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The effect of forest shrub vegetation on soil moisture, temperature, evaporation potential, and the survival, growth and bud activity of five species of Pinus was studied on planting sites placed on opposite exposures on two locations in southwest Oregon and northeast Mexico. Treatments applied were: Manual slashing; Manual slashing plus Simazine; Dead shade provided by spraying the brush with herbicides and leaving it standing dead; and Control (no treatment).

The location factor provided differences in season of moisture availability and temperature extremes in which maximum growing-season water and heat stress were observed in Oregon. Clearing led to different shifts in competitor type, to herbs in Oregon and to resprouting shrubs in Mexico.

The differences among treatments showed a similarity in tendencies in both locations; aspect affected the degree of

differences.

Eliminating all or part of the competing vegetation conserved soil moisture effectively, increased the radiation load on the ground, reduced the transpirational loss of soil moisture and increased the evaporation demand of the air. The lack of treatment kept the radiation load to minimum, reducing the potential evaporation and temperature, but the live cover strongly reduced the soil moisture availability and reduced photosynthetically active light. Lethality was greatest where aspect and location effects also led to minimum soil moisture.

Clearing in general increased tree growth and increased growth most with further reductions in root competition. On south slopes, the treatments in the cleared area increased the likelihood of heat damage during the dry season for seedlings located on rocky spots.

Dead shade ameliorated the temperature-related stress, and competition reduction ameliorated the soil-water related stress.

Differences among species reflect differences in strategies adapted to native environments. Ecological and physiological parameters indicate that complete vegetation control in Oregon and complete woody plant control in Mexico are essential to successful introduction of pine species into brush-covered commercial forest land.

Early Survival and Growth Response of Five Species of *Pinus* to Plant Competition and Aspect in Southwest Oregon and Northeast Mexico

By

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I want to dedicate this Thesis to my family, Blanca, Zinnia and Yordi, because their support was essential for me during this period.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Early Survival and Growth Response of Five Species of *Pinus* to Plant Competition and Aspect in Southwest Oregon and Northeast Mexico

1.- INTRODUCTION

Thousands of hectares in Northeastern Mexico, once occupied by temperate forests, are covered now by varied dense shrub cover. This often remains as a disclimax community contributing to extremes in soil moisture and microclimate. The intense competition from such communities impedes the re-establishment of the original forest cover.

Contrasting with the diversity of ecological conditions, the reforestation practices are largely limited to one kind of planting stock and one planting method for the entire country. Information on autecology for most conifer species is lacking or scarce.

Reforestation problems are complicated by the great ecological diversity in all forested areas. This is reflected by the abundance of both conifer and shrub species native to each of the potentially productive areas. The ecological ranges of these species frequently overlap and it is common to find stands with four species of pine plus other conifers.

Enormous amounts of money and human labor have been invested in attempts to reforest degraded areas. Many of these efforts have failed, yet most of these adventures remain undocumented.

Direct evaluation of the specific field conditions that seedlings and young stands confront has not been reported.

If trends of deforestation and the consequent land quality degradation are to be reversed, major research efforts must be directed to determine the responses of conifers to a variety of ecological conditions, both natural and those created by silvicultural practices already in use.

Much of the experience gained by researchers in other areas can be applied in Northeastern Mexico, once a technical "bridge" has linked Mexico with centers of research effort. Methods already proven in areas with similar problems can be adapted for testing and thus shortcut the long path of research activities. Establishment between regions of a consistent pattern of competitive interactions is a critical step in broadening a mutually useful data base.

One of the general hypotheses testable for bridging experiments is that the intensity of interspecific competition experienced by a plant population is inversely related to its growth and survival.

Southwest Oregon is a region in which an intensive research program focusing on regeneration problems has been functioning during the past ten years. It is a unique example of effective research with immediate application to very concrete problems (Hobbs et al., 1983). A wide variety of site preparation techniques has been tested with several conifer species under many ecological conditions. Many of the experiments have been conducted in semiarid climates. As in Northeast Mexico, the Southwest Oregon area has a mixed-conifer forest. The *Pseudotsuga- Pinus - Abies* type is common, with an understory of *Quercus-Arctostaphy-*

los-Ceanothus and sometimes Arbutus, reflecting a history of fire.

Both regions also have low rainfall, between 20 to 30 inches (500 to 750 mm), as well as a long dry season.

The main differences are:

1.-The rainy season is winter in Oregon and summer in Mexico.

2.-Soils are granitic at the Oregon study site while calcareous in the east Sierra Madre region of Mexico.

One of the most important generalizations that can be drawn from the studies in Oregon and elsewhere in the U.S.A., is that competing vegetation plays a principal role in reducing seedling survival and growth (Cleary et al., 1978; Burns and Hebb, 1972; Wakeley, 1954). The effect of reducing competing vegetation has been associated with reforestation success in many different environmental conditions and with dozens of tree species, both conifers and hardwoods. Treatments which decrease competition without disturbing other favorable conditions increase the survival and growth rates of planted seedlings to a maximum degree in most ecological situations and for most species. In spite of the abundant studies concerning the effect of competing vegetation on seedling performance and regeneration success, few studies have addressed the specific environmental parameters attributed to the changes in presence and abundance of competing plants due to site preparation.

Understanding how seedlings of different species react generically to a range of competitive stress and how the most important environmental factors are correlated with their survival and growth, will help to determine at what stage and under what circumstances a tree can become dominant under a variety of conditions.

This study establishes a data link between Southwest Oregon and Mexico. The general objective is to determine the early response of seedlings of five species of Pinus to the environmental conditions created by four site preparation methods conducted in each of two aspects in Southwestern Oregon and Northeast Mexico.

The specific objectives are:

-To evaluate the relative losses of soil-water, absolute soil temperature and potential evaporation due to treatments across the four aspect-location combinations.

-To compare survival and growth for each species in response to the treatments.

-To describe the autecological characteristics of root-shoot ratio, root growth capacity, height and stem diameter for each species at the time of planting.

-To describe the differences in period of bud activity among species and among treatments and localities within species.

-To determine which factors are most important in explaining variation in relative growth and percent survival.

-To use all the above information to develop site preparation prescriptions adequate for each environment and species.

The hypothesis tested here is that the treatments will cause differences in soil moisture and soil temperature and that these differences will be correlated to survival and growth of the seedlings.

2.- LITERATURE REVIEW

2.1 The nature of competition.

The environment of a plant has been defined as the summation of all living (biotic) and non living (abiotic) factors that can affect the growth, development or distribution of that plant (Radosevich and Holt, 1984). This definition is broad enough to include historical and evolutionary factors as well as the so called operational environment proposed by Mason and Langenheim,(1957). Within the operational environment an ecological factor can be defined as any element of the environment capable of exerting a direct action on the organism during at least one phase of its life cycle (see also Dajoz, 1974 and Atzet,1981).

Cleary et al.(1978) recognize five "variables" that directly influence tree seedlings' survival and growth: moisture, temperature, light, chemical and physical influences; (animals are listed under physical influences). These authors propose that differences among sites should be evaluated in terms of differences in those five variables.

It is at the level of the above five variables that competition takes place: neighboring individual plants may tend to utilize " the same quantum of light, ion of mineral nutrient, molecule of water or volume of space" (Grime, 1979). Even when temperature is not a resource but a "condition", it is related to light and varies with it.

Lavender (1981) presented evidence suggesting that soil temperature plays an important role in triggering the initiation of shoot growth at spring time. Thermograph records collected by Williamsom and Minore (1978) indicated a substantial increase of freezing nights during the summer in clearcut openings. Compared to partially cut stands, the minimum temperature was 5^{o}C colder in the openings. This was correlated to a twelve to thirty percent increase in mortality of ponderosa pine. This suggests that the thermal role of plant cover may also be assesed by measuring its effects on soil temperature in addition to soil moisture. The drying power of the air around the seedling's crown is strongly influenced by shade, hence by site preparation method. Evaporation and transpiration are the integrated effects of air temperature, humidity and wind speed. (Muelder, Tappeiner and Hansen, 1963; Petersen, 1980). Thus, vegetation, attenuated by climatic and soil factors, is the principal conditioner of seedling environment.

Competition reduces the availability of resources, by directing them to other species. Thus, the ability of a plant to cope with its environment will be modified by competition-related stress (Spurr and Barnes,1973; Weaver and Clements,1944). The need to separate the effects of competition from other processes influencing vegetation composition and species distribution, survival and growth, has been pointed out by Grime,(1979). Conceptual problems faced by the ecologist attempting to do such a separation include:

1. The competitive ability of a species is a combination of morphological, phenological and physiological characteristics emerging from selective pressures exerted during the evolutionary history of the species.

2. The relationship between a plant and its environment is holistic, not unidirectional (Billings,1974). This means that the organism responds to all factors combined and interacting, not to each isolated environmental factor, and each must be evaluated as a partial contributor to the stresses in the tree.

3. The same plant characteristics may lead to failure or success depending on slight changes in environmental or competitive conditions (Spurr and Barnes,1973; Grime,1979; Grubb,1977).

