African Journal of Agricultural Research Vol. 4 (10), pp. 1049-1057, October 2009
Available online at http://www.academicjournals.org/AJAR
ISSN 1991-637X © 2009 Academic Journals

Full Length Research Paper

Usability of the Taurus Cedar and Crimean Pine in green belt afforestations in semiarid regions in Turkey: A case study in Konya Province Loros Mountain - Akyokus

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Accepted 7 September, 2009

In this study, root collar diameter and height development of 9 year-old saplings of Taurus Cedar (*Cedrus libani*) and Crimean Pine (*Pinus nigra* subsp. nigra var. caramanica) in the green belt afforestation areas were researched in Akyokus (130 ha) and Loros Mountain (140 ha) in Konya province. For this reason, root collar diameters and heights were measured at 4 temporary sample plots, each 450 m² (30 m × 15 m) containing randomized 5 experimental areas with 10 replicates. The data obtained from measurement were compared with ANOVA test. The root collar diameters of Crimean pines in Loros Mountain and heights of Taurus cedars in Akyokus were significantly different and higher. On the other hand, volumes of Crimean pines in Loros Mountain and Taurus cedar in Akyokus were significantly different in favor of these species. Thus, it might be suitable to use Crimean pine in Loros Mountain and Taurus cedar in Akyokus for green-belt afforestation studies in the future.

Key words: Crimean Pine, green belt afforestation, height, root collar diameter, Taurus cedar.

INTRODUCTION

When aridity is considered, rainfall and water inadequacy come to mind first. To effectively speak on the aridity of a region, there should be rainfall and water inadequacy and these parameters should be constant (Uluocak, 1977). In a geographical point of view, regions with such drought are called “Arid Regions” (Erinc, 1965). On the other hand, low rainfall is not the only sign of aridity. In most definitions of aridity, in any region on the earth, during a certain period, lower rainfall with respect to average or normal is stated (Turkes, 1990). When we look at the various definitions of aridity by different authors’; according to Gibss (1975 -1987), aridity is defined as not having enough water for necessities. In a climate belt with normally enough rainfall for vegetation, agriculture, streams and springs; temporarily low conditions is aridity (Landsberg, 1975). According to Thomas (1962), it is a meteorological event that occurs after lower rainfall than the long term average in a certain period. According to Barry and Charley (1976), it is not to have significant rainfall in a certain period which results to humidity deficit as a result of fall in evapotranspiration stream flow values. Urgenc (1998), by referring to FAO, defines the places which have 300 mm and lower rainfall annually as arid and places which have 300 - 600 mm rainfall annually as semi-arid. According to Uluocak (1977), places which have up to 250 mm annually are arid and, places which have 250 - 600 mm rainfall annually are semi-arid and places with more than 600 mm are humid.

In Anatolia, the Taurus Cedar is distributed in West, Middle and East Taurus naturally and exists as isolated stands at North, near Erbaa and Niksar. The mountains between Acipayam–Bozdag and Koycegiz–Caldagi form the west border, while Engizek–Ahir Mountains at the northeast of Kahramanmaras forms the east border. Cedar forests are most dense at forestry operation areas of Elmali, Kas, Anamur and Feke. This is a really des-

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tructed tree species in Turkey. It is mixed with Junipers (Juniperus excelsa Bieb., J. foetidissima Willd.) and partially with Taurus Fir [Abies cilicica (Ant. Et Kotschy.) Carr.] at high altitudes, with Crimean pine (Pinus nigra Arnold. ssp. pallasiana (Lamb.) Holmboe) in deep and with Calabrian pine at lower altitudes, rather than pure forests. Locally, it can be found with Beech (at Bolkar, Bangras). Normally, the vertical distribution limit is between 1000 - 2000 m, however, it can be found at 2050 m as individual trees (Aksoy, 1987; Genc, 2004). Although, it does not require soil humidity so much, for better growth, it needs humid soils. Cedar forms a root system which consists of a taproot at a great depth and a secondary root on the taproot. The roots can go really deep by using the breaches and cracks on limestone soils. It is a semi-light tree and, it has good resistance against side and top shade stress (Aksoy, 1987).

