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Age Structure and Current Status of Aleppo Pine (*Pinus Halepensis*) Trees on the Western Side of Sidi Alhumry Pine Plantation in Aljabal Al-Akhdar Region

Attia. A. Alsanousi and Abdusalam. M. Ali

Department of Forests and Rangelands, Faculty of Natural Resourcesand Environmental Sciences, Omar Al-Mukhtar University, Al-Bayda- Libya

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Abstract: Aleppo pine trees have been extensively planted in many areas in Aljabal Al-Akhdar region for ecological and recreational purposes. The objectives of this study were to investigate the age structure and current status of *Pinus halepensis*. Miller trees on the western side of Sidi Alhumry plantation. More than 70 pine trees were sampled to estimate the year of establishment, parameters for dbh and tree-height were noted for every sampled tree in the study design. The oldest pine tree found on the site was established in 1962 while the youngest tree found was established in 1984. Our results indicated a gap of over 20 years between pine trees on the study area which suggests either a long afforestation process or an effective regeneration during the first 2 decades. Average dbh and height for pine trees were typical for similar pine stands in the area with an overall dbh average of 29cm and tree-height of 10m. However, thinning would be advisable to ensure better growth and high yield for pine trees on the site.

Keywords: *Pinus halepensis* , Age structure, Sidi Alhumry Pine Plantation.

INTRODUCTION

Pinus species are planted in many areas around the world for multiple purposes. They provide both ecological (recreational areas, carbon sequestration, and preventing soil erosion) and commercial benefits (logs and wood production) (Richardson, 1998) (Barbéro, Loisel, Quézel, & Richardson, 1998) (Lavi, Perevolotsky, & Kigel, 2005). In eastern Libya (Cyrenaica), the establishments of pine plantations took place roughly around the 1950s, and were mostly for environmental purposes. *Pinus halepensis* Mill. (Aleppo pine) is the most widespread coniferous species in the Mediterranean basin (Barbéro, Loisel, Quézel, & Richardson, 1998) (Prevosto, Amandier, Quesney, & de Boisgelin, 2012) (Maestre & Cortina, 2004) (Puglisi, 1995) (Novak, et al., 2016) (Micheloz-zi, Loreto, Colom, Rossi, & Calamassi, 2011), and it is among the few conifer species which can thrive in semiarid regions (Que´zel, 2000) (Nahal, 1981), and favorable for afforestation purposes due to its tolerance to drought (Schiller, 2000). In Cyrenaica, it is considered to be second only to Phoenician Juniper (*Juniperus phoenicea)*, and grows naturally in pure or mixed stands across Aljabal Al-Akhdar region. Nevertheless, the vast number of Aleppo pine trees in the region occurs in plantations established over 60 years ago. Sidi Alhumry Pine Plantation is one of the largest Aleppo pine plantations in Cyrenaica, and expands on an area of approximately 108 ha. The plantation is considered as one of the oldest pine plantations in the

***Corresponding Author:** [1](Attia Alsanousi) *attiaalsanousi@yahoo.com. Department of forests and Rangelands, Faculty of Natural resources& Environmental Sciences, Omar Al-Mukhtar University. Al-Beida, Libya*

southern part of Al-jabal Al-Akhdar and classified as a pure *P. halepensis* stand. Previous report stated that the plantation was established in 1951 (OMUReport, 2005). The same report mentioned that the actual establishment of the plantation took place between 1954- 1956. However, the shortage of information about the afforestation process and whether the site was occupied by pine trees prior to the establishment was a great motive to investigate the age structure for this site.

This study aims at examining the age structure at which the majority of *P. halepensis* trees on the western part of the plantation occur, and to determine whether the natural regeneration was effective especially during the first years of establishment to create different cohorts of pine trees.