4. The measurement of competition in field conditions is a technically difficult task in segregating the various influences of plants on one another. Frequently, a biomass-related parameter (e.g. cover or leaf area) is used as a measure of competition. Some differences have been proposed, however, between low and high cover as competitors. Newton (1981), listed several of those differences that have clear practical consequences. Howard and Newton (1984) reported that cover taller than Douglas-fir *Pseudotsuga mensiezii*(Mirb.) Franco had the most severe impact on long term growth in the moist Oregon Coast Range, but numerous workers <Newton (1964), White and Newton (in preparation), Preest (1973 and 1975)>, report strong competition from herbs in early years after planting. We will discuss later some of the specific differential effects of shrubs and grasses.

The future dominance of an individual plant depends not only on its inherited characteristics but also on its actual present relative position regarding its access to site resources with respect to other species. This relative position has been called dominance ratio (Newton, 1973).

The outcome of succession after disturbance in a forest appears to be decided in the very early stages of this process (Grubb, 1977), depending on the nature of the disturbance, the availability of propagules and the residual root systems of sprouting species. The species with high dominance potential will outgrow the other species if they arrived at the site at the same time and in similar numbers. Dominance potential is defined as the summation of all features (morphological and physiological) of a species related to its ability to assume dominance in a given time and place (Newton, 1973). Dominance potential is relative.

Foresters have applied this knowledge by silvicultural prescriptions aimed at placing the desired species in a developmental path of continuously high dominance ratio: site preparation and release are used to reduce the growth and vigor of competitors in the first years after planting, an approach that increases the dominance potential of the crop (Newton, 1981).

In harsh environments, the effects of competition will aggravate the scarcity of resources (Heidmann et al, 1982), and site preparation can enable a plant to establish itself. In some conditions, like on dry south slopes, where extreme heat can become the main limiting factor, the effect of competition may be partially masked. Regeneration may take place under the shade of an overstory that reduces temperature. In this example, the role of shade in reducing evaporative demand will facilitate tree establishment where litter and moisture stress are not lethal. But shading and moisture use by the same sheltering species often prove lethal or greatly slow growth because of competition (Means,1981; Zavitkovski and Woodard, 1970; Zavitkovski et al,1969).

2.2- Competition from shrubs and herbs

Several authors have been working on the differential effects of grass and shrub competition. I will review some of these works to clarify some basic differences between shrubs and grasses regarding water consumption, hence seedling survival and growth.

In the southwest, drought is blamed for most of ponderosa pine (Pinus ponderosa) natural regeneration failures. Even during the summer rainy season, dry periods of one to three weeks are common. Since ponderosa pine in this region germinates in midsummer, these dry spells are responsible for the loss of entire seedling crops. Surface soils dry quickly within the reach of germinating seedlings' roots (Larson and Schubert, 1969). Under the shade of brush, this drying process is not delayed but some seedlings survive due to a reduction in transpirational demand, only to die one or several years later or to remain dominated by the brush (Pearson,1934; Anonymous,1955; Meagher, 1943).

In other cases, the shade or cooling effect of shrubs can delay the growing activity of seedlings by several weeks, during which soil moisture is being exhausted. Shade also reduces photosynthate production, weakening the seedlings. Over-all competition reduces the length of the growing season by delaying bud break, accelerating budset or reducing the period when moisture is available during the growing season (Merryl and Kilby, 1952 Zahner and Whitmore, 1960; Flint, 1985). Additionally, a shrub cover will produce falling debris which may damage seedlings, hence reduce growth.

No part of the soil volume is free of root competition in a well-established undisturbed shrub stand. Planting seedlings in these conditions will place them in intense competition. (Gratkowski, 1967).

Experiments in mixed herb/shrub stands from which only herbaceous vegetation is eliminated show that water remains available in the upper zone of the soil until herbs develop or the new niche is occupied by shrubs or conifer seedlings.

Zavitkovski et al (1969) found a reduction of 50 percent in height growth in ponderosa pine seedlings planted under brushy conditions compared to plots from which snowbrush plants had been removed. By 1986, all conifers planted in brush three or more years old were dead (Newton, M., 1986. Oregon State University College of Forestry, Corvallis. Personal comunication.).

On one site in southcentral Oregon, Ross (1985), found that growth of ponderosa pine and lodgepole pine (<u>Pinus contorta</u> Dougl.) was inversely related to the amount of understory brush present within each of several site preparation treatments. At the two other sites, harsh environmental conditions (snow) or uncontrolled factors (cattle grazing), masked the influence of competing vegetation.

Tappeiner and Radosevich (1982), working in the Sierra Nevada in California, markedly improved survival and growth of planted ponderosa pine seedlings by controlling bearmat (*Chamaebetia fololiosa* Benth.).

Some beneficial effects of brush in conifer plantations are discussed by Gottfried (1980). His treatments for controlling new-Mexican locust (*Robinia neomexicana* A. Gray) did not increase ponderosa pine survival, because of drought and a dense herb cover that occupied the site immediately after treatment. In this report the herbage production was about 1,000 pounds per acre (1,120 kg per ha) independently of treatment, and dominance shifted from locust to herbs. Resulting ponderosa pine mortality remained at 81 percent on all vegetated ground. The best initial survival (39%) was produced by hand slashing that stimulated locust to sprout profusely. Gottfried reported that partial shade was the cause of this increase in survival the first year, but that shrubs must be eliminated by the second year.

Gottfried (1980) also studied the depletion of moisture from three plots in New Mexico: one covered by grass and two others covered by five- and twenty- year-old stands of locust. In the top 60 cms (24 inches) of the soil, moisture was greatest in the five year old stand, intermediate in the grass and lowest in the 20 year -old stand. The pattern of depletion was similar for all three vegetation types: the 0-15 cm depth had the least soil moisture, the 15-30 cm depth more than the surface soil, and the 30-60 cm depth more than the two upper zones. The changes in soil moisture during the June- October season showed that the grass plots kept the soil dryer than the other two vegetation types during July, at the end of the critical spring drought in New Mexico.

In a study in northern California, Oliver, 1984, concluded that any amount of brush cover will restrict diameter growth of ponderosa pine saplings; brush crown cover (Arctostaphyllos sp.) was significantly and inversely related to periodic annual increment in diameter, height and volume.

The effect of mixed young whiteleaf manzanita (Arctostaphyllos viscida) and herbs (grasses and forbs) on soil moisture was found to deplete soil moisture more rapidly than manzanita alone in a study by White (unpublished data, 1984. Oregon State University, Department of Forest Science). She created a series of density levels of herb-free manzanita and in some plots herbs were permitted to grow. At the 30 cm. soil depth zone, there was a significant difference in moisture content during July and August caused by the presence of herbs. The differences were less marked at the 60 cm depth but were still significant. Those plots without vegetation and those with only conifer seedlings lost moisture more slowly, leading to a longer effective growing season and greater growth for the conifers.

White also measured the plant moisture stress (PMS) of the seedlings (Douglas-fir and ponderosa pine); PMS at midday was highest in the manzanita-plus-herbs treatment and lowest in the no-vegetation treatment. She also found that shrub densities of 20 percent canopy cover or more caused a quantitative decrease in height and diameter growth. Ponderosa pine stem diameter was twice as great with no competition as with the highest level of plant cover; fourth-year height was 113 cm in the ultra-dense manzanita plots and 181 cm with less than 20 percent cover. Douglas fir showed similar trends. All plots had received herbaceous weed control in their first year to assure survival.

The general pattern appears to be that soil moisture depletion and plant moisture stress increase as the amount of vegetation cover increases.

Petersen (1980) demonstrated that, for the 0-40 cm depth, the difference in soil water potential caused by herbs is significant during late July and August in a zone of the western Cascades of Oregon receiving 2,000 mm or more precipitation. Freedom from shrubs or mixed shrubs and herbs produced growth differences that have increased through the seventh year after release. (Newton, M. unpublished data. 1986. Oregon State University Dept. of Forest Science, Corvallis).

Similar results are reported by Newton and Preest (unpublished manuscript. O.S.U. Dept. of Forest Science, 1986); they separated the effects of grasses and forbs, finding that bentgrass (<u>Agrostis</u> <u>tenuis</u> Sibth.) causes a rapid elevation of moisture stress early in the season, while forbs show a slower depletion rate but greater total withdrawal, leading to maximum soil water stress during the critical midsummer period (July 14-

August 18). They explain that bentgrass aestivates toward midsummer, while forbs transpire for longer and have deeper roots.

Barrett and Youngberg, (1965), found that understory shrubs increased water consumption by 45 % in a ponderosa pine stand. Barrett (1983) reported that the same stands displayed a strong positive response to elimination of brush in all stands open enough to support an understory.

Flint, (1985), studied the water availability and temperature under under several microenvironments created by shading and mulching. She found that competing vegetation (shrubs), on a leaf area basis, transpires far more water than conifer seedlings regardless of treatment, and that the degree of control of vegetation was highly correlated with seedling growth, seasonal water loss and water use efficiency. The seasonal growth of the seedlings was modified by the treatments: the differences were attributable to interactive effects of temperature, availability of water and the timing of budburst-budset.