The natural distribution area of Crimean Pine extends from North Anatolia and Thrace to South Anatolia. Nowadays, finding some species that are known as escort to the Crimean pine like *Quercus pubescens* Willd., *Quercus* cerris L., *Pyrus elaeagnifolia* Decne. subsp. *elaeagnifolia*, *Cistus laurifolius* L. in Central Anatolia show that there was Crimean Pine in this region previously but it was destroyed (Ansin and Ozkan, 1997). Crimean pine forms pure forests between 700 and 1400 m altitudes and forms stands with Scots pine (*Pinus sylvestris* L.) between 1400 and 1700 m altitudes. In Anatolia, it is the closest forest tree species to steppe and exists. It is located at 900 - 1500 m at steppe borders in Central Anatolia and at 1000 - 2000 m in Taurus. The most significant characteristics in its existence is that it lives at south hillside in north Anatolia, at north hillside in Taurus, at east hillside in west Anatolia; which shows that it is not capable to compete with other species at seaside hillsides (Aksoy, 1987).

The Crimean pine can grow on various soil structures that are composed of various main rocks. But it grows best on the soils that are rich in lime. It is sensitive to soils with variable humidity and to spates (Ansin and Ozkan, 1997). In addition to being a suitable species in afforestation of drought regions close to steppe in which enough water is stored in the soil due to snow fall; it is an important taxon for windbreaks against strong winds of sea (Urgenc and Cepel, 2001).

The aim of this study is to determine which species of Taurus cedar and Crimean pine could be preferred in future green belt afforestation studies at semi-arid areas which exhibit similar ecological conditions in Turkey. In this study, the root collar diameter-height growth of 9 year-old Taurus Cedar and Crimean Pine saplings in the semi-arid regions at Loros Mountain and Akyokus green belt afforestation areas of Konya are comparatively analyzed. Since no study has been done in this region until today, the value of this study increases. It is aimed to contribute future green belt afforestation studies in regions which have same climatic and edaphic condition as this region.

MATERIALS AND METHODS

Description of study area

This study is carried out in 4 sample plots of Taurus Cedar and Crimean Pine afforestation areas which are Loros Mountain and Akyokus green belt afforestation areas planted by Konya AGM Head-Engineering Office. Loros Mountain research area is near Cayirbag Village of the Meram District of Konya, on the Konya-Antalya road. Akyokus research area is at the southwest of the Akyokus hill, which is at the beginning of the Konya-Beysehir road. Research areas are between 32º east meridian and 37º north latitude (Figure 1). Average slope of the areas is less than 40%. The average altitude of Loros Mountain is 1475 m, where Mindostepe is the highest point with 1615 m and Konya-Antalya (Konya-Seydisehir) as the road intersection and the lowest altitude is 1340 m. The average altitude of Akyokus research area is 1300 m (Anonymous, 1996). General characteristics of afforestation areas of Taurus cedar and Crimean pine of this study is given in Table 1.

Climate

Climate data was obtained from the nearest observation station, which is Konya Meteorological Observation Station at 1016 m altitude. According to meteorological data, the highest temperature was experience in August with 40°C and the lowest temperature was in January with -28^{0}C. The meteorological data was transformed to study areas (Table 2 - 3). According to Rubner (1949); the vegetation period was 5 months for Loros Mt. between May (13.7°C) and September (15.7°C) while it was 6 months for Akyokus between May (14.5 ^{0}C) and October (10.5 ^{0}C). Annual average rainfall in Loros Mt. was 578 mm while it was 482 mm for Akyokus. The rainfall amounts in the vegetation period are 198 and 201 mm in Loros Mt. and Akyokus, respectively (Anonymous, 2004). When climate data was evaluated according to Thornthwaite method, Loros Mt. has a clime of "arid-less humid, micro thermal, more extra water in winters, close to oceanic climate effect" with symbols of $C_1B_1's_2b_2'$ and Akyokus has a climate of "arid-less humid, micro thermal, moderate extra water in winters" with symbols of $C_1B_1'sb_3'$ (Tables 2 - 3 and Figures 2 - 3).

