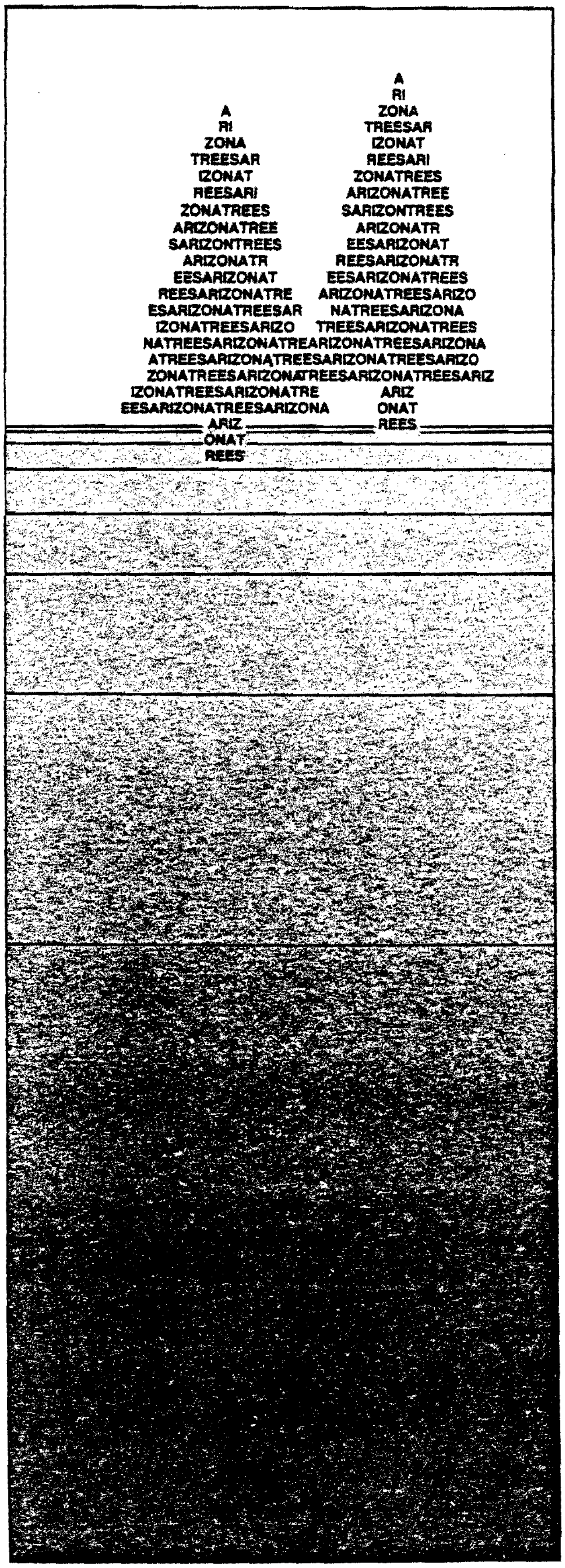

SOUTHWEST CHRISTMAS TREE INDUSTRY

Research Needs and Commercial Opportunities

Proceedings of the Conference
held May 11, 1984
Tucson, Arizona

University of Arizona,
College of Agriculture
and
Arizona Christmas Tree Growers' Association

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Proceedings of the Symposium Held May 11, 1984, Tucson, Arizona

compiled by

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Arizona Christmas Tree Growers' Association

and

University of Arizona
College of Agriculture
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FERTILIZER AND WATER REQUIREMENTS OF PINUS ELDARICA

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Abstract

Pinus eldarica Med. fertilization and irrigation studies were conducted in southern New Mexico over a 3-year period. Growth response to N fertilization was substantial in field and greenhouse studies. Plantation response to P and K fertilizers was generally insignificant. Municipal sewage sludge shows promise as a calcareous soil amendment. The effect of irrigation level on growth is discussed in addition to the consumptive irrigation requirement of a juvenile plantation. Research results and regional tree farming practices are reviewed in establishing concrete and provisional guidelines for production of Christmas trees and ornamentals.