Heidmann,(1968 and 1969), working in northern Arizona found that the top 50 cm of soil remained significantly more moist under dead grass (killed with herbicides) than on scalped or untreated plots. Scalping was not different from the check plots for the soil moisture contained in the 0-20 cm layer. Moisture in the upper few tens of centimeters of soil is the most important factor in initial survival of ponderosa pine seedlings. Heidmann indicates that the mat of dead grass reduced evaporation and runoff, while temperature, radiant energy, wind movement and infiltration rates were favorably altered. An additional advantage of herbicide was that the herbicide treatment prevented the reinvasion of grasses but scalping did not.

Arizona fescue (Festuca arizonica Vasey) was found to cause an important reduction in soil moisture content in an experiment near Flagstaff, Arizona. Twice during the year, (July and October, bracketing the rainy season) the soil moisture tension went down below -1.5 Mpa. while in denuded plots it remained well above that level (Larson and Schubert, 1969). This study demonstrated that grass species with different growing seasons have different effects on ponderosa pine seedlings when growing together.

Pearson (1942) reported results from experiments in which grasses were controlled in different degrees: survival and growth for ponderosa pine sown under the conditions created by diffe- rent degrees of control of competing vegetation were greater where grass and all other competing vegetation were completely removed and kept out by hand weeding. The soils under this treat- ment showed higher moisture content than vegetated soils during the dry period of late June and early July. Clipping grass as short as 5 cm (2 inches) twice annually did not have an effect on moisture use by vegetation, suggesting that grass is an effective transpirator. In one experiment, however, summer mortality was not decreased on completely devegetated plots during an extremely dry season. This suggests that in extreme drought, elimination of all competing vegetation is not always an adequate safeguard unless surface evaporation is reduced in some way.

Pearson also studied the water loss from soils in cans with different levels of plant cover and some with bare soil: He found that loss from bare soils was less than from cans with grass or weeds, concluding that soil loses more water to transpiration than to evaporation.

Newton (1964) observed that more than four-fifths of all loss of summer-stored soil moisture was attributable to transpiration by herbs in clay soils of western Oregon meadows.

Stein (1955), analyzing the problem of competition from sedges and its effect on ponderosa pine on pumice soil reported that the sedge has depleted soil moisture to depth of 48 inches by midsummer so that all seedlings died; on scalped plots within the sedge cover, excellent moisture was found just below the surface and seedling survival was acceptable.

In shallow soils in southwestern Oregon, grasses and other low-cover species quickly consume soil moisture and complete their annual growth cycle early in the season, before total exhaustion of soil moisture(Newton,1982; White and Newton,1983). Grasses are lethal competitors during the critical first and second seasons after planting. In addition, dead grasses increase the reflected energy incident on the seedlings, which in time increases air temperature around the seedlings' crowns. It seems, then, that the moisture regime of planted seedlings in an established shrub field or shrub-herb community is similar to that of a grassfield. On balance, the potential benefits from living shrubs that partially offset competitive effect on seedlings are a reduction in transpiration, and some protection against freezing. Both could be provided artificially or by dead vegetation.

(Helgerson and Bunker,1985; Newton,1981; Minore, 1969; Meagher,1943).

Some long term beneficial roles of vegetation cover are: protection against soil erosion; maintenance of organic matter and soil microflora; retention of nutrients within the ecosystem; nitrogen fixation by some species on nitrogen-deficient sites, and animal habitat (Newton, 1981; Conard et al,1985). This last one could be considered negative in most circumstances regarding silvicultural objectives.

The advent of herbicides has made possible the preservation of most of the positive effects of brush while eliminating many of its undesired properties in a conifer plantation. Removing vegetation can have several environmental effects important in reforestation:

-Increase in soil and air temperature

-Increase in soil moisture availability

-Increase in air movement

-Increase in the rate of litter decomposition and

-Decrease in activity of rodents.

In any conditions of high radiation, low relative humidity and deficient soil moisture, extreme plant moisture stress will occur (Newton, 1973). Depending on land management objectives and the nature of the vegetation and animal problems faced, a wide array of management approaches are available. But there seems to be no exception to the rule that weed control is increasingly necessary with increasing climatic moisture deficit (Newton,1973).

2.3-Benefits of control of competition in pines

Evidence that controlling competition benefits tree seedlings is abundant. In recent reviews, Stewart (1984) and Ross and Walstad (1986), summarize numerous reports on this topic, clearly establishing that tree seedlings respond positively to vegetation-control treatments. In this part the focus will be mainly on pine seedlings.

Schubert et al(1970) and Schubert(1974) (summarizing their experience with artificial reforestation in the Southwest) generalize that a dense vegetative cover depletes soil moisture, intercepts light and precipitation, and provides favorable habitats for insects and animals that feed on conifer seeds and seedlings in southwest U.S.A. The most important reasons for site preparation are to provide light and conserve soil moisture for establishment and early rapid growth of conifer seedlings. Complete neutralization of all competing vegetation is preferred to clearing of small, individual spots.

Working in central Oregon, Hermann(1968) studied the germination and first year survival of ponderosa pine under different conditions of watering and shading. In two sites water was identified as the major aid for first year survival, but in two other sites shade showed to be the most important factor.

Stein (1957) studied germination and survival of sugar pine (<u>Pinus lambertiana</u> Dougl) in southwestern Oregon. He concluded that the best results were obtained where debris and vegetation had been eliminated, because this treatment accomplished two main objectives of site preparation: a more suitable physical environment for the seedlings and a more unsuitable environment for rodents.

There is general agreement among researchers in the southern U.S. that controlling competing vegetation increases survival and growth. In monographs on problems related to planting Southern pines, Wakeley (1954) and later Burns and Hebb (1972) conclude that the intensity of site preparation is directly related to pine survival: competition from existing vegetation must be reduced to the point where planted or seeded pines can become dominant over recovering woody species. Table 2.1 summarizes some selected references about pine response to vegetation control.

2.4-Reforestation problems in Mexico

Mexican pine forests have been regarded as important not only from the economic perspective (more than 80 percent of timber production is pine) but also because of the richness in pine species. Forty percent of the world's pine species are found in Mexico (Eguiluz,1978), reflecting the diversity of ecological conditions existing in the region (Mirov,1954 and 1967; Zobel,1961; Rzedowski, 1978).

Numerous investigators have emphasized the importance of Mexican pines as a gene pool (Zobel,1961; Eguiluz,1978). Taxonomists (Little,1961; Debazac,1964), as well as silviculturists (Durland,1931; Montenegro, 1957; Ganguli,1967; Marx,1975) are also interested in Mexican pines.

In the forested regions, most of the silvicultural practices seek to obtain natural rather than artificial regeneration and most of the artificial reforestation practices are to recover areas lost long ago to fire, agriculture or overgrazing (Ganguli,1967). Reforestation campaigns are designated to recover marginal areas; they have social and political, as well as silvicultural and soil conservation objectives. Hence, maximum economic gain is not always the main objective.

Whether planting is conducted in the subtropical mountains of southern Mexico, in the vicinity of the timberline at 2700 m (9000 ft), or in the semiarid pinyon pine areas, the stock used and the plantation method is the same. One or two-year-old containerized seedlings with a ball of earth attached ("cepellon") are planted in holes, normally of 30x30x30 cm (Gaugli,1967 Mathus,1978). Elaborate site preparation is done in small areas and for soil conservation purposes. Heavy machinery and intensive site preparation are used only in the sites most difficult to plant (intensely eroded soils). Seedlings planted in or close to the best forest sites are left to themselves once planted (Pimentel,1978; Zerecero,1978; Ganguli,1967).

Reports on experiments with site preparation techniques include few recent papers <De Hoogh and Cavazos (unpublished, Fac.de Silvicultura y Rec. Renov. U.A.N.L., Linares, N.L., Mexico), Ramirez M. and Torres Rojo,1983>.

Experimental plantations are not abundant and most of the reports about them do not mention site preparation or weeding practices; notable exceptions to this are : Hernandez (1974), Mathus (1978), Verduzco (1962), Griffith and Dyson (1962) and Gonzalez (1978).

Verduzco (1962) writes:

> "...In the case of conifers, we have had no experience on this kind of cultivation (weeding). On the other hand, in view of the hardiness of the species of the genus Pinus in tolerating both natural competition on the growing site and destructive biotic agents it is felt that in Mexico, especially with conifer species it is not very important to free the seedlings of herbaceous and shrub species that compete with them."

Coming from one of the most influential foresters in Mexico, these sentiments have become the basis for Mexican forestry practices.

The existence of a "grass-stage" in several of the main species (including P.montezumae Lamb. and P.hartwegii Lind.) complicates artificial regeneration because special nursery proceedures and site preparation needs must be determined.

In the face of poorly funded research-supported reforestation activities, deforestation is advancing very rapidly. At the end of 1965, the total planted area in Mexico was 50,000 ha (FAO,1971); in 1980, 19,000 ha were planted while one government agency alone was responsible for the deforestation of 400,000 ha for agriculture. It has been estimated that the country has lost between 20 and 100 million ha of forested land since the arrival of the conquerors. Figures vary according to the criteria applied, but even the most conservative ones indicate very large areas of deforestation (Bonilla and Avila,1980). Today, millions of hectares are covered by a dense shrub community that remains as a disclimax due to fire, erosion, grazing, absence of seed source and competition (Patino and Vela, 1980).

