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Nursery Propagation and Field Establishment Evaluation of *Pistacia chinensis* under Two Ecologies in Ethiopia

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Abstract

The present study was conducted to look for viable means of nursery propagation for *Pistacia chinensis* and evaluate its field adaptation and carbon sequestration potential. It was hypothesized that germination percentage of *Pistacia chinensis* is unrelated with substrate types used for propagation and removal of seed coats prior to sowing. Matured seeds of *Pistacia chinensis* with protective seed coats were sown on standard soil mixtures (SSM) that comprised 3% top soil, 2% cow dung and 1% sand and germination was compared to seeds with protective seed pods that were sown on composted farm yard manure (FYM). Two independent experiments were conducted in completely randomized design with four replications each replication containing hundred pure viable seeds. The study results showed that germination percentages of the treatment group (seeds with protective seed coats sown on farm yard manure) were significantly higher at alpha <0.05 than the control group (seeds with protective seed coats sown on standard soil mixtures). In a separate experiment seeds without pods were also sown in replicates on standard soil mixture and their germination was compared to intact seeds (Seeds with their pods) sown on standard soil mixture. Germination percentages of seeds without pods was significantly lower as compared to the control groups(intact seeds) at P<0.05.The study revealed that the most viable means of propagating *Pistacia chinensis* under the nursery conditions of Debre Zeit was sowing seeds with pods on farm yard manure. The likely explanation for this could be composted farm yard manure is an approximate simulation of the forest floor . Height and collar diameter of trees averaged 194.61 cm and 4.82 cm at Debre Zeit and thus were found significantly higher than their counterparts (141.1 cm height and 3.35 cm diameter) at Wondo Genet in the across location performance study. There was no significant difference between survival percentages at Debre Zeit (82.6%) and Wondo Genet (90.6%). Carbon was estimated through height and diameter measurements of trees on research plot and subsequent calculations using established allometric relations. The total amount of carbon sequestered by planted trees at Debre zeit amounted to 1.33 tons/ha/year. The promising field performance of the tree species has currently led to its use for urban street side greening of Debre Zeit town.

Keywords: Carbon sequestration; Farm yard manure; Germination percentage; Nursery propagation; Standard soil mixture

Introduction

Tropical fruit trees are important crop, which supplement and improve the quality of diets. Many of the species have multipurpose uses as they produce non-food products such as fuel, timber, fodder, medicines and industrial products for small holders in addition to fruits. In Africa domestication efforts are already showing success in meeting livelihood security needs of farmers and conserving biodiversity [1]. *Pistacia chinensis* is one of the many economically important tree species for drier areas. It is also vernacularly known as Chinese pistachio. *P. chinensis* is a member of the family Anacardiaceae with kaleidoscopic colors despite prolonged heat and a dearth of summer rain.

P. chinensis is native to China. It stands up to pollution, drought, nutrient poor soil, or restricted root space and still grows into an impressive, spreading 20 to 35 foot tree. Its notable adaptability to drought conditions is attributed to its tap root which provides strong anchorage as well as the ability to reach deeper water sources (Koller, year unmentioned). *Pistacia* is a xerophytic genus, which is shown by the presence of many adaptations to aridity, such as advanced development of palisade tissue and extensive root growth [2].

P. chinensis requires good soil drainage and exposure to full sun to encourage optimum growth and best form. Its spring flowers are not visible from distance. It produces bitter oily nuts that have comparable size with ground nuts on the female trees. The nuts are attractive like berries maturing from yellow to red and ultimately metallic blue if they haven't been eaten up by birds. It is a dioecious tree, meaning male and female flowers are produced on separate trees. It has an underutilized potential for wider use in urban street tree plantings and in other adverse sites in Ethiopia in spite of its drought tolerance, adaptability, moderate size, and wonderful form and radiant color of the leaf during Autumn. Chinese Pistachio grows quickly in full sun to partial shade on moderately fertile, well-drained soils and will withstand heat and drought extremely well. The crown is quite round and symmetrical on older specimens when grown in full sun but becomes misshapen in too much shade showing that it best prefers full sun areas. It grows in clay, loam, or sand in a wide range of soil pH and can be used as the under stock on which the commercial pistachio nut (*Pistacia vera*) is grafted [3].