Geological structure and soil

The geological structure of Loros Mountain and Akyokuş green belt afforestation areas consist of Neocene and cretaceous limestone. In Loros Mountain forestation area, from place to place, there are sandstone and claystone. The soil has middle depth, while physiological depth was high. Soil is reddish in color with clay loam, sand loam and loam texture. Surface stone was less than 50%, but, stone in the soil was found to be more than 50%. Drainage condition was intermediate and good and the pH was 7.2. The soil was rich in clay and there was no salinity problem. On the other hand, in Akyokuş green belt afforestation area, soil type has a characteristic of clay loam, loam and from place to place, heavy loam. The soil depth was approximately 30 cm, but it was more at flat areas on the peak and at places with low grade. Stone found on the surface was found to be less than 50% (Anonymous, 1996).

Land preparation, planting of saplings, protection and culture tending

The size of Loros Mountain afforestation area is 140 ha and that of Akyokus green belt afforestation area is 130 ha. At afforestation areas under consideration, the weakness of the flora that was supposed to protect the soil caused removal of most of the vegeta-

Figure 1. Location of the study areas in Turkey map and Google earth satellite image.

Table 1. General properties of sample plots.

Sample plot number	**1**	**2**	**3**	**4**
Location	Loros Mt.	Akyokus	Loros Mt.	Akyokus
Species	**Taurus cedar**		**Crimean pine**	
Establishment year	1996	1996	1996	1996
Origin	Kahramanmaras	Abanoz	Ahirdagi	
Plant Type	**1+0 Containerized**			
Age	9	9	9	9
Regeneration type	**Artificial**			
Elevation (m)	1475	1300	1475	1300
Aspect	NW	N	NW	N
Slope (%)	20	20	20	20
Main rock	Limestone		Limestone	
Soil type	Reddish-chesnut colored soil		Reddish-chestnut colored soil	
Soil texture	Clayey loam-Loess-Clay		Clayey loam-Clay-Heavy clay	

ble top soil and a decrease in organic substances. Grazing of livestock animals compacts the soil, for this reason, 70 - 80 cm soil cultivation in full area (parallel to contour lines, with triple ripper on dozer) and top soil cultivation at places where stoniness was less than 20% (plows with 3 m intervals on 4 × 4 tractors with rubber wheels) was carried out. The planted Taurus cedar and Crimean pine saplings (containerized 1+0) were provided from Konya Eregli and Eskisehir forest nurseries and planted on 3 x 3 intervals at the end of December, 1996. Afforestation areas were surrounded with barbed wire fence. Planting was finished in the following two years. Weed cleaning was done in April - May, hoeing, terrace restoration, shoot controls in June and shoot controls in 3rd, 4th and 5th years and terrace restorations were completed (Anonymous, 1996).

In the green belt afforestation areas in Loros Mountain and Akyokus which are under consideration in this study; height from root to joint point of the peak bud to the bole and root collar diameters of fifty 9 year-old individuals from 4 temporary sample plots of 450 m^2 (30 m x 15 m) were measured in mm precision, respectively, at 2005 summer. The experiment was designed at randomized 5 experimental areas each with 10 replicates; for each of the 4 temporary sample plots. The startup heights of planted Taurus cedar and Crimean pine are assumed to be same. Obtained height and root collar diameter data were analyzed with ANOVA test (Minitab v15, Minitab, Inc.) in order to determine the relationship between root collar diameter and height of Taurus cedar and Crimean pines in the sample areas.

RESULTS AND DISCUSSION

According to measurements on Taurus cedars, in number 1 and 2 sample plots, in Loros Mountain and Akyokus

Table 2. Water balance of study area (Loros Mt.).