Table 2.1. Summary of Past Results from Selected Studies on Response of Pines to Site Preparation and Release.

Species	Cover	Years	Method used	Response ( ) = control	Source
P. clausa Chapm.	Scrub hardwood	10	Double chopping	Surv = 87.5 (73.5) Vol = 710 ft^3/ac (165)	Outcalt and Brendemuehl, 1984
P. echinata Mill.	Hardwood	8	Clearcut plus release by ax cutting	Surv = 42 to 75% (48) Ht = 342 cm (204)	Minckler and Ryker, 1959
P. elliottii Engelm.	Understory shrub	4	Release by herbicide	15% increase in volume	Pienaar et al., 1983
P. lambertiana	Brush	3	2-4, D and 2-4-5, T sprays	Ht = 143% (100)	Baron et al., 1964
P. palustris Mill.	Shrub	20	Aerial spray 2-4-5, T	Ht = 978 cm (833)	Michael, 1980
P. taeda L.	Herbaceous weeds	3	Shearing/hoeing plus Hexazinone	Ht = 267 (186) Ht = 174 (114)	Nelson et al., 1981
P. taeda L.	Shrub	5	Total brush cutting Partial brush cutting plus burning	Surv = 62% Surv = 73%	Breuder and Nelson, 1952
P. taeda L.	Shrub	6	Handcut Handcut plus 2-4, D	10.7 ft taller than check	Cain and Mann, 1980

Table 2.1 continued

Species	Cover	Years	Method used	Response ( ) = control	Source
P. taeda L.	Herbaceous weeds	4	Various herbicides	Ht = 351 cm (180)	Knowe et al., 1985
P. ponderosa Dougl. ex Laws	Sagebrush	7	Hand clearing	Surv = 39% (19%) Ht = 25.5 cm (5.5)	Baker and Korstian, 1931
P. ponderosa	Grass and Forbs	10	Atrazine	Surv = 55% (25) Ht = 222 cm (150)	Crouch, 1979
P. ponderosa	Brush	7	Bulldozing plus 2-4-5, T	Ht = 87.5 cm (50)	Bentley et al., 1971
P. ponderosa	Grass	2	Dalapon Atrazine	Surv = 58 (39) Surv = 62 (39)	Stewart and Beebe, 1974
P. ponderosa	Grass	2	No grass	Surv = 52% (17) Wt = 6.76 gr (.24)	Larson and Schubert, 1969

3.- M E T H O D S

3.1 Locations

The experimental core of this study consisted of plantations under four site preparation methods conducted on two exposures on two sites. One site is near Sykes Creek, five miles north of Wimer, Jackson Co.,Oregon (Latitude 42° 33' N, Longitude 123° 07' 30'' W, 380 m <1252 ft. > elevation). The other site is located at Canon de la Carbonera, Arteaga, Coahuila, Mexico (Latitude 25° 27' N, Longitude 100° 35'W, 2700 m <9000 ft.> elevation).

A description of the two locations follows.

The Sykes Creek site is in the general area known as The Rogue River Valley. Annual precipitation is estimated to be about 600 mm. (24 in.) of which more than 80 percent falls during the winter, from October to May, and mean annual temperature is 12.2° C. The mean for January is 2.8° C and the mean for August 22.4° C. The Soil is coarse sandy-loam derived from both metamorphic and unaltered granitic rocks. It belongs to the series Siskiyou (Dystric Xerochrepts). The depth of this soil goes from 50 to 100 cm (20 to 40 inches). See table A-2 for detailed information about soils. A communnity of *Arctostaphylos viscida*, *Ceanothus cunneatus*, *Arbutus menziesii* and *Quercus kellogii* occupies the place as a result of fire 30 years ago. Evidenced by charred stumps and mature sprout clumps, a scattered stand of Douglas-fir and ponderosa pine with associated oak, manzanita and *Ceanothus* species had occupied the site before burning.

The canyon in Arteaga is in the higher elevations of the general area known as Sierra Madre Oriental, northern part. Annual precipitation is about 600 mm (24 in.) of which 80 percent falls as rain during the summer, from May to September and mean annual temperature is about 12 ^{o}C. Mean temperature for January is 6 ^{o}C, and the mean for August 22 ^{o}C. Maximum extremes are 39 ^{o}C and minimum extremes are -8 ^{o}C ; maximum evaporation is registered during April- July. The hottest month is July and the maximum precipitation is registered in September. Using data from twelve stations in the area, Valdes (1981) estimates that the temperature decreases 0.52 degrees centigrades for each 100 m of elevation, corresponding to 10 degrees for 2500 m. Table A-1 contains information on climatic data from some stations near the planting site. Figures 3.1 (a-d) contain climograms of some nearby stations. Soil is originated from calcareous rocks (calcites and lutites), medium -textured with numerous cobbles and the average depth is 42 cm. The climax forest in this site is a mixed forest of <u>Pseudotsuga menziesii var. glauca</u>, <u>Abies vejarii</u> Mtz., and several species of pines, mainly <u>P. montezumae</u>, <u>P. hartwegii</u>. Engelm., and <u>P. ayacahuite</u> var. <u>brachyptera</u> Shaw. South-facing slopes have an important amount of <u>P. cembroides</u> Zucc. and negligible amounts of the other conifers. Most of the land is covered with a secondary vegetation consisting of several species of <u>Quercus</u>, <u>Arbutus</u>, <u>Arctostaphyllos</u>, <u>Ceanothus</u>, <u>Rhus</u>, <u>Yucca</u> and <u>Garrya</u>. Table A-3

LEGEND

1 Maximum extreme annual temperature
2 Annual oscillation of temperature
3 Annual mean temperature
4 Annual maximum extreme temperature
5 Altitude (meters)
6 Period of records
7 Station name and state
8 Longitude (W)
9 Latitude (N)
10 Total precipitation (cm)
11 Days with rain
12 Sunny days
13 Cloudy days
14 Days with hail
15 Days with frost
16 Days with snow
17 Climate type

——— Maximum precipitation
— — — Minimum precipitation
——— Maximum average temperature
— — — Minimum average temperature

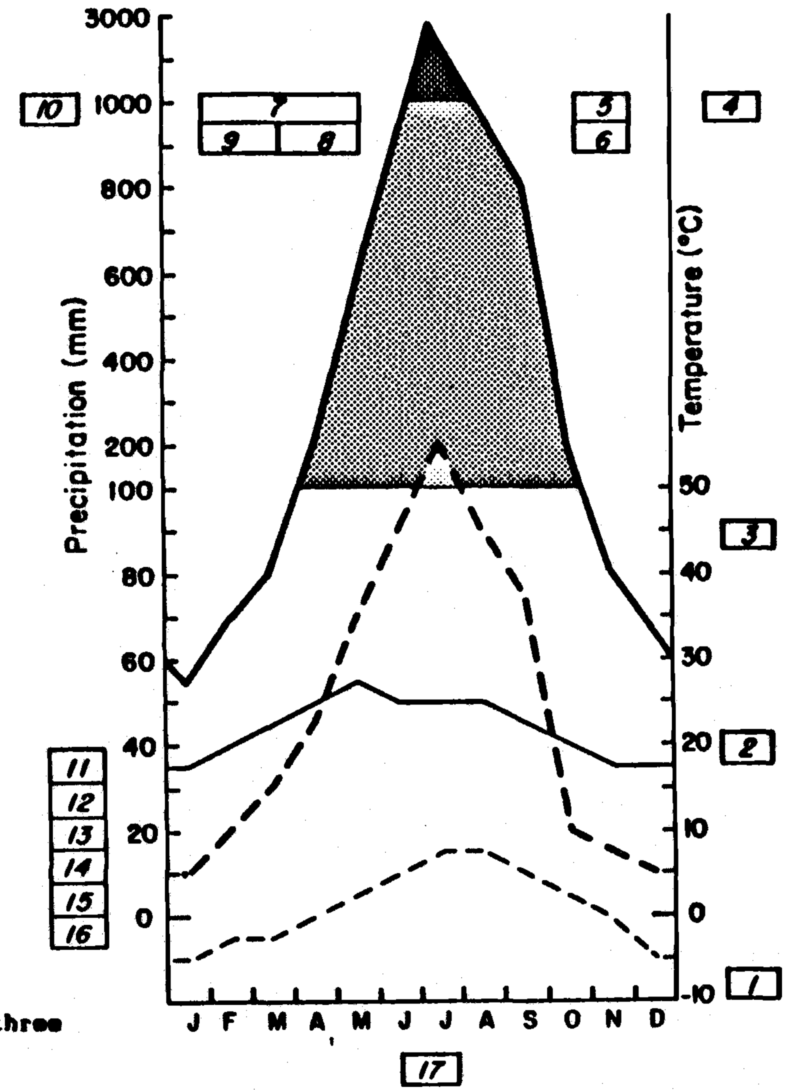
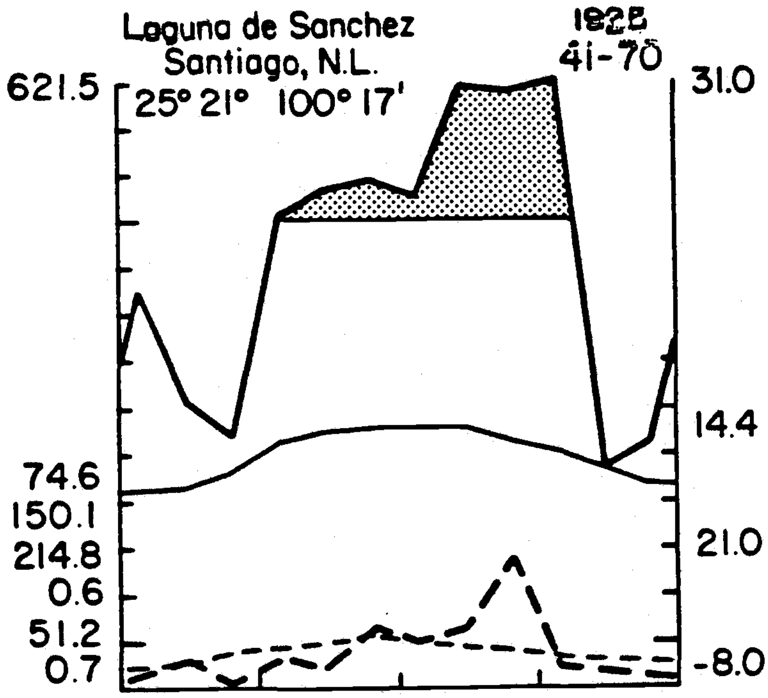