Introduction

Pinus eldarica Med. was introduced to the United States in 1961 from Afghanistan (Fisher and Widmoyer, 1978). It occurs naturally in a semiarid region of southern Russia where it is confined to a single low mountain southeast of Tbilisi, Georgia, Transcaucasia. Considered an Oligocene relic, it grows along the eastern extremity of the Choban-Dagh Range, along the south side of the Iori River, and occupies only 550 hectares (1,400 acres). Guseinov and Guseinova (1976) reported extensive P. eldarica plantings in southern Russia, namely the Transcaucasia Republics and Central Asia where it grows rapidly and appears drought resistant. Major P. eldarica afforestation projects in Pakistan and Iran have been successful, as witnessed in 1976 by Fred B. Widmoyer, Department of Horticulture, New Mexico State University. Among the common names given P. eldarica are eldarica pine, eldar pine, Afghanistan pine and, in the nursery industry, Mondell pine and blue eldarica. We will refer to eldarica pine as this accords with the Russian scientists responsibie for documenting the location and ecology of the natural stands which indirectly gave rise to North American introductions.

In the United States, P. eldarica is rapidly gaining attention in the Southwest because it grows rapidly while maintaining attractive Christmas tree form and color. Some growers are producing Christmas trees in 2 to 3 years from planting, depending upon season of planting and crop management practices. However, growth rate and tree quality may vary widely within and among plantations. Lack of crop uniformity creates marketing difficulties and points to the need for closer supervision of fertilization and irrigation practices determining growth rate and tree form. The intent of this paper is to review the rather limited information on crop requirements available from research and farm operations observed in southern New Mexico.

Fertilizer Requirements

Plantation pine culture is in the developmental phase in the Southwest and few regional fertilization guidelines have been established. It follows that beginning tree farmers rely initially on fertilization practices common to the perennial crops of their area. As plantations are successively grown, rates and forms are revised to avoid tree mortality, poor growth or excessive internodes between branch whorls. Many problems can be averted by consulting experienced tree farmers and we often draw from them in establishing fertilization studies.

Most of the general principles governing plantation fertilization responses are not specific to a given region or pine species. Fertilization can markedly improve the survival, growth rate and quality of plantation-grown conifers (Fisher and Mexal, 1984). Excessive fertilization or incorrect selection of fertilizer form may cause adverse impacts including: 1) root burning; 2) the creation of nutrient imbalances; and 3) reduction in tree quality. Special attention should be given to the relationship between moisture availability and fertilizer effectiveness. Fertilization without vegetation control is counterproductive because weeds rob young trees of the water and growing space necessary for a favorable growth response. Lack of soil moisture also contributes indirectly to root burning caused by fertilizer salts. In this context, it is possible to reduce fertilizer hazard on sites with marginal moisture supply by applying the element in a form with a low salt index (Rader, 1943).

Compared to most pines, P. eldarica and its taxonomic affinities (e.g., Pinus halepensis and Pinus brutia) are unusual in being adapted to moderate soil alkalinity and drought. Eldarica pine appears able to maintain rapid growth when planted in soils having a pH within the 7.8 to 8.2 range. In addition, the carbonate content of many sites would disallow the survival of most pine species. Lime-induced chlorosis, a common malady of pines grown in alkaline soils, is symptomatic of a plant's inability to maintain the levels and proportions of essential elements required in photosynthesis. Under alkalinity stress, soil iron (Fe) becomes less available resulting in needle yellowing and slow growth of species adapted to acid soils. Chan et al (1982) determined, at 4-month intervals, leaf tissue nutrient concentrations of P. eldarica, P. brutia and P. halepensis included in an international provenance (geographic seed source) trial. Although these species are closely related, nutrient levels differed among juvenile trees in what proved to be a predictable manner. Eldarica pine was clearly superior in maintaining high levels of tissue N during the growing season. This may explain why eldarica pine grows much faster than P. brutia and P. halepensis in the Rio Grande Valley (Fisher et al, 1982).

Studies performed by Fisher et al (1980) demonstrated under controlled greenhouse conditions the influence of N availability on P. eldarica growth and form. Seedlings grown in perlite for an 8-month period received one of six levels of urea (50, 75, 124, and 250 ppm) in addition to a standard greenhouse nutrient solution (Hoagland's 1 X solution). Trees fertilized with 250 ppm urea were tallest, and possessed the greatest number of lateral branches and secondary needles. Urea at 50, 75, and 125 ppm produced trees of similar size but needle color improved with increasing levels. Similarly, Will (1976) observed a close ationship between Pinus radiata lateral branch development and N availability.