Element of balance	Months												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
Temperature (^{0}C)	-2.3	-1.3	2.7	8.7	13.7	17.7	20.7	20.7	15.7	9.7	4.7	-0.3	9.2
Temperature Index	0.00	0.00	0.39	2.31	4.60	6.78	8.59	8.59	5.65	2.73	0.91	0.00	40.55
Uncorrected PE (mm)	0.00	0.00	11.40	38.50	70.00	96.50	121.00	121.00	85.50	45.50	19.00	0.00	
Corrected PE (mm)	0.00	0.00	11.74	42.35	84.70	118.70	151.25	141.57	88.07	44.14	16.15	0.00	698.67
Precipitation (mm)	61.00	53.00	51.00	52.00	66.00	47.00	27.00	25.00	33.00	51.00	50.00	62.00	578.00
Store Alteration (mm)	0	0	0	0	-18.70	-71.70	-9.60	0	0	6.86	33.85	59.29	
To store (mm)	100	100	100	100	81.30	9.60	0	0	0	6.86	40.71	100	
Actual Ev-Tr (mm)	0	0	11.74	42.35	84.70	118.70	36.60	25.00	33.00	44.14	16.15	0	412.38
Water absent (mm)	0	0	0	0	0	0	114.65	116.57	55.07	0	0	0	286.29
Extra Water (mm)	61.00	53.00	39.26	9.65	0	0	0	0	0	0	0	2.71	165.62
Surface flow (mm)	31.17	42.10	40.67	25.15	12.57	6.28	3.13	1.56	0.78	0.39	0.20	1.36	165.62
Humidity ratio	0	0	3.34	0.22	-0.22	-1.19	-0.82	-0.82	-0.62	0.15	2.09	0	

Table 3. Water balance of study area (Akyokus).

Element of balance	Months												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
Temperature (^{0}C)	-1.5	-0.5	3.5	9.5	14.5	18.5	21.5	21.5	16.5	10.5	5.5	0.5	10.00
Temperature Index	0.00	0.00	0.58	2.64	5.01	7.25	9.10	9.10	6.10	3.08	1.16	0.03	44.05
Uncorrected PE (mm)	0.00	0.00	13.55	44.75	70.00	93.50	102.75	102.75	78.50	48.00	24.50	1.75	
Corrected PE (mm)	0.00	0.00	13.96	49.22	85.40	115.00	128.44	120.21	80.85	46.56	20.82	1.45	661.91
Precipitation (mm)	53.00	45.00	43.00	44.00	58.00	39.00	19.00	17.00	25.00	43.00	42.00	54.00	482.00
Store Alteration(mm)	26.27	0	0	-5.22	-27.40	-67.38	0	0	0	0	21.18	52.55	
To store (mm)	100	100	100	94.78	67.38	0	0	0	0	0	21.18	73.73	
Actual Ev-Tr (mm)	0	0	13.96	49.22	85.40	106.38	19.00	17.00	25.00	43.00	20.82	1.45	381.25
Water absent (mm)	0	0	0	0	0	8.62	109.44	103.21	55.85	3.56	0	0	280.68
Extra Water (mm)	26.73	45.00	29.04	0	0	0	0	0	0	0	0	0	100.77
Surface flow (mm)	13.37	29.19	29.12	14.56	7.28	3.65	1.82	0.91	0.46	0.23	0.12	0.06	100.77
Humidity ratio	0	0	2.08	-0.11	-0.32	-0.49	-0.85	-0.85	-0.69	-0.07	1.02	3.24	

regions, the average root collar diameters were 2.36 cm (minimum 1.10 cm, maximum 3.70 cm) and 2.53 cm (minimum 1.10 cm, maximum 4.40 cm) and the average heights were 78.44 cm (minimum 45.0 cm, maximum 93.0 cm) and 72.79 cm (minimum 35.0 cm, maximum 133 cm), respectively. According to measurements on Crimean pines in number 3 and 4 sample plots, the average root collar diameters were 2.98 cm (minimum 1.8 cm, maximum 5.0 cm) and 2.59 cm (minimum 0.9 cm, maximum 4.4 cm) and the average heights were 80.68 cm (minimum 50.0 cm and maximum 108.0 cm) and 50.47 cm (minimum 23.0 cm, maximum 82.0 cm), respectively.

The results of the analysis of the relationship between root collar diameter of Taurus cedar and Crimean pine from Loros Mountain and Akyokus green belt afforestation is shown in Table 4. According to the results of the ANOVA, location and species interaction was significant ($F_{1,196}$ = 6.17; $P < 0.05$). The root collar diameters of Taurus cedar and Crimean pine saplings from Loros Mountain was found significantly different in favor of Crimean pine ($F_{1,98}$ = 16.6421; $P < 0.05$) where as, the difference was not significant in Akyokus. On the other hand, the difference between root collar diameters of Taurus cedar saplings from Loros Mountain and Akyokus was not significant, however, the Crimean pine saplings from Loros Mountain and Akyokus was significantly different and was in favor of Loros Mountain ($F_{1,98}$ = 5.5963; $P < 0.05$).