MATERIALS AND METHODS

Field data for this study were collected in the time between July and October of 2013 from Sidi Alhumry Pine Plantation in the southern part of Al-Jabal Al-Akhdar (32^{o} 32` N, $21^{o}47$`E). Four random locations were chosen to set triangular experimental design (methods were similar to Binkley, et al., 2014). At each location, an equilateral triangle (50 m each side) was placed and 3 sampling points were conducted at each of the triangle points (total of 12 sampling points). At each sampling point, a BAF (basal area factor) prism of 2 $m^2.ha^{-1}$ for high density coniferous stands was used to determine Pine sampled trees (Bentley, 1996) (Nyyssönen, Kilkki, & Mikkola, 1967). All pine trees included by prism were cored at the height of 1.4 m to determine the year of establishment, and all of the uncertain borderline trees were counted in to avoid data misinterpretation. A circle of 5m radius was made at each sampling point to count the number of emerging seedling of pine trees on the site. Other parameters including diameter at breast height (dbh) and tree height were also recorded for statistical analysis. All sampled pine cores were left to air drying for several days, then were mounted on wooden trays and sanded with a fine sandpaper to obtain a better vision of the annual rings. Annual rings for these trees were dated by using a binocular microscope and following standard dendrochronological procedures (Stokes & Smiley, 1968). Missing rings for Aleppo Pine cores which failed to reach the pith were calculated by estimating the length of the missing radius and ring width (Duncan, 1989). dbh was measured for all sampled trees by using dbh tape or a caliper, and trees heights were measured by using Silva clinometer (Avalos, Salazar, & Araya, 2005) at a distance of 20 m from the tree base (Wright, Jessen, Burke, & Garza, 1997). The data obtained in this study were extrapolated to give a better representation of the age structure of Aleppo Pine trees on the site. The number of trees/ha represented by each tree included by the prism had been calculated by using the basal area for each tree and the chosen basal area factor. Then, the age of the sampled tree was assumed to be the age of the calculated number of trees.

RESULTS

Out of 81 core samples of *P. halepensis*, 73 were dateable and suitable to count the annual rings for each. The rest were either damaged or difficult to identify their total rings, therefore, they were eliminated form statistical analysis. 46 out of 73 (almost 63% of the total core samples) hit the pith of the tree, and 28 (37% of the total core samples) failed to reach the pith and the missing rings were calculated according to the radius of the previous rings, and by estimating the remaining rings to hit the pith (Duncan, 1989). The oldest tree in our sampling plots was established in1962 (current age is 56 years) while the youngest tree was established in 1984 (current age is 34 years). The estimated number of pine trees per hectare on the western side of the plantation was 747 trees/ha. The establishment of those trees occurred during the time from 1962 to 1984 creating multiple cohorts of more than 20 years differences in their age. Since the establishment, the number of pine trees/ha has increased to reach its peak at age class of (1977-1979),

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which has the highest presentation of pine trees on the site, with approximately 243 trees/ha (32% of the total pine occupation) followed by age class of

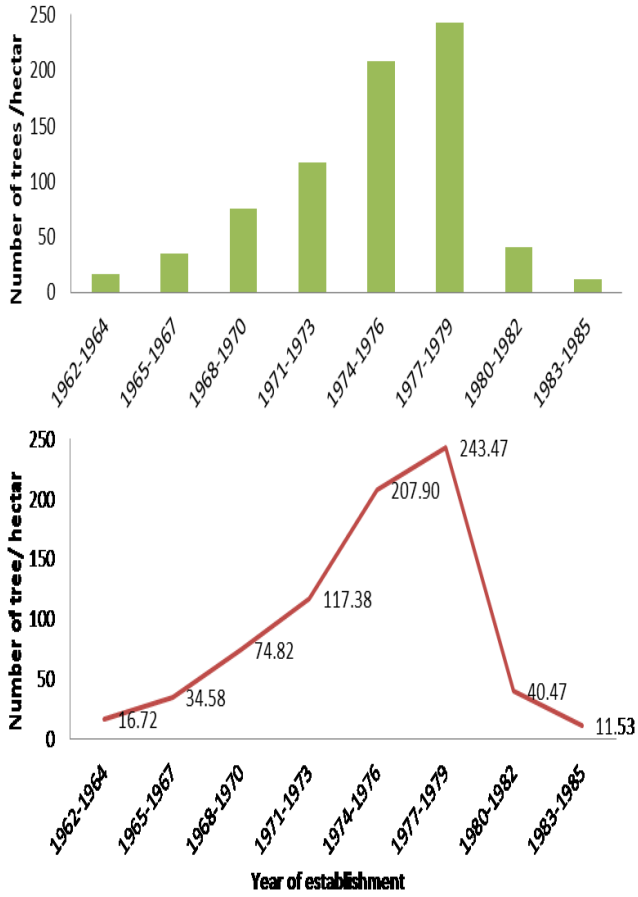

Figure (1): Age distribution of Aleppo Pine (*P. halepensis)* on the western side of Sidi Alhumry Pine Plantation.

(1974-1976) with 208 trees/ha (around 28% of the total pine occupation) as shown in (figure1) (table 1). The number of trees/ha dropped significantly in age class of (1980-1982) to only 40 trees/ha. The lowest pine recruitments encountered were in age classes (1962-1964) and (1983-1985) with just 16.8 and 11.5 trees/ha respectively.