Field fertility trials were begun in the spring of 1981 to determine nitrogen (N), phosphorus (P) and potassium (K) requirements for optimum growth in the lower Rio Grande Valley. Within a 0.8 ha experimental plantation, trees spaced 2.4 m-by-2.4 m received factorial combinations of four levels of ammonium nitrate (35.5-0-0) equivalent to 0, 60, 120, and 180 kg N per ha, P (superphosphate, 0-20-0) at 0 and 75 kg, and potassium chloride (0-0-62) equivalent to 0 and 50 kg K per ha. Height and caliper growth measured 1 year following application was best at 120 kg N, followed by 60, 0, and 180 kg treatments. Figure 1 compares tree responses to control and 120 kg N treatments. Phosphorus at 75 kg was superior to none, but there was no apparent response to K. Soils of the Rio Grande Flood Plain generally contain relatively high K levels and this may explain the absence of a K response. Potassium fertilization may be essential on sandy sites commonly lacking levels adequate for pine growth. Potassium deficient plants are less able to control transpirational water loss and are more prone to suffer drought damage.

Southwestern soils are frequently low in organic matter and poor retention of water and nutrients present crop management problems. In addition, high carbonate levels often cause micronutrient deficiencies (e.g., Fe). Sewage effluents and sludges provide potential water and nutrient sources for intensive culture of tree crops (Urie, 1975). Sewage sludge is relatively low in nutritive value of N, P and K compared to inorganic fertilizers. However, it contains organic matter and micronutrients. Sewage sludge is also an excellent Zn, Fe and P fertilizer for calcareous soils of the Southwest (McCaslin and O'Connor, 1982). The high pH of desert soils greatly reduces availability to plants of many heavy metals commonly found in sludges.

In Las Cruces, research conducted in cooperation with Sandia National aboratories compared P. eldarica plantation response to several levels of amma-irradiated sludge and ammonium sulfate. Irradiation following anaerobic igestion disinfects the sludge without altering nutrient availability. Seedlings eceiving sludge at 66 and 100 ton/ha accumulated 30 percent more height rowth during their first year following planting than those found in plots ertilized with ammonium sulfate (84, 168 and 336 kg N/ha) or animal manure (66 on/ha). Sludge treatments also increased the number of lateral branches hereby improving compactness and nursery quality. Ranked on the basis of verall appearance and consumer appeal, plots receiving sludge at these rates roduced about 16 percent more trees of the highest nursery grade. This finding eserves special attention because nursery sales are largely determined by roduct quality.

Water Requirement

Demands on southwestern water resources are increasing due to urban velopment and prolonged drawdown to meet agricultural production. Facing a creasing supply of fresh water, agriculture must find means of maximizing nefits while minimizing waste. Judicious irrigation scheduling conserves water providing just enough water to satisfy crop demand. Because demand varies accordance with species, plant stage of development and cultural practices, e irrigation requirement of regional economic crops receives considerable earch attention.