There are 11 species (*P. atlantica*, *P. cabulica*, *P. chinensis*, *P. falcata*, *P.* integerrima, *P. vera*, *P. kurdica*, *P. mutica*, *P. palestine*, *P. terebinthus* and *P. khinjuk*) of genus *Pistacia* according to Zohary's classification [4]. But only four species are widely used in the pistachio industry. The other species grow in the wild and are used as root stock sources and for fruit consumption, oil extraction and soap production [2,4]. The nut produced on *P. chinensis* cannot be eaten since it is not the edible pistachio tree. However, *P. chinensis* could be used as an under stock for growing *Pistacia vera*, the edible nut. *P. vera*, commonly known as Pistachio has edible seeds and considerable commercial importance. Pistachio nuts provide fiber, vitamins B1 and B6, thiamin, magnesium, phosphorus and copper, plus smaller amounts of other nutrients [5].

P. vera, with reduced vigor, is the most used rootstock in the world. However, commercial pistachio nursery production needs to raise fast growing rootstocks to allow early budding and transplanting to orchard. In addition, vigor is a desirable character in pistachio rootstocks, due to its effect on the time needed by the scion to form a large canopy (related with yield capacity) and on the adaptation of the tree to adverse growing conditions in which usually the crop is placed. The achievement of a good rooting system is a very important characteristic for transplanting to the orchard. The interest for pistachio rootstocks is mainly related to their capacity of adaptation to environmental conditions in which the crop is developed [6]. Many kinds of pistachio trees are not cultivated for their nuts, but instead are used as rootstocks to which the upper, nut-bearing portion of the tree, or scion, is grafted. Or, these species are planted as street trees, especially those like *Pistacia chinensis*, which has spectacular red and orange foliage in fall [5].

Except a few introduced mother trees at Debre Zeit Agricultural Research Center *Pistacia chinensis* is virtually unknown all over Ethiopia. Out planting of the species was also restricted in the research center because of its very low germination percentage (20-25%) on nursery soil mixes. The tree's hardiness potential has not been fully evaluated through research across locations in Ethiopia. Little is known about the carbon sequestration potential of the tree and no attempts are made on popularizing the species for large scale propagation and urban greening. Thus the present study was initiated with the objective of studying nursery propagation, field adaptation, urban greening potential and carbon sequestration potential of the species.

Carbon sequestration potential could be assessed through non-destructive sampling technique and allometric relationships. Allometry is the measure and study of relative growth of a part in relation to an entire organism or to a standard [7]. Allometry is a less harmful way for it allows to estimate the mass of a tree from a few simple measurements of it, and then to apply equations to the trees in a forest. Allometric relationships are developed on the basis of the total or green weight of the live trees. The growth parameters considered for evaluation of field adaptation study included tree height, collar diameter and survival.

Materials and Methods

The experiment was conducted in two phases. The first was on the means of nursery propagation at Debre Zeit while the second was an on station field adaptation and growth performance evaluation at Debre Zeit and Wondo Genet Agricultural Research Centers.

Nursery trial

Freshly collected seeds were air dried on plastic mats for two weeks in the nursery. The air dried seeds were immersed in a bowl of cold water as a simple test for their purity in the lab. All those pods that seemed to be sinking were discarded for they were suspected to be either empty or impure. Unlike other tree seeds it is the pure, viable air dried seeds of *P. Chinensis* that floated. The floated seeds were then recovered and soaked in cold water to loosen the fleshy outer layer (exocarp and mesocarp) that surround the hard seed bearing shell or endocarp containing two greenish cotyledons. After a through removal of the fleshy outer layer (Figures 1 and 2) pure seed pods containing cotyledons were left socked in cold water for 24 hours prior to experimentation. This was to induce imbibitions and make the seeds ready for sowing.

