, given that two studied plants were kept until 90 days after cultivation, the increase in number of seeds in the ratio with respect to *A. aucheri* is more likely to increase the yield. But regarding *B. tomentellus* species and the allelopathic effect of *A. aucheri* species, it has been specified that the most allelopathic effect has been observed on the vegetative stage of *A. aucheri* [19, 20]. Thus, this probability can be discussed that due to the allelopathic effect of it, this plant had no significant difference regarding the weight of *B. tomentellus* plant among the desired treatments.

CONCLUSION

In total, results have shown that after the germination of *B. tomentellus* seeds, the mixture ratio has had no considerable effects on the growth of stem, root, seedling and dry and wet weight of aerial organs, thus, it can be concluded that the allelopathic effect of *A. aucheri* seeds had a significant impact on the primary germination of seeds in relation to high density and after the germination of seeds, *B. tomentellus* species grew in comparison with *A. aucheri* species. This fact can be useful in the appropriate conditions and moisture supply. Though during the droughts, the existence of *B. tomentellus* seeds in crown cover of *A. aucheri* plant causes high water absorption with respect to the competitive effects of these plants; on the other hand, it will result in the dryness of soil and finally, the removal of *A. aucheri* stands.

In the end, because of *B. tomentellus* can grow in the shadow of *A. aucheri*, with the purpose of feeding animals, Cultivation of *B. tomentellus* is suggested in the shadow of *A. aucheri* in rangelands. But in dry conditions, it is recommended that *B. tomentellus* in the canopy be removed before seeding of *A. aucheri*. As, the competition causes damage to *A. aucheri* and rangeland will go into decline.

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