The results of the analysis of the relationship between heights of Taurus cedar and Crimean pine from Loros Mountain and Akyokus green belt afforestation is shown in Table 5. According to the results of the ANOVA, location and species interaction was significant ($F_{1,196}$ = 22.57; $P < 0.05$). The difference between the heights of Taurus cedar and Crimean pine saplings in Loros Mountain was not significant. However, in Akyokus, the difference was significant and was in favor of Taurus cedar ($F_{1,98}$ = 27.73; $P < 0.05$). On the other hand, the

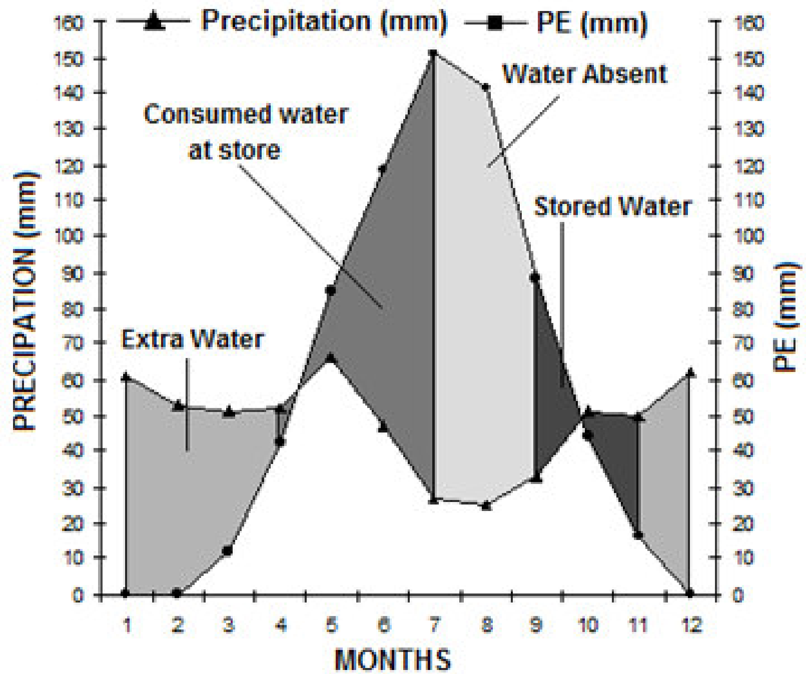

Figure 2. Water balance graphic of the research area (Loros Mt.).

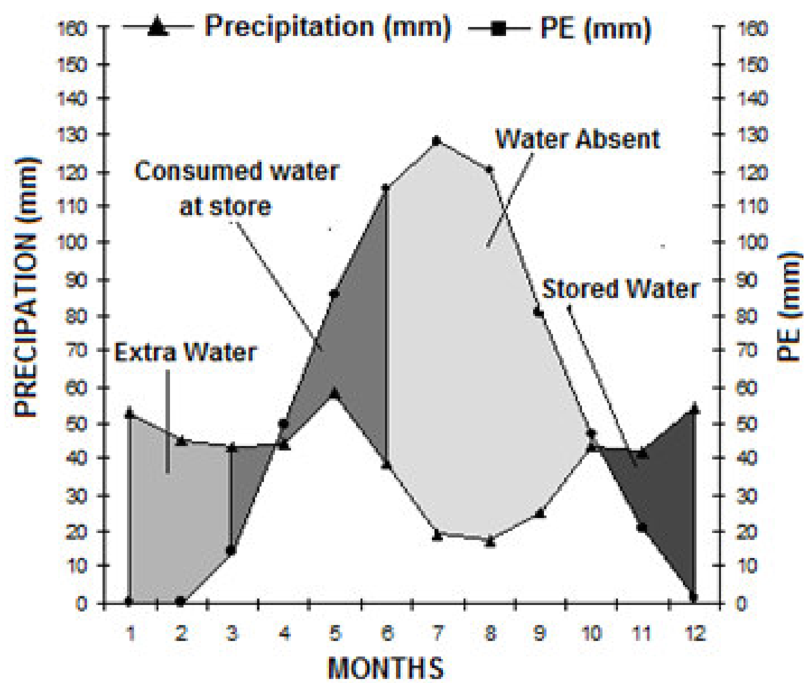

Figure 3. Water balance graphic of the research area (Akyokus).