Figure 1: Freshly collected seeds of *P. chinensis*.

Figure 2: Extracted nuts of *P. chinensis*.

For the germination test, completely randomized design (CRD) with four replications was used. 100 seeds of the species with pods were sown on standard soil mixtures (3% top soil: 2% manure: 1% sand) per replication. In a separate experimental set up 100 seeds of the species with pods were sown on farmyard manure per replication. In both cases the sown seeds were covered with light soil and mulched uniformly with straw to facilitate warmth and smooth percolation of moisture during watering. Data on germination count was taken starting from three weeks after sowing on every other day for test duration of sixty days. Independent sample t-test in SPSS was used for data analysis. To evaluate the effect of pod removal in facilitating the emergence and enlargement of essential structures (plumule and radicle) a third experimental set up was laid out in CRD with four replications. This was done by sowing seeds without pods on standard soil mixture and comparing their germination with that of intact seeds (Seeds with their pods) sown on standard soil mixture. Data on germination count was taken starting from three weeks after sowing on every other day for test duration of sixty days. Independent sample t-test in SPSS was used for data analysis.

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Field adaptation

To evaluate across location performance differences and species adaptation 75 mature twelve months old seedlings of *P. chinensis* were planted in three plots at Debre Zeit and Wondo Genet Agricultural Research Fields. A plot comprised 25 trees. Within tree distance was 2.5 m while the space between plots was 3 m. The testing site at Debre Zeit is 1800 m above sea level (a. s. l.) and receives an annual rainfall of 740 mm while the site at Wondo Genet is at an elevation of 2000 m and receives annual rainfall of 1200 mm. This was done to study effect of location difference (rainfall, temperature, soil and other cumulated biophysical attributes in general) as treatment. Appropriate silvicultural practices like weeding and mulching were provided for the planted seedlings and the adaptive potential of the species under the prevailing condition of the test sites was evaluated with no supplementary irrigation in the off season. Data collected on mean survival, collar diameter and height after six years of planting were subjected to two tailed independent samples t- test in SPSS at P<0.05 for statistical analysis.

Estimation of carbon sequestration potential

From the already established plots at Debre Zeit that comprised a total of 75 trees, height and diameter of all individual trees were measured. The weight of CO_2 in a tree per year is measured by following five stepwise procedures [8]. The detailed information of each step is shown in Appendix 1. The equation for the measurement of CO_2 sequestered in a tree per year is summarized as follows:

$$W=\frac{0.25*D^2*H*120\%*72.5\%*50\%*3.6663}{\text{Tree age}} \text{ (When D<11 inches)}$$

$$W=\frac{0.15*D^2*H*120\%*72.5\%*50\%*3.6663}{\text{Tree age}} \text{ (When D} \geq \text{11 inches)}$$

Where:

W= Weight of CO_2 sequestered in a tree per year in pounds

D= Tree diameter in inches

H= Tree height in feet

Results and Discussion

The best propagation medium and method for large scale seedling production for the conditions of Debre Zeit for *Pistacia chinensis* has been identified. Mean comparisons of germination percentages using two tailed independent samples t-test in SPSS revealed highly significant differences between the treatment (Farm yard manure) and control (Standard soil mixture) groups at P<0.05. Sowing seeds of *P. chinensis* with pods on farm yard manure gives significantly better germination percentage (at p<0.05) than doing it so on standard soil mixtures (Figure 3).

It was also observed that seeds that were sown on standard soil mixtures have difficulty in penetrating substrate upwards during emergence of the essential structures i.e. the plumule and the radicle. As germination of *Pistacia* is epigeal most of the seedlings soon died out just after emergence due to the very soft and delicate nature of the plumule. This problem however was not encountered when seeds were raised on a more porous and coarse textured growing medium like composted farm yard manure. Significantly higher germination percentage (at p<0.05) was observed using the latter technique. This could partly be attributed to the reason that composted farm yard manure is an approximate simulation of the forest floor that is considered to be the most convenient propagation medium for naturally falling mature seeds of *P. chinensis*.