Figure 3.1 (a)

Key to the climatic diagrams (next three pages). From Eguiluz, 1978.



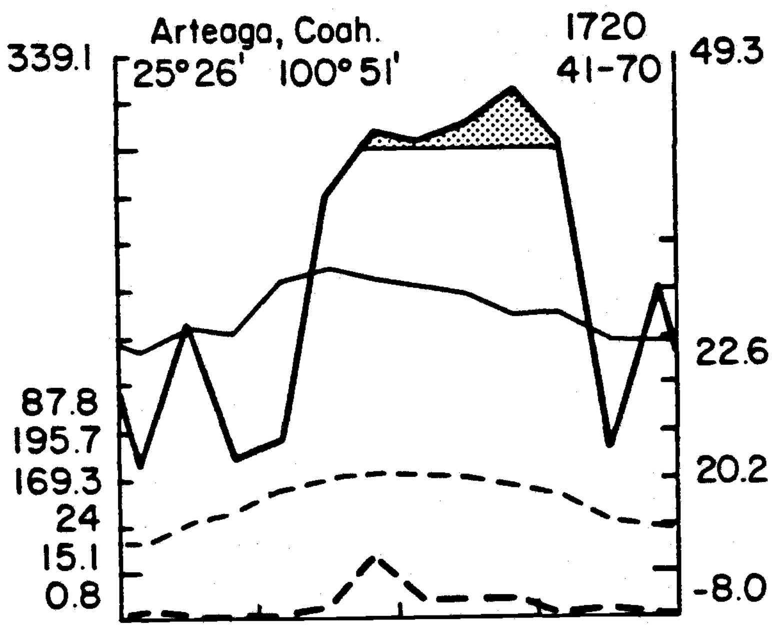


Figure 3.1

(b). Typical Climatic Diagrams of stations near the planting site in Mexico. From Eguiluz, 1978.

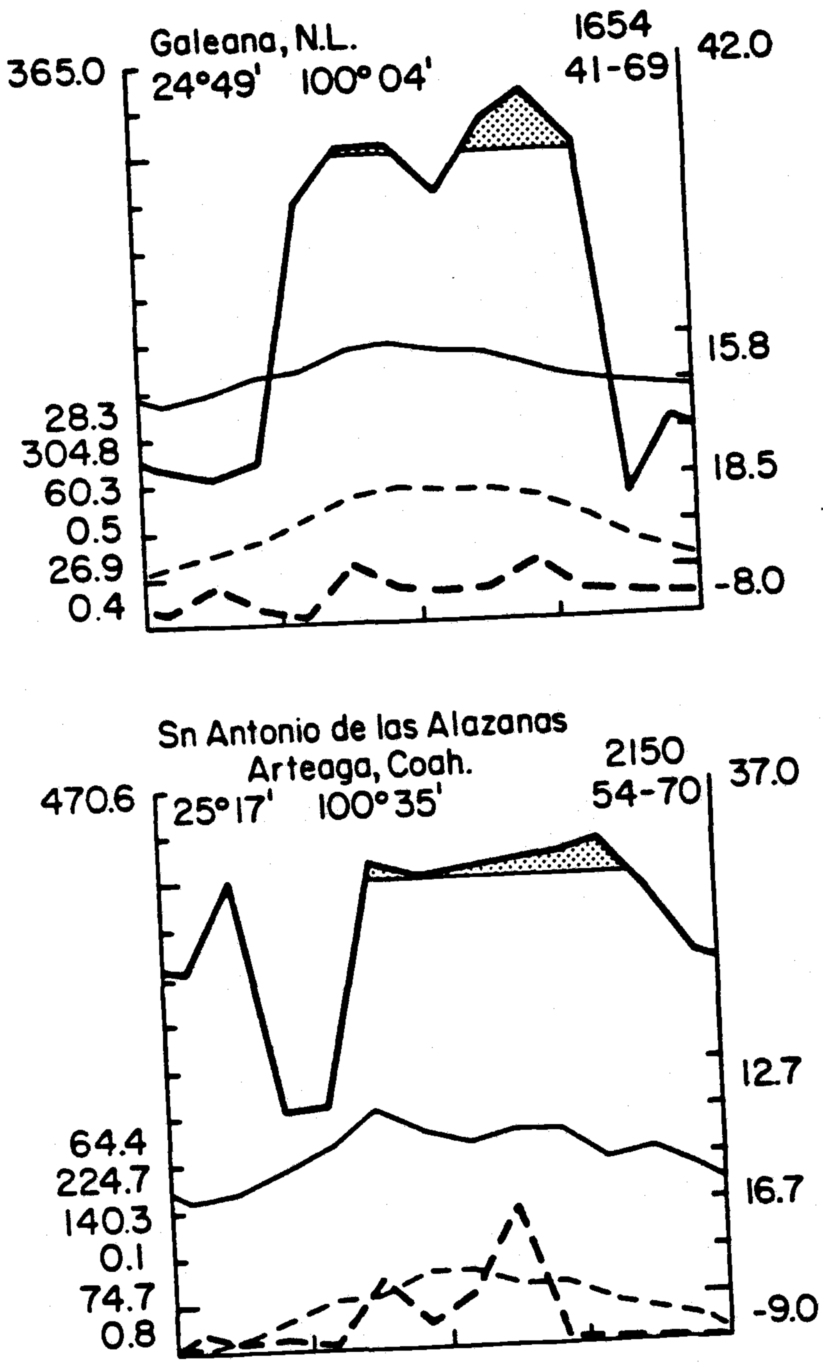


Figure 3.1

(c). Typical Climatic Diagrams of stations near the planting site in Mexico. From Eguiluz, 1978.

