

INITIAL SURVIVAL AND GROWTH OF TREE SEEDLINGS IN A WATER HARVESTING AGRISYSTEM

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Introduction

Water harvesting is a technique for developing surface water resources that subsequently can be utilized to provide water for livestock and domestic use, and small-scale subsistence agriculture and forestry practices. Water harvesting systems are artificial methods that collect and store precipitation until it can be utilized beneficially. These systems include a catchment area, usually treated to improve surface runoff efficiency, and a storage facility for the harvested water, unless the water is to be applied immediately for the growing of drought-hardy plants (Frasier and Myers, 1983). For systems established for irrigation purposes, a water distribution scheme also is required.

The purpose of water harvesting is to either augment the existing water supplies, or to provide water where other sources are not available or too costly to develop. A principal aim is to furnish water in sufficient quantity and of suitable quality for the intended use. The technology of water harvesting can be applied in almost any arid region of the world.

In this paper, the initial survival and growth of tree seedlings planted in two catchments of a water harvesting system, located in Avra Valley, 40 kilometers west of Tucson, Arizona, is reviewed. This water harvesting system, developed by the University of Arizona in cooperation with the City of Tucson, was established to demonstrate a potential use for retired farmland, with rainfall as the only source of water for irrigation.

Study Area

The water harvesting system, consisting of a gravity-fed sump, a storage reservoir, sixteen catchments, and an irrigation system, occupies nearly 2 hectares in Avra Valley. Elevation of the system is about 600 meters, the terrain is relatively level, and the soil is sandy clay loam. Annual precipitation is 300 millimeters, occurring in a bimodal summer-winter distribution pattern. Summer temperatures reach 45 degrees Celsius, with winter temperatures rarely below 0 degrees Celsius.

As mentioned above, the study area originally was farmland. However, the City of Tucson began to purchase and retire farmland in the vicinity, including the study area, in 1975, utilizing the groundwater to augment its

water needs. The native vegetation was disturbed by the earlier farming activities, with the area currently occupied by invading "weed" species.

The Water Harvesting System

The combined design capacity of the gravity-fed sump and the storage reservoir is approximately 2,400 cubic meters of water (Karpiscak et al., 1984). The sump and the storage reservoir were treated with NaCl to decrease infiltration, and the main reservoir is covered with 250,000 empty plastic film cans to decrease evaporation.

Sixteen catchments, also treated with NaCl to decrease infiltration, are used to concentrate rainfall runoff around planted agricultural crops and tree species in untreated planting areas at the base of the catchments (Karpiscak et al., 1984). Excessive runoff flows directly into a collecting channel and then into the sump. Each catchment, about 1.6 hectares in size, is approximately 90 meters in length, varies from 6 to 18 meters in width, and slopes about 0.5 percent.

The irrigation system consists of a 6,000 Watt centrifugal pump, an 8-centimeter pipeline connecting the sump and the storage reservoir to the pump, two 5-centimeter PVC pipelines connecting the pump to the field plots, and 2-centimeter polyethylene driplines equipped with 0.01-cubic meter per hour drip emitters (Karpiscak et al., 1984). The valving system permits the movement of water from the sump to the storage reservoir, from the storage reservoir to the sump, and from either the sump or the storage reservoir to the field. A water meter records the amount of water applied to the plants.

Description of the Study

On July 28, 1984, 103 tree seedling of Aleppo pine (*Pinus halepensis*) and Brutia pine (*Pinus brutia*), grown in containers for 8 months in a greenhouse, were hand-planted in two of the 16 catchments in the water harvesting system. Fifty-two tree seedlings were planted in Catchment No. 8, and 51 tree seedlings were planted in Catchment No. 10. Spacing between the tree seedlings was approximately 2 meters along the planting lines. Measurements of survival and growth of the tree seedlings, made annually in an initial three-year evaluation period, form the basis for this paper.

The two tree species selected for this study commonly are found in arid environments in the world. Aleppo pine is a common tree species throughout southern Europe to Asia Minor. It occurs in the eastern Mediterranean region in mixed stands, with several species of oak; it also grows mixed with several broad-leaved shrubs to form the upper-story of these stands. Aleppo pine typically is found on shallow sedimentary soils. It is reported that the tree species is resistant to soil salinity, drought, and a limited amount of frost (Abido, 1986). Because of its ability to endure severe climatic and edaphic conditions, Aleppo pine has been utilized in reclaiming poor soils and for afforestation purposes in many Mediterranean countries. The tree species also has been introduced into many arid regions of the world.