Figure 3: Comparison of germinations under different substarate conditions. (a) Germination of *p. chinensis* seeds with pods on standard soil mixture. (b) Germination of *p. chinensis* seeds with pods on composted farm yard mannure. (c) Germination of *p. chinensis* seeds without pods on standard soil mixtures. (d) Twelve months old *p. chinensis* seedlings ready for planting.

Seeds with their pods removed were also sown in replicates on SSM to see if the removal of pods would make germination better. But the experimental results revealed to the opposite i.e. Most of the seeds sown without pods decayed (Figure 3) in the soil prior to germination leading to a very low germination percentage. Mean comparisons of germination percentages using two tailed independent samples t- test in SPSS revealed a highly significant decline in germination of seeds sown without pods than the control groups i.e. seeds sown with pods at P<0.05. The data analysis produced a t_{obs} value of 2.151, with df=6, p=0.075. Therefore we reject the null hypothesis and conclude that sowing seeds of *P. chinensis* with pods gives significantly better germination percentage (at p<0.05) (Figure 4).

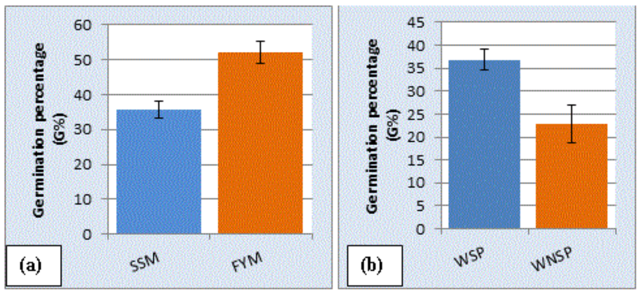

Figure 4: Germination percentages under varying substrate conditions and planting methods. Error bars are SEM with n=4 (a) *P. chinensis* with pods under different substrates. (b) *P. chinensis* with no seed pod on standard soil mixture. SSM: Standard soil mixture. FYM: Farm yard manure. WSP: With seed pod. WNSP: With no seed pod.

The tree characteristics considered for evaluation of field adaptation and growth performance included tree height, collar diameter and survival. Twelve months old seedlings of *P. chinensis* were planted on test plots at the mentioned locations. Accordingly the species gave a mean height and diameter of 194.61 cm and 4.82 cm respectively in six years at Debre Zeit. Mean comparisons of height and diameter growth using paired two tailed t- test in SPSS showed significant differences between two and six years after planting at P<0.05. This was revealed by a t_{obs} value of 5.721, with df=4, p=0.005 for height and a t_{obs} value of 2.883, with df=4, p=0.045 for diameter (Figures 5 and 6).

Height performance of *Pistacia chinensis* was significantly higher at Debre Zeit than Wondo Genet This difference was disclosed through the use of error bars. As the upper error bar of height values at Debre Zeit did not overlap with the range of height values at Wondo Genet there is more likelihood that these two mean height values differ significantly (Figure 7a). There was also significant difference in mean diameter growth across locations (Figure 7b). Accordingly the upper error bar of height values at Debre Zeit did not overlap with the range of height values at Wondo Genet. Across location survival percentage of the species was not found out to be significantly different. As the margin of error for survival percentage at Wondo Genet overlaps with that of Debre Zeit there is a much lower likelihood that these two survival percentages values differ significantly (Figure 7c).

The carbon sequestration potential of the species at Debre Zeit was calculated using the allometric relationships specified in the materials and methods. To calculate the above ground weight of a tree in pounds the relation $W=0.25D^2H$ was used as all the trees had diameters below 11 inches. Sequential steps to calculate carbon dioxide sequestered in the tree per year were followed to finally arrive at the amount of carbon dioxide sequestered on hectare basis which is 1.33 tons/ha/year.