difference between the heights of Taurus cedar saplings in Loros Mountain and Akyokus was not significant, however, the Crimean pine saplings in Loros Mountain and Akyokus was significantly different and was in favor of Loros Mountain ($F_{1,198} = 86.1086$; $P < 0.05$).

The results of the analysis of relationship between the volumes of Taurus cedar and Crimean pine from Loros Mountain and Akyokus green belt afforestation is shown in Table 6. According to the table, location and species interaction was significant ($F_{1,196} = 15.66$; $P < 0.05$). The

Table 4. ANOVA results of root collar diameter values of Crimean pine and Taurus cedar saplings in Loros Mt. and Akyokus.

Source	DF	Sum of squares	Means of squares	F	P
Species	1	5.9512	5.9512	9.30	0.003
Location	1	0.6160	0.6160	0.96	0.328
Interaction	1	3.9481	3.9481	6.17	0.014
Error	196	125.4386	0.6400		
Total	199	135.9540			

Table 5. ANOVA results of height values of Crimean pine and Taurus cedar saplings in Loros Mt. and Akyokus.

Source	DF	Sum of squares	Means of squares	F	P
Species	1	5042.1	5042.1	15.10	0.000
Location	1	16070.7	16070.7	48.13	0.000
Interaction	1	7537.5	7537.5	22.57	0.000
Error	196	65450.9	333.9		
Total	199	94101.1			

Table 6. ANOVA results of volume values of Crimean pine and Taurus cedar saplings in Loros Mt. and Akyokus.

Source	DF	Sum of Squares	Means of squares	F	P
Species	1	220664	220664	1.36	0.245
Location	1	654655	654655	4.03	0.046
Interaction	1	2541495	2541495	15.66	0.000
Error	196	31800208	162246		
Total	199	35217022			

volumes of Taurus cedar and Crimean pine saplings in Loros Mountain and Akyokus were significantly different ($F_{1,98}$ = 12.8870; $P < 0.05$ and $F_{1,98}$ = 3.9707; $P < 0.05$, respectively) and in favor of Crimean pine in Loros Mountain and in favor of Taurus cedar in Akyokus. On the other hand, the difference between volumes of Crimean pine saplings from Loros Mountain and Akyokus was not significant, however, the Taurus cedar saplings from Loros Mountain and Akyokus was significantly different and was in favor of Loros Mountain ($F_{1,98}$ = 16.5173; $P < 0.05$).

The advantage of north exposure in terms of soil humidity conditions is of great important especially at saplings and young ages of the forest species. According to the results of a research of Elmali cedar research forest, exposure affects the average survival percentage of saplings (Akan, 1979). Since snow in south slopes starts melting earlier, the planted saplings get damaged (30 - 40%) due to the late frosts in spring. On the other hand, since the north slopes are covered with snow for a longer time, they get over the frost undamaged. Moreover, the saplings that could not realize deep root growth dies; because the south slopes' are more exposed to sunlight and early drying of the soil. Being mostly at north exposure of Loros Mountain and Akyokus green belt afforestation areas may be taken as a factor in the success.

According to Cepel and Zech (1990); cedar forests usually exist on dolomitic limestone naturally. On the other hand, it is known that the natural distribution of cedar does not depend on limestone directly; however, it is possible to be successful at similar ecosystems since it spreads on the other main rocks which are rich in terms of calcium (Kantarci, 1990). Considering these issues in the selection of Taurus cedar for afforestation areas within research area is another important factor in the success.

Due to the presence of unsuitable main rock, soil, climate and altitude; most of the afforestation studies with Taurus cedars with bare rooted saplings was unsuccessful (Cengiz, 1990). Considering this situation, containerized saplings are used in such afforestation areas.