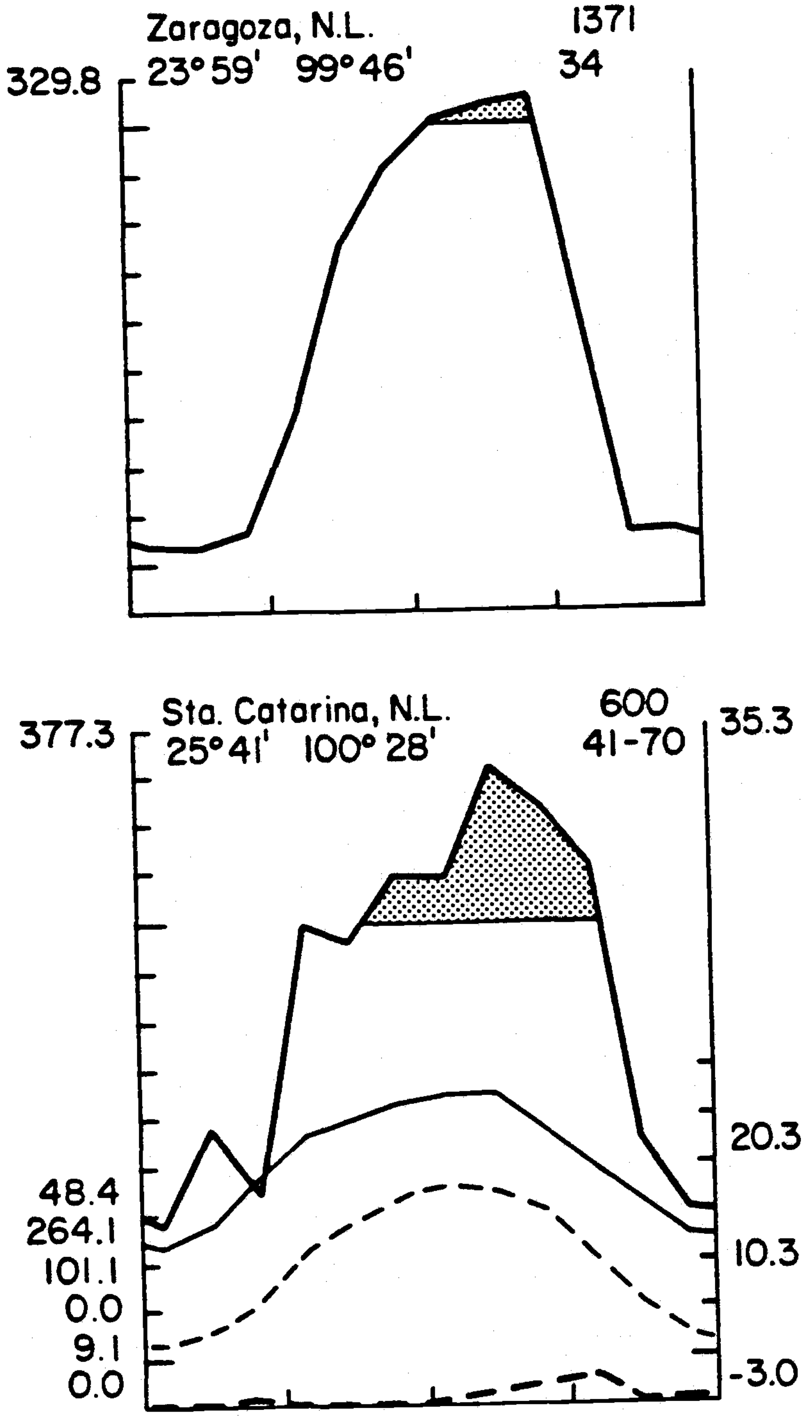


Figure 3.1

(d). Typical Climatic Diagrams of stations near the planting site in Mexico. From Eguiluz, 1978.

lists species found at the planting site. This community, dominated by oaks, forms a shrub cover of 5-6 m in height that is dense enough to be hard to walk through (Valdez, 1981).

Sites in each location were chosen so that north and south facing slopes were available at the same elevation and gradient, and being no more than 300 m apart.

3.2 Species

Seeds for this experiment were collected in the following locations :

-P.ponderosa in Seed Zone 511, elevation 330 m (1000 ft.), Oregon.

-P.lambertiana in Seed Zone 502, elev. 180 m (600 ft.) in southwest Oregon.

-P.ayacahuite var. brachyptera and P. montezumae in Ejido La Encantada, Zaragoza, N.L., Mex., at 2500 m., in September, 1981.

- P. hartwegii in Cerro Jocotitlan, Mexico, at 3700 m., in October, 1979.

A description of these species is given in the Appendix C. Seedlings of all species except sugar pine were nursery grown in "Styro-4'' containers from March to December, 1984, then lifted and stored at 0-1 ^{o}C. until planting date. Champion International Nursery at Lebanon, Oregon, provided all except sugar pine seedling production and provided storage for all seedlings according to their standards and procedures for Oregon pines. The U.S. Department of Interior Bureau of Land Management Nursery at Merlin, Oregon, produced and stored the sugar pine seedlings during this period of the experiment. These were also container-grown, but were in 10 cubic inches containers.

3.3- Treatments

Site preparation was accomplished between June and August, 1984 and consisted of the following treatments:

Manual (M).-All vegetation was manually cut, and the debris removed, with no further treatment. The objective of this treatment was to provide freedom from brush competition for at least the first year after planting.

Simazine (S).-In addition to manual removal of all competing vegetation, an application of Simazine (4 kg. per ha.) was provided three months before planting. After planting, chemicals were used to keep brush from sprouting or forbs from outgrowing the seedlings on the Oregon site. There were no subsequent treatments on the Mexican site. The objective of this treatment was the maximum freedom from competition with the maximum of solar radiation, at least during the first year after planting.

Herbicide (H).- The soil was sprayed with Simazine and the brush was sprayed with 2,4,D (7.7 kg /ha) in Oregon and with a mixture of 2,4,5-T (4.4 kg./ha.) and triclopyr(2.2 kg./ha.) in Mexico during August of 1984. The objective of this treatment was to provide complete freedom from competition with maximum dead shade and freedom from physical disturbance.

Control (C).- No treatment; the objective was to provide conditions that germinants from natural regeneration and many planted seedlings face in Mexico: Maximum competition and living shade.

3.4- Experimental Design

The basic design for this experiment was a randomized block split-split-split plot with four replications. In the split-split-split plot design, locations were split on aspects; aspects were split on cleared vs not cleared. In each site, a rectangular area of 30 x 35 m. was hand slashed using chain-saws. Inside this area treatments M and S were randomly asigned to each of four quadrants (replications). Treatments C and H were placed in the area adjacent to the cleared area so that one of each was external to the analogous M and S inside the clearing (Figure # 3.2 illustrates the layout of the experiment). In each replication, an area of 10 x 15 m. was treated, but the plantation was restricted to an inner 4 x 13 m. rectangle, to provide a buffer zone. Seedlings were planted in five rows of 14 individuals each, one meter apart. Species were randomized among rows.

Plantation dates were: Mexico, December 18- 28, 1984; Oregon, January 18- February 10, 1985.

The number of seedlings of *P. montezumae* was adequate for only three Oregon replications. The following plots in Oregon were omited: south aspect, rep. # 1, all treatments; North aspect, rep. # 4, all treatments and replications numbers 2 and 3 of treatment Control.

To insure initial establishment, each of the seedlings in Mexico received 10 liters of water within twenty-four hours after

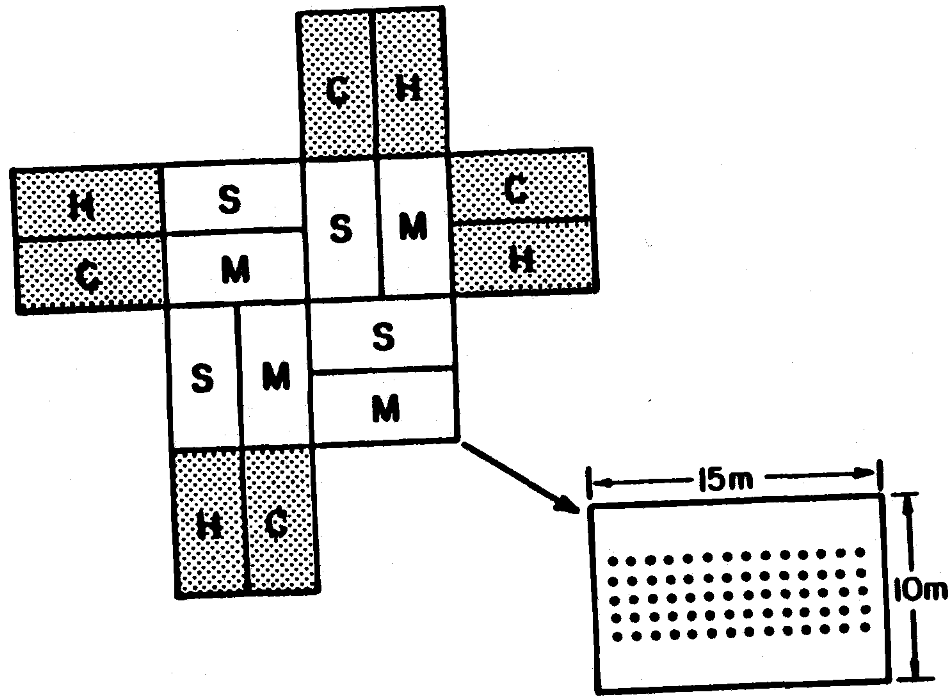


Figure 3.2 Diagramatic representation of the experimental layout in one of the slopes. The shape and size of a plot unit, with the planting pattern, is also shown.

planting.

3.5 Measurements and Data Handling

Bud activity.- In Oregon, every seedling was inspected each month during the growing season and the activity of the apical bud registered as active or not. In Mexico, the seedlings were inspected in February, August, and December,1985, and June and August, 1986. Later, the percent of bud activity was calculated as:

(No. of "active plants")x 100/No. of live plants.

The number of days that the bud remained open in the Oregon plots was estimated by observation of each seedling at approximately monthly intervals for evidence of active bud development. The observation is simply the number of days between the date of first activity and the last date on which activity was observed. Twelve days was arbitrarly added to the observed interval to allow for activity before the first and after the last dates when seedlings were active.

The sum of days that the average seedling remained open during each year was called "BUDAYS".

For the 1986 Mexican data it was not possible to compute this value due to the discontinuity of observations.

Mortality was registered each time while observing for bud activity. Percent of survival was calculated as:

(No. of live plants) x 100/Inital number.

Before planting, a random sample of 15 seedlings from each species was used to obtain a sample of length of shoot, stem diameter, and dry weight of shoot and root. The average of shoot length and diameter for each species were considered initial parameters. Stem diameter of every live planted seedling was measured in December, 1985 and August, 1986.

Relative diameter increment was calculated as:

(diameter at that date - initial diameter)/ initial diameter.

The row mean of each replication, was then used as the observation for analysis of variance (ANOVA).