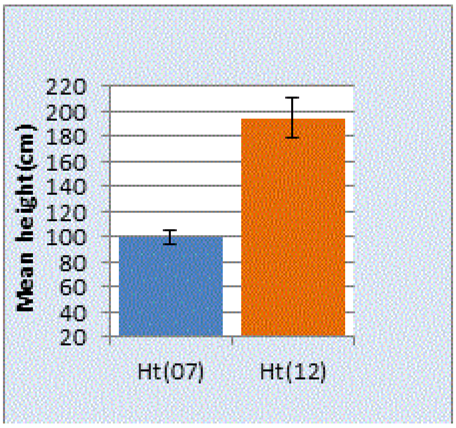

Figure 5: Mean height growth of *P. chinensis*.

Observation trials on germinations of *Pistacia chinensis* on nursery soil mixes of Debre Zeit agricultural Research Center revealed very low percentages (mostly below 25%). Establishment of *Pistacia chinensis* stands for future vegetative propagation of *Pistacia vera* scions is not well addressed in Ethiopia. The achievement of a good rooting system is a very important characteristic and vigor is a desirable character in pistachio rootstocks [6]. *P. chinensis* has been reported to be potential root stock for nut bearing *Pistacia vera* though it is susceptible to severe cold in winter. However this is not the case with the adaptation trial in this study for prolonged winter colds are not peculiar characteristics of the study areas. Mean comparisons of germination percentages in the nursery propagation study revealed highly significant differences between the treatment (Farm yard manure) and control (Standard soil mixture) groups at $P<0.05$ where in both cases seeds of the species were sown without removing their pods. This signified that sowing seeds of *P. chinensis* with pods on farm yard manure gives significantly better germination percentage averaging to 51.55% (at $p<0.05$) than doing it so on nursery soil mixes that averaged 35.7%. This could partly be attributed to the coarse textured nature of FYM to facilitate emergence and prolongation of the essential structures. Yet pretreatment techniques like stratification of seed before sowing ought to be tried out to better enhance the germination percentage than what is acquired through cold water treatment and varying substrate conditions as above (Figures 7-10).

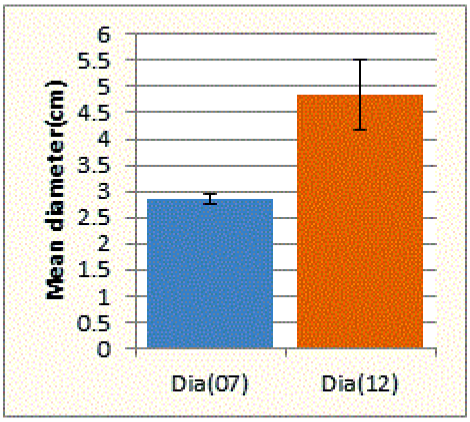

Figure 6: Mean diameter growth of *P. chinensis*. (*Debre Zeit*).

Error bars are SEM with n=3. Ht(07): height in 2007. Ht(12): height in 2012. Dia(07): Diameter in 2007. Dia(2012): Diameter in 2012.

Mean comparisons of germination percentages on SSM revealed a highly significant decline in germination of seeds sown without pods versus the control groups i.e. seeds sown with pods at $P<0.05$. Thus it can be concluded that removal of seed pods is not advisable to mass propagate *Pistacia* in the nursery. Height and diameter growth showed significant differences between two and six years after planting at $P<0.05$ for Debre Zeit location. This was revealed by a mean height and diameter of 194.61 cm and 4.82 cm respectively in six years while the averaged counterparts in two years were 99.1 cm and 2.8 cm for Debre Zeit location. Across location data on height, diameter and survival of trees were also subjected to statistical analysis. Accordingly height and diameter performance of the tree species was significantly higher at Debre Zeit than Wondo Genet based on the comparison of error bars. This difference could be attributed to the relatively warmer and drier climate at Debre Zeit due to the relatively lower altitude as compared to Wondo Genet. In contrast across location survival percentages were statistically non significant after six years of planting.