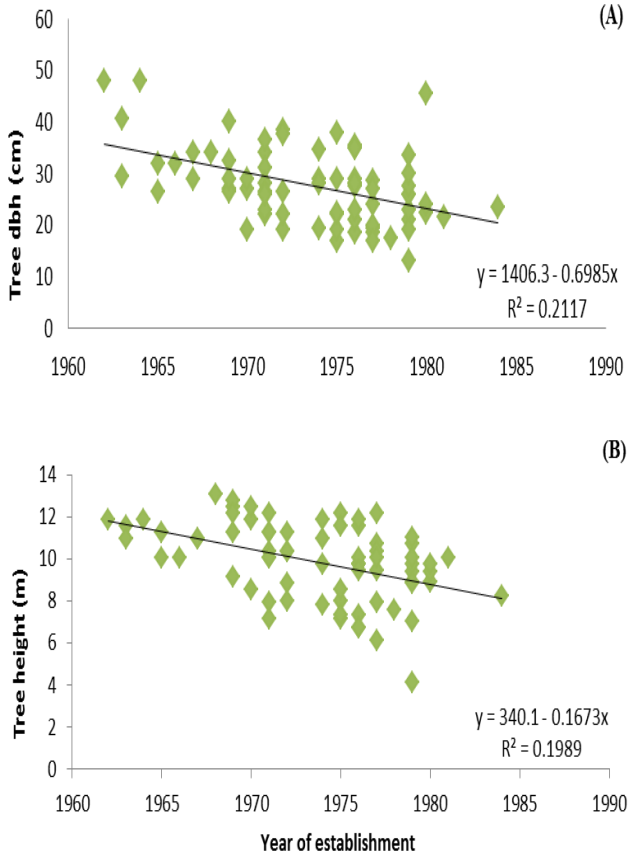

Figure (2): The relationship between tree age and other parameters: **(A)** Age-dbh relationship. **(B)** Age- tree height relationship of Aleppo Pine tree on Sidi Alhumry Pine Plantation.

As the tree grows, it encounters an increase in both size and height. Older trees have the highest dbh recorded with 41.5 cm for age class (1962-1964), more than 10 cm bigger than the next age class (1965-1967) with 30.7 cm. The gap between dbh averages for the rest of age classes were tight and ranged from 29.3cm to 23.5cm for all age classes from 1968 to 1985. Average pine tree height as well showed a steady but narrow increase over years. Youngest age class of (1983-1985) showed the lowest height of approximately 8.2 m while the highest tree height recorded was for the oldest age class of (1962-1964) with an average of 11.55m. (Figure 2, and table 1). Results showed also that average height for pine trees of age class (1968-1970) (11.51m) was higher than that for the older age class of (1965-1970) (10.64m).

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Not a single *P. halepensis* seedling was found in a radius of 5m at any of the twelve sampling points in this study, which suggests a very low regeneration percentage in the recent years.

Table (1): Number of trees/ha and average diameter at breast height (cm) and average tree height (m) for each age class of Aleppo pine trees on Sidi Alhumry Pine Plantation.

Year of establish-ment	Num-ber of tree/ha	Percentage of the total occupation %	Avg.db h (cm)	Avg..heigh t (m)
1962-1964	16.72	2.23	41.5	11.55
1965-1967	34.57	4.62	30.7	10.64
1968-1970	74.81	10.01	29.33	11.51
1971-1973	117.37	15.71	28.5	9.9
1974-1976	207.89	27.83	26.95	9.38
1977-1979	243.47	32.6	23	9.04
1980-1982	40.47	5.41	28.37	9.5
1983-1985	11.52	1.54	23.5	8.2