Since (2+0) year-old saplings were more successful than (1+0) year-old saplings at Guven (1975)'s study with (1+0) and (2+0) year-old containerized saplings and success rate with (1+0) year-old saplings was low; it is recommended to make planting studies with (2+0) year-old saplings (Guven and Cengiz, 1990). However, in the research area, the study carried out with (1+0) year-old saplings was successful.

In another study by Dagdas (2001) at Ankara-Ilyakut afforestation project area, the resistance of origins against cold and drought conditions around Central Anatolia was analyzed with an experiment of Taurus cedar which was presented by 35 origins. Dagdas determined that Saimbeyli-Catak, Anamur-Abanoz, Finike-Aykiricay, Goksun-Mursel Village, Goksun-Malakhasan, K.Maras-Elmalar, Sarkîkaraagaç-Belcegiz, Mersin-Baspinar, Ermenek-Damlacali, Ermenek-Guveycali, Kozan-Hancukuru origins of Taurus cedar could be used in afforestation studies at the region. Using Kahramanmaras and Abanoz origins of Taurus cedar in Loros Mountain and Akyokus afforestation areas can be a factor in the acceptable success of the study.

Simsek et al. (1996) established 21 experimental areas at Central Anatolia, East Blacksea, West Blacksea, West Mediterranean and Southeast Anatolia regions with origins which were provided from domestic and abroad origins at the end of 1985. Containerized 1+0 Taurus cedars were used in studies. In experimental areas at Ankara and Konya region saplings of Sarkikaraagaç origin were used. At the end of the 9th year, average height was 121.6 cm in Ankara and 63.1 cm in Konya; where the survival rate of sapling percentage was 96% in both areas (Dagdas et al., 1997). In this study (1+0) year-old Taurus cedars of Kahramanmaras and Abanoz origins were used and the average height was measured as 75.62 cm.

In another study by Simsek et al. (1995), 12 experimental areas were established in Mediterranean, Central Anatolia, West Blacksea and Marmara regions in 1984, in order to determine the success rates of origins at afforestation and suitable locations for Crimean pine. 36 origins of Anatolia black pine (containerized 2+0 year-old) were used at the experimental areas in Konya-Kizilviran of 1400 m altitude and Eskisehir-Yusuflar of 1100 m altitude. In analysis, heights of saplings after 9 years and the survival rate of saplings were considered. Although, there was no significant difference in terms of height between the origins, a significant difference between experimental areas was determined. The average height in Konya region was 0.05 more than the average height in Eskisehir experimental area (Konya: 110.6 cm; Eskisehir: 96.50 cm). Although, there was no significant difference in terms of survival percentage of saplings between the origins; a significant difference between the experimental areas was determined, too. Saplings losses in experimental areas of Central Anatolia were too much. In general, the survival percentage of two experimental areas was found as low as 14.7%. By considering this information, it is stated that making a Crimean pine afforestation in Central Anatolia is economically impossible. However, in this study, the height values of Crimean pine cultures in Loros Mountain and Akyokus green belt afforestation areas were measured as 80.68 cm and 50.47 cm, respectively. When study data and statistical analysis were evaluated together, the root collar diameters of Crimean pines in Loros Mountain, heights of Taurus cedars in Akyokus were significantly higher ($P < 0.05$). On the other hand, volumes of Crimean pines in Loros Mountain and Taurus cedar in Akyokus were significantly different in favor of these species. Thus, it might be suitable to use Crimean pine in Loros Mountain and Taurus cedar in Akyokus for green-belt afforestation studies in the future.

Conclusion

At Taurus cedar afforestations, field preparation of arid and drought regions is more important than the field preparation of temperate regions, because the lack of humidity and the weakness of nourishment power of soil entails removing living cloth competition (Urgenc, 1998). It is compulsory to apply a culture tending including preparing the field carefully in order to ensure the settlement of saplings with a efficient root system, determining the saplings intervals decent and wide, using appropriate origin in addition to appropriate species, using saplings with good top/root balance and if possible containerized saplings, an intensive weed struggle and cultivation of soil in order to reach the required success.