Seedling height was measured in August,1985 and 1986. Relative growth was calculated as:

<(Height at date) - (initial height)>/Initial height.

An ANOVA used the row means as observations.

Two error terms were utilized: one for the location- aspect-treatment factors and interactions and the second for species and interactions.

The ratio height:diameter was calculated by simply dividing the values of height by the values of diameter, using the row means. A high value of this ratio corresponds to a slim, tall seedling, which is allocating resources primarily to height growth while a low value represents a short seedling, with growth distributed more evenly to diameter increment and elongation.

When necessary, missing values where replaced with "dummy" values, created using the formula:

$$X_{ij} = (IX_{i.} + JX_{.j} - X_{..}) / \langle (I-1)(J-1) \rangle$$

where : $X_{i.}$ = total of the other replications in the same treatment and aspect for that species.

$X_{.j}$ = total of the other treatments for that species in the same aspect and replication.

$X_{..}$= Grand total.

I= number of replications.

J= number of treatments.

This way the analyis of variance could be performed using a balanced model.

Plant cover.- Herb cover was visually estimated as percent of ground covered using a 50 x 50 cm. frame which was placed at random five times in each of the treatment plots. In Oregon this was done in May, 1985 and April, 1986. In Mexico the inventory was conducted during September, 1985 and August, 1986

Soil moisture.- At planting time, one gypsum block (Model GB-1, Forestry Suppliers Inc., Jackson, Missisipi) was placed in the center of every plot in the four replications of each site, at a depth of 45 cm (1.5 ft.). In Oregon, the electric resistance of the blocks was measured every month, from February to December, 1985 and from February to August, 1986, using a Boyoucos moisture Meter model BN-2B (Beckmann, Cedar Grove, N.J.). This displayed a moisture reading in percent. In Mexico, the resistance was measured using a commercial resistometer, in March, April, August and September, 1985 and June and August, 1986.

The number of days that the treatments in Oregon remained with indicated values of more than fifty percent soil moisture content was computed, for 1985 from January to October, for 1986 from January to August. The totals were then subjected to an ANOVA. The moisture content at each date was also analyzed with the ANOVA procedure. Since the dates and devices used were not the same for each location, and because no calibration procedure was conducted to equate real soil moisture content to the indicated values, the ANOVAS were done separately for each location assumming that the texture of the soils remain esentially the same within each location and that the readings reflect real relative differences in soil moisture.

Soil Temperature.- A Soil Thermometer (Reotemp Inst. Corp., San Diego, California) was used to measure soil temperature at 30 cm. depth when measuring soil moisture. The observations for each date were subjected to an ANOVA. Since the dates of measurement were not the same, each location was analyzed separately.

A Index of Soil Conditions (SCI) was developed for each date using the Formula:

SCI=Percent of soil moisture/(Soil Temperature+10).

The index value increases directly with the increase in soil moisture and is proportionally inverse to temperature. A high value will indicate wet, cool conditions, while low values indicate very dry or hot conditions.

The addition of 10 to the soil temperature is used to avoid the negative values during the winter.

An averaged index for the dry season was obtained, and correlations between the averaged Index and percent survival, relative growth and relative diameter increment were calculated to see how the environmental and biological data were linked.

Evaporation potential was spot checked using modified Piche Atmometers as described in Waring and Hermann, (1966). Two atmometers were placed in each of two replications of each treatment at 30 cms. above ground. In each site, 16 atmometers were used, four in each treatment. Duplicate atmometers were placed one meter apart in two randomly chosen replication in each treatment. The devices were left for 72 hours before reading. The difference in milimeters beteween the initial and the final height of the water column was then measured and the results converted to cubic millimeters per hour. Potential evaporation was measured from July 8 to 11 and August 16 to 19, 1986, in Oregon and Mexico, respectively. For each location, an ANOVA was performed with the treatment means of each replication.

Root Growth Capacity Test (RGCT). A Greenhouse test (according to Stone and Norberg, 1979) was performed to evaluate root viability using a randomized block design. Four groups of six seedlings from each species were planted in metallic boxes containing a mix of sand and vermiculite. These were placed in a greenhouse for 8 weeks at 25^{o} C and a 12 hour photoperiod, starting January 15, 1985. All new growth of more than one centimeter in length was measured. The averages were used to perform an analysis of variance to test the different potential of root growth among species.

4.- R E S U L T S

4.1.- The enviroment and the effects of treatments.

4.1.1 Plant cover.

Table 4.1 shows the means of plant cover for each treatment, by aspect and location. The ANOVA for the 1985 data appears in Appendix A, table A-4.

The most visible changes in environment resulting from treatments was in plant cover. The ANOVA's for cover in each location showed significant differences among treatments in the first and second years after the treatments were applied.

In 1985, in both locations, the Tukey's test grouped the treatments H and S in one group, while C and M were different from H and S and different from each other (P=<.05). The highest second year increment of cover (recovery) was registered in the Mexican plots, treatments S and M, as a consequence of strong resprouting of oaks. In Oregon, the moderate increment of cover was due to forbs. In the north slope, bracken-fern made up most of the cover recovery.

4.1.2- Soil temperature.

Figure 4.1 (a) and (b) shows the temperature of the soil at 30 cm depth for each treatment, and aspect, in degrees centigrades for Mexico and Oregon, 1985. In Oregon, during 1985 there was a significant difference due to aspects for all except two dates (June 14, Dec. 28). At all dates. The south aspect was

Table 4.1 Percent plant cover after treatments.

TMT	Oregon 1985 N		Oregon 1985 S	Oregon 1986 N		Oregon 1986 S	Mexico 1985 N		Mexico 1985 S	Mexico 1986 N		Mexico 1986 S
Simazine	20.00	c	7.5	16.8	c	28.25	15.5	c	6.94	80	b	68
Manual	26.67	b	31.25	31.2	b	52.4	33.5	b	17.64	84	b	73
Herbicide	18.33	c	9.17	25	c	16	7.5	c	4.44	16.5	c	20.5
Control	112.5	a	100	108	a	102	107.5	a	104.75	100	a	104

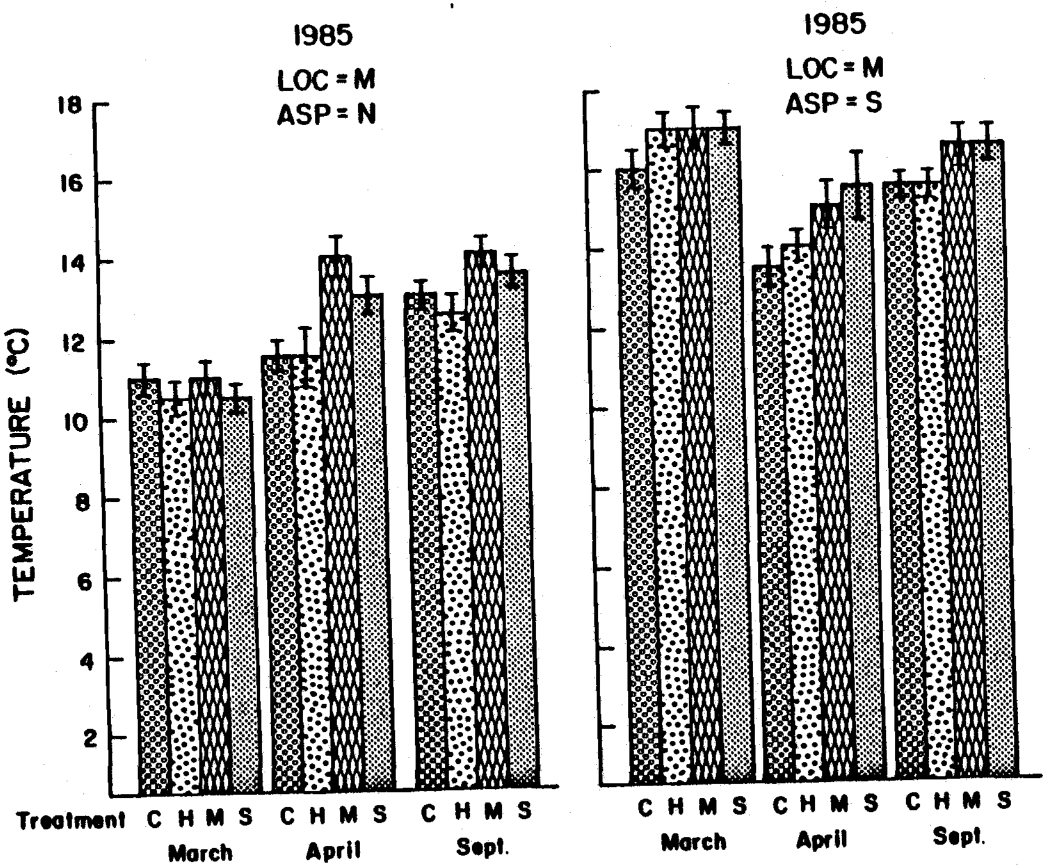


Figure 4.1 (a). Soil Temperature at 30 cm depth in Mexico, during 1985. Values are means of four replications.