Therefore for future out planting on large scale basis for either street side or plantation Debre Zeit is relatively preferred over Wondo Genet. Due to its highly desirable characteristics like high drought tolerance, capability to thrive under poor soil conditions, radiance and beauty of the leaf under full sun conditions and less likelihood of being browsed by cattle (as uncontrolled grazing is a potential bottleneck for tree survival in Ethiopia) *Pistacia chinensis* is presently under rigorous popularization and urban greening program (Figure 10) for streets of Debre Zeit city. Having the information on well adapted root stocks pistachio scions could also be grafted to further study the potentials of nut bearing in the future.

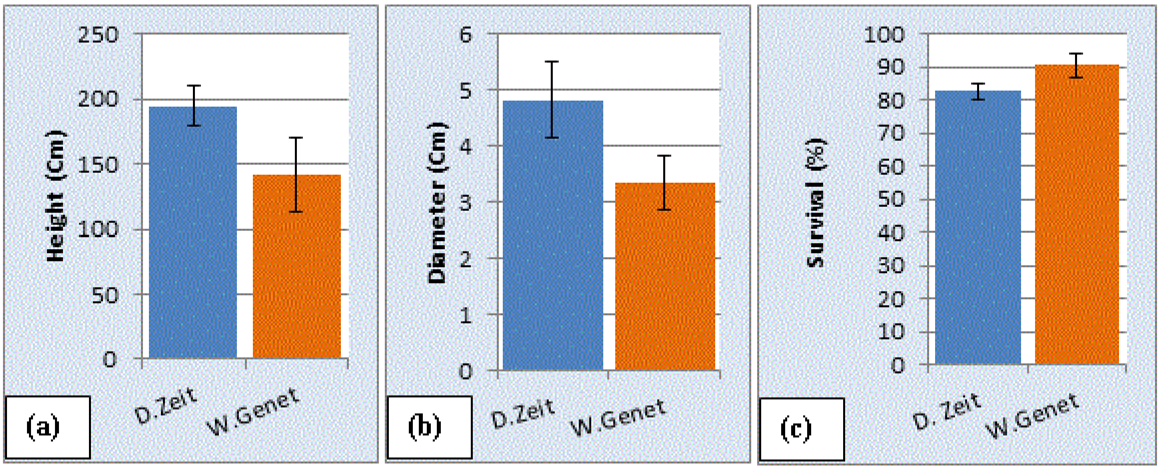

Figure 7: Across location growth performance of *P. chinensis*. Error bars are SEM with n=3.

Figure 8: *Pistacia* at Debre Zeit.

Figure 9: *Pistacia* at Wondo Genet.

Figure 10: Urban greening with *Pistacia*.

References

1. Tesfaye H, Mohamed A (2004) Forestry Research News Letter. 1.
2. AL-Saghir, Duncan M, Eric N (2006) Leaf Anatomy of Pistacia species (Anacardiaceae). Journal of Biological Sciences 6: 242-244.
3. Edward F, Gilman D, Watson G (1994) Pistacia Chinensis. Forest service department of agriculture, USA: Fact Sheet ST-482.
4. Zohary M (1952) A morphologic study of the genus Pistacia. Palestine Journal of Botany 5: 187-228.
5. Wood M (2004) Unique Pistachio Trees Preserved in California Collection. USDA.
6. Vargas FJ, Romero MA, Calve J (1998) Nursery behavior of Pistachio root stocks. Acta Horticulture 470: 231-236.
7. Janssen M, Manfred D, Jürgen P (2003) Allometric Relations in Tropical Agro forestry. Tropical Agroforestry Systems (PTS151)–ARTS B.IV-3
8. Broward County (2012) How to calculate the amount of CO2 sequestered in a tree per year.