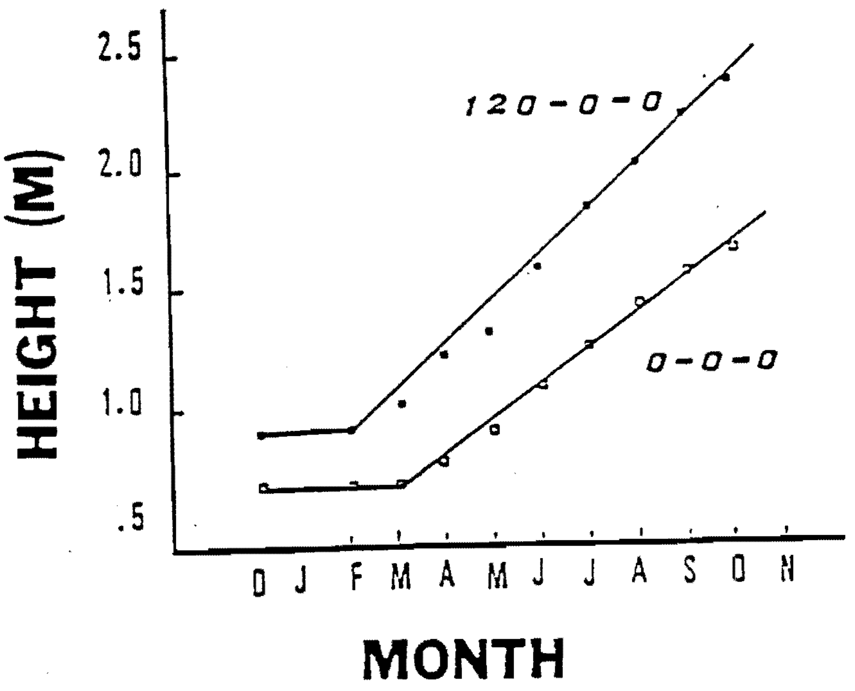


Figure 1. Eldarica pine response to no fertilizer and ammonium nitrate applied at 120 kg N/ha.

Crop water requirement is determined by the total amount of water necessary to replace the water lost to evapotranspiration (ET), representing the water lost to the Earth's atmosphere from soil and plant surfaces. It has been estimated that soil evaporation losses make up 25 to 50 percent of ET losses. Thus, crop transpirational losses generally exceed soil evaporative losses. The rate of ET is largely dependent upon climatic factors including intensity and duration of solar radiation, air temperature, wind speed and water vapor content of the atmosphere. Within environmentally determined limits, the plant can control transpiration through stomatal response to moisture availability and demand. Therefore ET is determined by biological as well as physical parameters particular to a given location.

Studies were begun in 1983 to determine eldarica pine's consumptive irrigation requirement (CIR) and response to several irrigation levels. The experimental approach was to determine plantation growth and ET under three irrigation levels. Spaced 2.4 m-by-2.4 m within and between rows, experimental trees were in their second growing season and occupied 0.8 ha. Irrigation was in addition to the 200 mm of annual rainfall (25.4 mm = 1.0 in). The water balance method, described by Federer (1970) was used to calculate consumptive use. Soil moisture depletion under the three treatments was determined at routine intervals with a soil neutron probe. A null balance porometer measured canopy transpiration. We are continuing to collect and process data and will therefore present a partial analysis here.

The consumptive water use of eldarica pine during the third year of growth varied with irrigation level. Experimental basins receiving 460, 360 and 270 mm, consumed 280, 330 and 210 mm, respectively. In the same order, height growth from May through September 1983 was about 3.0, 2.5 and 2.0 m. However, only the differences between the highest and lowest treatments were statistically significant.

It is not practical to measure CIR at all potential plantation sites and indirect methods requiring climatic data are routinely used to predict ET. The open-pan method, described in detail by Doorenbos and Pruit (1977), estimates potential ET (ETO) by measuring the depth of water that evaporates from an open pan. Potential ET is the maximum rate of crop evapotranspiration at a given location. The daily measure of pan water loss essentially integrates the climatic determinants of ET, including: day length, air temperature, humidity and wind speed. The mathematical expression of ETO is as follows:

$$ETO = KPAN \times EPAN \quad (1)$$

where: ETO = potential evaporation
KPAN = pan coefficient
EPAN = evaporation from the open water surface

Doorenbos and Pruit (1977) suggest that KPAN values from 0.60 to 0.65 are appropriate for arid climates characterized by high temperature and moderate to high wind loads. We applied a KPAN value of 0.6 in our calculations. The following equation estimates ETCROP, the maximum water consumed by a crop.

$$ETCROP = KCROP \times ETO \quad (2)$$

where KCROP = the crop coefficient

Following the determination of ETO and ETCROP, KCROP can be determined and used in combination with pan evaporation data to estimate water use at any geographic location having a suitable climatological record. Table 1 predicts crop water use at several sites where eldarica pine has been successfully introduced. Crop water demand is referenced against alfalfa, an irrigated crop common to all sites.