At afforestation areas under consideration, the weakness of the flora that supposed to protect the soil caused removal of most of the vegetable top soil and decrease in organic substances. Grazing of livestock animals compacts the soil. For these reasons, 70 - 80 cm soil cultivation in full area (parallel to contour lines, with triple ripper on dozer) and top soil cultivation at places where stoniness was less than 20% (plows with 3 m intervals on 4 x 4 tractors with rubber wheels) was carried out. 1+0 year-old containerized saplings were used in planting and necessary culture tending was completed in the following years. These aforementioned applications were effective on high success.

Consequently, according to both the findings in research area and the literature (Savill et al., 1997; Smith et al., 1997, Oner and Uysal, 2006), it will be useful to consider the following in the afforestation of arid and semi-arid areas that constitutes 37% of Turkey.

Especially in afforestation studies at arid and semi-arid areas, more experience and technical knowledge is required than traditional afforestation studies. In afforestation of arid and semi-arid regions; avoiding wind and water erosion, fixing the top soil and making it productive by nourishing with organic substance should be the aim rather than wood production. Before starting the afforestation studies in arid and semi-arid regions, the contented species in terms of growing environment demands, fixing the soil and improvement studies should be considered (Uluocak, 1977; Zoralioglu, 1990; Boydak and Zoralioglu, 1992).

Since it is observed that the origins of species that are adapted to the arid and local conditions in arid and semi-arid regions are more durable against aridity and cold rather than the other origins of the same species; the species, populations and even individuals under consideration should be given priority. Priority should be given to the usage of Crimean pine which is the most approached species through the steppe areas. By considering the edaphic and topographical structure of the area, the usage of bushy xerophyte taxa which are adapted to the area should be extended. In the arid regions, since they fix the nitrogen of the air to the soil by their roots, the species like ash, honey locust and black locust should be used primarily. Moreover, since they can grow well in the considered region tree of heaven, silverberry, maple, elm and oak should also be used (Urgenc, 1998; Urgenc and Cepel, 2001).

Since the microorganism activation near the thin roots which realize the main process gets harmed because of drought; tree species with shallow root should not be used at semi-arid regions. A compatible balance between root and sapling height, strata, vigority etc. are considered to be direct factors of a successful afforestation. Moreover, a small body that will reduce transpiration and a deep root that will provide taking water up and go deep faster should be the most important aim of the applicant in arid and semi-arid regions (Dwivedi and Gupta, 1993; Oner et al., 2007).

At arid regions, the soil may dry through 10 - 30 cm depth during the vegetation period. Thus, planting depth should be arranged considering these conditions. Moreover, since the collar root gets harmed as a result of the hotness in summer, the planting should be completed as root collar stays under soil (1 - 2 cm) after root and shoot pruning. In order to improve the water holding capacity of the soil, ventilating conditions and enabling the saplings' growing roots to go deep in arid and semi-arid regions, intensive culture tending is necessary. Hoeing and weed removal should be the main subject of the tending in these regions (Goor and Barney, 1976; Urgenc, 1998; Oner et al., 2007).

Water losses due to evapotranspiration should be reduced by breaking capillary spaces near the surface with hoeing and living flora that will compete with saplings in drought seasons should be eliminated by weed removal. Hoeing should be done by utilizing disc harrow between the sapling lines where the slope is appropriate and by man power where the slope is not appropriate. Hoeing should be done right after the spring rains or latest in the beginning of drought season and should continue 3 - 4 years following the plantation (Urgenc and Cepel, 2001).

Soil protection measures in order to increase the success in arid and semi-arid regions where annual planting is done rotationally, contour agriculture, mixed-product agriculture, reduced soil cultivation and zero cultivation, establishing windbreaks against wind, establishing terraces and drip irrigation method should be considered if possible within the facilities. Since trees growing in arid and semi-arid areas are sensitive to diseases and insect pests, the control of these agents is really important. In order to control these agents, silvicultural and also other control methods may be applied. The afforestation studies in the past, in semi-arid areas seem to be successful, however, the studies should be analyzed in long term and a species recommendation should be determined according to these findings (Urgenc, 1998; Oner et al., 2007).

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