Brutia pine, once recognized as a variety of Aleppo pine, currently is considered a separate tree species (Abido 1986). Unlike Aleppo pine, the natural range of Brutia pine is restricted to the eastern Mediterranean regions. It is found from Greece to Iraq, concentrated principally in Turkey and Cyprus. The tree species, typically a fast-grower in its early stages, is found on most soil types.

It has been reported by many investigators that Aleppo pine and Brutia pine are the most important tree species in afforestation, control of erosion, and sand dune fixation in the arid regions of the world (Abido, 1986). However, defining the minimal rainfall regimes required for initial survival is a frequent problem when attempting to introduce these two tree species.

Results and Discussion

Approximately six weeks after the planting, on September 8, 1984, the first measurement of tree seedling survival was made, the results of which are summarized below:

Catchment No. 8

Species	Total	Live	Dead	Percent Survival
Brutia pine	26	22	4	84.6
Aleppo pine	26	21	5	80.1
Total	52	43	9	82.7

Catchment No. 10

Species	Total	Live	Dead	Percent Survival
Brutia pine	26	17	9	65.4
Aleppo pine	25	14	11	56.0
Total	51	31	20	60.8

A second measurement of tree seedling survival was made on October 13, 1984, with the results presented below:

Catchment No. 8

Species	Total	Live	Dead	Percent Survival
Brutia pine	26	17	9	65.4
Aleppo pine	26	17	9	65.4
Total	52	34	18	65.4

Catchment No. 10

Species	Total	Live	Dead	Percent Survival
Brutia pine	26	13	13	50.0
Aleppo pine	25	9	16	36.0
Total	51	22	29	43.0

On October 13, 1984, a replacement planting of tree seedlings also was made. Brutia pine seedlings, the same age as those in the original planting, were planted for every dead tree seedling recorded on this date, regardless of the tree species originally planted.

Two years after the original planting, on July 26, 1986, a third measurement of tree seedling survival was made. The results of this survey are summarized below:

Catchment No. 8

Species	Total	Live	Dead	Percent Survival
Brutia pine	17	15	2	88.2
Aleppo pine	35	28	7	80.0
Total	52	43	9	82.7

Catchment 10

Species	Total	Live	Dead	Percent Survival
Brutia pine	13	7	6	53.8
Aleppo pine	38	21	17	55.3
Total	51	28	23	54.9

A fourth measurement of tree seedling survival was made on August 8, 1987, three years after the original planting. These measurements indicated the following:

Catchment No. 8

Species	Total	Live	Dead	Percent Survival
Brutia pine	17	15	2	88.2
Aleppo pine	35	27	8	77.1
Total	52	42	10	80.7

Catchment No. 10

Species	Total	Live	Dead	Percent Survival
Brutia pine	13	6	7	46.2
Aleppo pine	38	19	19	50.0
Total	51	25	26	49.0

Throughout the three-year evaluation period, survival within a catchment has been essentially the same for the two tree species. However, overall survival of the tree seedlings consistently has been higher in Catchment No. 8 than in Catchment No. 10 throughout the evaluation period. At the present time, the reason for this difference in survival rates is unknown.

Initial growth of the tree seedlings, regardless of the species, has been relatively slow. At the end of the three-year evaluation period, the average height of the surviving tree seedlings was 12.5 centimeters, ranging from less than 10 to over 16 centimeters. Diameter growth of the tree seedlings has been insignificant. Once established, it is presumed that the growth rate of the tree seedlings will increase.

Conclusions

Initial survival and growth of the tree seedlings, over a three-year evaluation period, suggest that Aleppo pine and Brutia pine can be planted with relative success in a water harvesting system, such as the one utilized in this study. Although growth has been relatively slow, survival after three years has ranged from nearly 50 to 80 percent. Long-term survival and growth of these tree seedlings will continue to be monitored, with the results utilized in determining the feasibility of planting Aleppo pine and Brutia pine in the arid environments of southeastern Arizona.

References Cited

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