Table 1

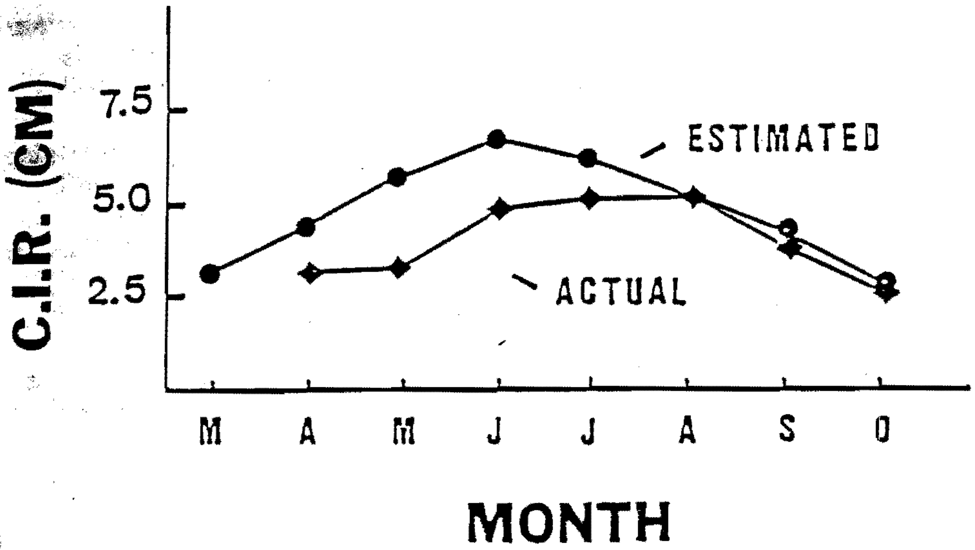
Eldarica Pine Evapotranspiration at Several Southwestern Sites as Referenced Against Alfalfa

	Evapotranspiration (cm)	
Location	Pasture Alfalfa	Eldarica Pine
Las Cruces	110	33
El Paso	145	44
Las Vegas	135	40
Phoenix	130	40
Pomona	105	32

Figure 2 compares ETCROP and empirically determined water consumption at monthly intervals for a plantation in its third growing season. Predicted and determined values were in close agreement during the final 3 months of the growing season. However, ETCROP overestimated water consumption during the first 5 months. Our first approximation of KCROP is 0.3 and this can be applied to juvenile eldarica pine plantations having similar above-ground biomass to land surface relationships. This figure may be revised slightly as we analyze 1984 data.

First growing season response to the frequency of irrigation was determined in a separate study. Plots received 50-mm irrigations at 1-, 2-, and 3-week intervals. The 2-week interval appears adequate in view of growth and survival. On the basis of our studies and observations we recommend that trees planted in moist soil be irrigated soon following planting and again within 1 week to 10 days. Post planting irrigation establishes root and soil contact. A 2- to 3-week interval should be sufficient after the first few irrigations. During the second year, monthly intervals should be adequate due to increased rooting depth. During the third and final growing season, 100-mm applications at 6- to 8-week intervals will meet the crop water requirement.

We have not addressed eldarica pine response to excessive irrigation. However, we have seen numerous examples of poor tree performance and mortality where inadequate drainage or flooding were obvious. In addition, porometry studies indicated that transpiration was reduced for a period of 2 weeks following an irrigation in the 460-mm treatment. Stomatal closure



re 2. Eldarica pine consumptive irrigation requirement (CIR) estimated by ETCROP Model and determined by soil moisture depletion measurements.

following irrigation suggests that P. eldarica is a flood-intolerant species (Kozlowski, 1982).

Conclusions

Rapid growth and the absence of lime-induced chlorosis indicate that eldarica pine is well adapted to the moderately alkaline soils of southern New Mexico. With proper irrigation, fertilization and weed control, trees can be harvested in 2 to 3 years. In the lower Rio Grande Valley, trees have responded to N at all stages of juvenile development. This supports the general view that species producing several whorls of growth over the growing season are highly responsive to nutrient amendments. Fertilization alters tree form, evidenced by increases in lateral branches in response to N fertilization.

Detectable responses to P and K were slight to nonexistent in the studies discussed but the demand for these and other elements will likely increase with repeated N fertilization. A favorable seedling response to sewage sludge demonstrates a feasible means for sustaining rapid growth rate while providing an environmentally safe waste disposal method.

Irrigation and water use experiments demonstrated the limitations of the ETCROP model. Further calibration is needed to widen the time period over which the model can be confidently used. Juvenile plantations can be grown successfully in the Las Cruces area with about 370 mm of irrigation water applied during the growing season. This is considerably less than the amounts being applied by many farmers.

Our efforts point to several research needs. Among them is the need for research on shearing, fertilization and irrigation interactions largely determining cut Christmas tree quality and flammability.

Acknowledgments

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