DISCUSSION

According to previous reports, Sidi Alhumry Pine Plantation was established in 1951 (OMUReport, 2005) and the actual recruitment of the current stand occurred in 1956. Local references stated that the afforestation process started first on the Eastern side of the plantation, which suggests a possible later date for the establishment on the subjected study area on the western side. The outcome of the present study indicated that the majority of *P. halepensis* trees on the site were established in the period between 1962-1984 with more than three-quarters of these trees established between 1971 and 1979 (76.14% of the total pine recruitments). These results suggested that the establishment of *P. halepensis* trees on the site either occurred on a long period of time and the afforestation process last for over two decades, or the natural regeneration was effective during the first two decades of the establishment and then dropped substantially afterward. *P. halepensis* can live up to 150 years. However, it is often susceptible to major disturbances such as fire (Agee, 2000) and its life span is much shorter.Diameter at breast height ranged from 23 cm for the younger age cohorts (established after 1977) to 41cm for the oldest age cohort (1963). Average dbh for more than 70% of the actual pine recruitment on the site ranged from (23-29.3 cm). Largest Aleppo pine trees can reach up to 50cm of diameter (Mòdol & Casals, 2012) (Elaieb, et al., 2017). However, the chance of getting rotten cores and inner damages is higher when the trees exceed 40cm in diameter. Average pine trees height varied from 8.2 m for the youngest age cohorts to 11.55m for the oldest trees found on the site. On individual bases, the highest tree recorded on the site reached 13.1 m and was established in 1968 while the least height recorded was 4.1 m for a pine tree that was established in 1979. Although Aleppo pine trees may reach 20 m height, they usually do not grow higher than 15 m (Elaieb, et al., 2017) (Mòdol & Casals, 2012) (Way, 2006). Competition between different or same tree species, particularly for light interception, is a determinant factor for the growth and the development of trees (Schulze & Chapin, 1987) (Rouvinen & Kuuluvainen, 1997) and most competition-related mortality occurs in lower diameter classes with small crown at or below the stand mean (Oliver & Larson, 1996) (Jokelaa, Doughertyb, & Martin, 2004).

Our study indicated the complete absence of new emerging pine seedlings beneath mature trees canopies in a radius of 5m from the mature pine trunk. The existed understory vegetation was mainly consisting of *Urginea maritima* and *Sarcopoterium spinosum* and both species were concentrated mostly in the gaps between tree canopies where they receive a full sunlight. The site is in inappropriate condition. It is used as a landfill site and subjected to illegal logging by locals. An effective administrative protocol to protect the plantation from overgrazing, possible disease outbreak and fire hazards, and invaders interfere is required to maintain the site on appropriate and productive levels. Moreover, silvicultural practices such as thinning to reduce fire hazard and diseases out-

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break, and to retain profitable basal area are needed to enhance the site and make the most out of it.

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التركيب العمري والوضع الحالي لأشجار الصنوبر الحلبي *pinus halepensis* النامية في الجزء الغربي من مشجَّر صنوبر سيدي الحمري في منطقة الجبل الأخضر

عطية عبد الكريم السنوسي*، عبد السلام اقويدر

قسم الغابات والمراعي، كلية الموارد الطبيعية وعلوم البيئة، جامعة عمر المختار البيضاء، ليبيا

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المستخلص: أشجار الصنوبر الحلبي تزرع بكثرة في مساحات كبيرة من منطقة الجبل الأخضر للعديد من الأغراض البيئية والترويحية. استهدفت هذه الدراسة معرفة التركيب العمري والوضع الحالي لأشجار الصنوبر الحلبي *Pinus halepensis* في الجانب الغربي من مشجر سيدي الحمري. تم أخذ عينات لأكثر من 70 شجرة صنوبر لتقدير سنة الإنبات، كما تم تسجيل بيانات للقطر عند مستوى الصدر وارتفاع الشجرة لكل عينة من عينات الأشجار الموجودة في موقع الدراسة. أقدم شجرة وجدت بالموقع كانت قد زرعت سنة 1962، بينما أصغر شجرة وجدت كانت قد زرعت سنة 1984. أشارت نتائجنا إلى وجود اختلاف عمري بأكثر من 20 سنة بين أشجار الصنوبر الموجودة بمنطقة الدراسة مما يشير إلى إمكانية أن يكون التشجير قد تم على فترات زمنية طويلة، أو احتمالية أن يكون التجديد الطبيعي وخاصة في السنوات العشرين الأولى فعَّالاً لتكوين هذه الاختلافات العمرية. متوسطات القطر عند مستوى الصدر dbh، وارتفاع الأشجار كانت مماثلة إلى حد ما لمشجَّرات الصنوبر الموجودة في المنطقة بمتوسط عام للقطر عند مستوى الصدر بحوالي 29 م ومتوسط ارتفاع للأشجار بحدود 10 م. ومع ذلك، فينصح بتطبيق التخفيف في هذا المشجَّر لضمان نمو أفضل ومحصول أمثل من أشجار الصنوبر في المنطقة.

الكلمات المفتاحية: *Pinus halepensis*. الصنوبر الحلبي؛ التركيب العمري. مشجَّر غابة سيدي الحمري.

*عطية السنوسي attiaalsanousi@yahoo.com قسم الغابات والمراعي، كلية الموارد الطبيعية وعلوم البيئة، جامعة عمر المختار البيضاء، ليبيا.