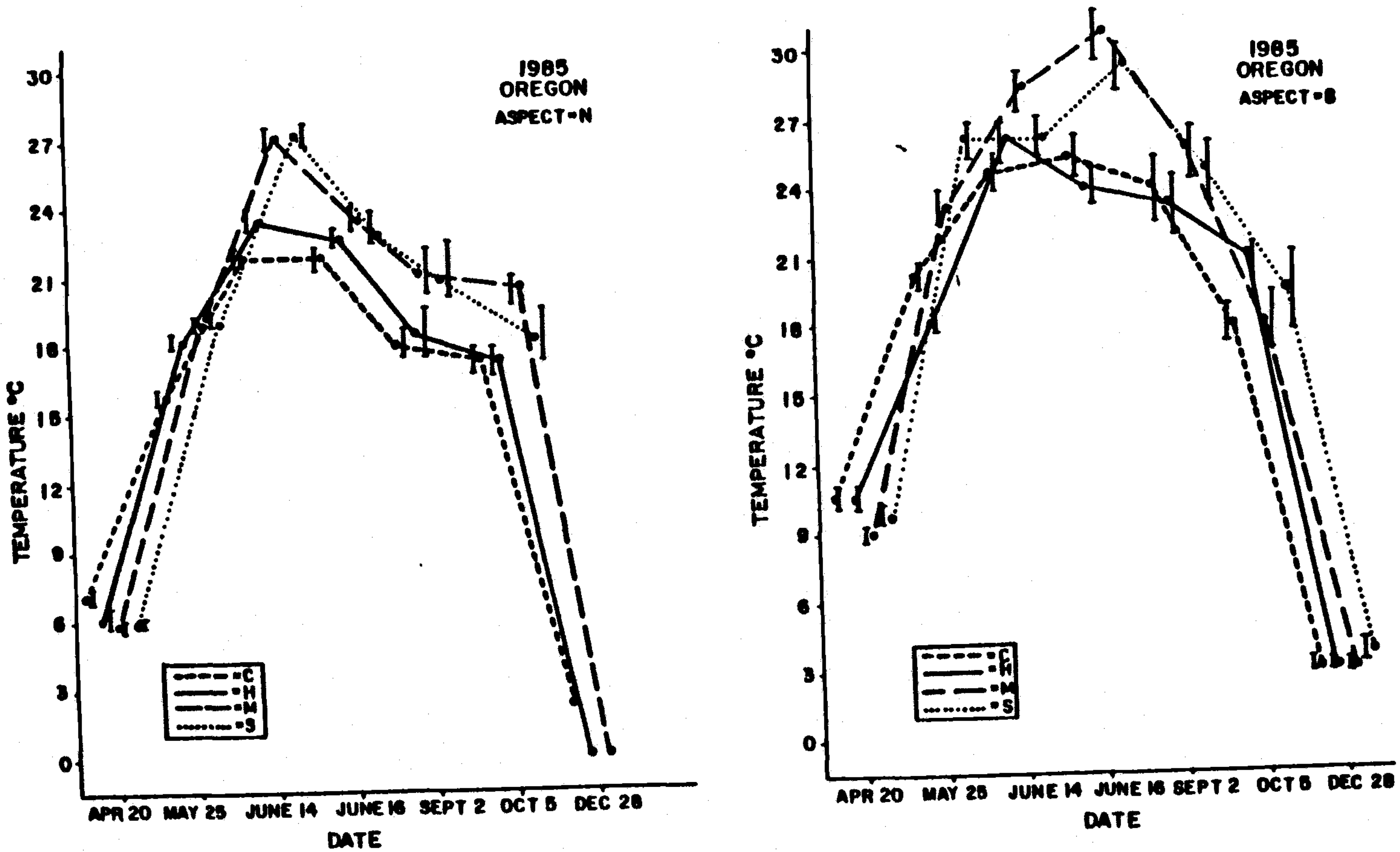


Figure 4.1. (b) Soil Temperature (°C) at 30 cm depth in Mexico (a) and Oregon (b), during 1985. Values represent means of four replications.

warmer than north slope by 2 to 5 degrees. Treatment had a significant effect on soil temperature on May 25, Sep. 2 and Dec. 28. During the early part of the dry season, the C and H treatments were cooler than the S and M treatments by 3 degrees, reflecting differences in cover.

In Mexico, the ANOVA results showed significant differences for aspects during March, 1985, but no difference was found for treatments <Table A-5 (a)>. By April '85, Treatments were significantly different. As in Oregon, treatments M and S formed one group, C and H another. Soil temperature in the cleared area were almost 2 degrees higher than those in the shade, whether living or dead. The rest of the dates did not show significant differences for treatments. See tables A-5 (b) and (c).

For the Oregon 1986 data, the ANOVA and Tukey's tests showed significant differences for aspect during during February (one degree difference), March (1.4 degrees difference), and August (4.5 difference). See figure 4.2 (a) and (b) and table A-5 (h). By July 08, 1986, the control treatment was clearly separated from the rest (3 to 4 degrees cooler). The partly defoliated herbicide treatment was intermediate, while the S and M treatments had the highest temperature <Table A-5 (g)>. In Mexico, where revegetation was more complete than in Oregon, no detectable second year difference was attributable to treatments.

4.1.3 Soil moisture

Figure 4.3 shows the average soil moisture content (in

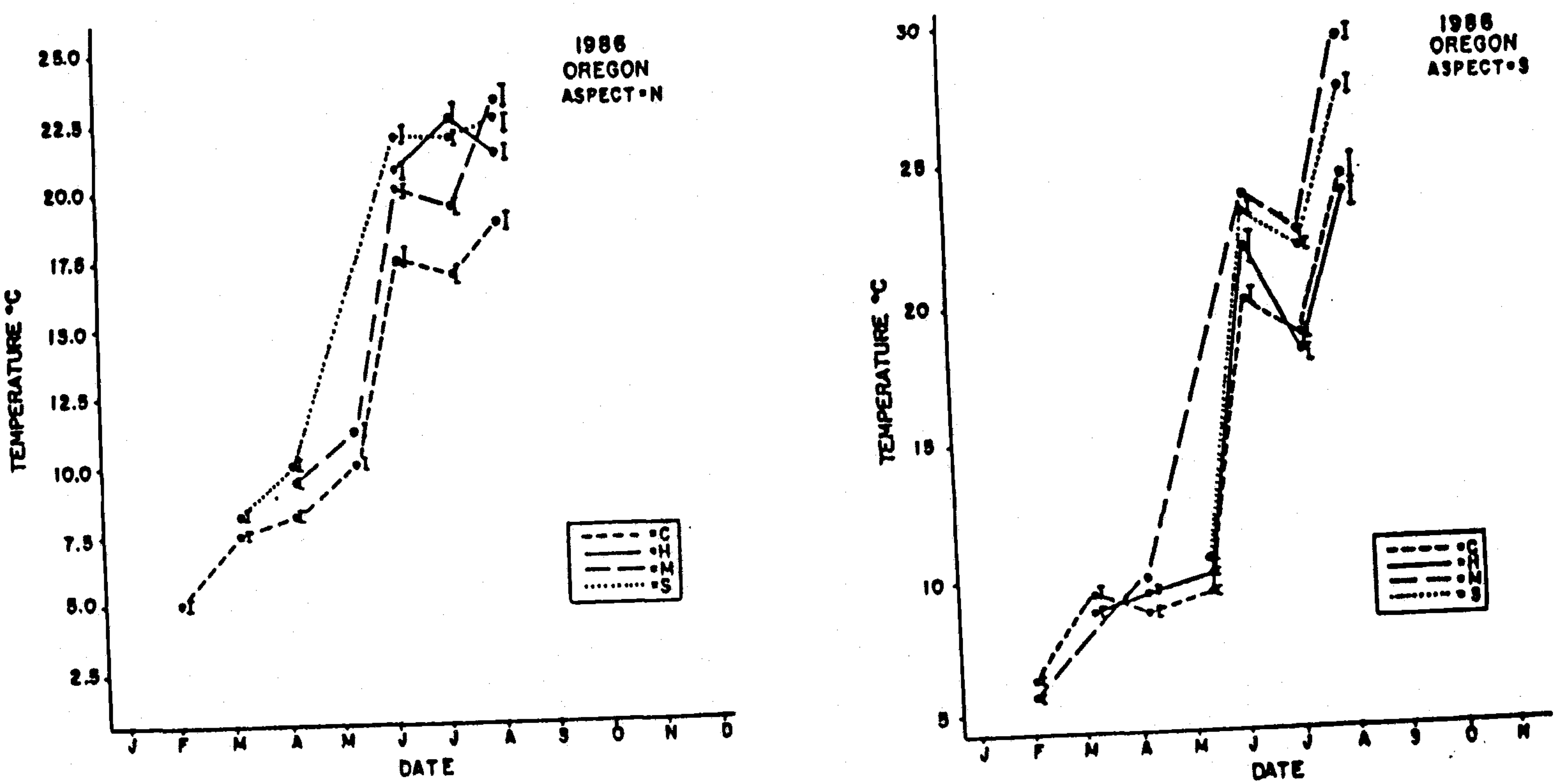


Figure 4.2 Soil Temperature at 30 cm depth in Oregon, North and South slopes.

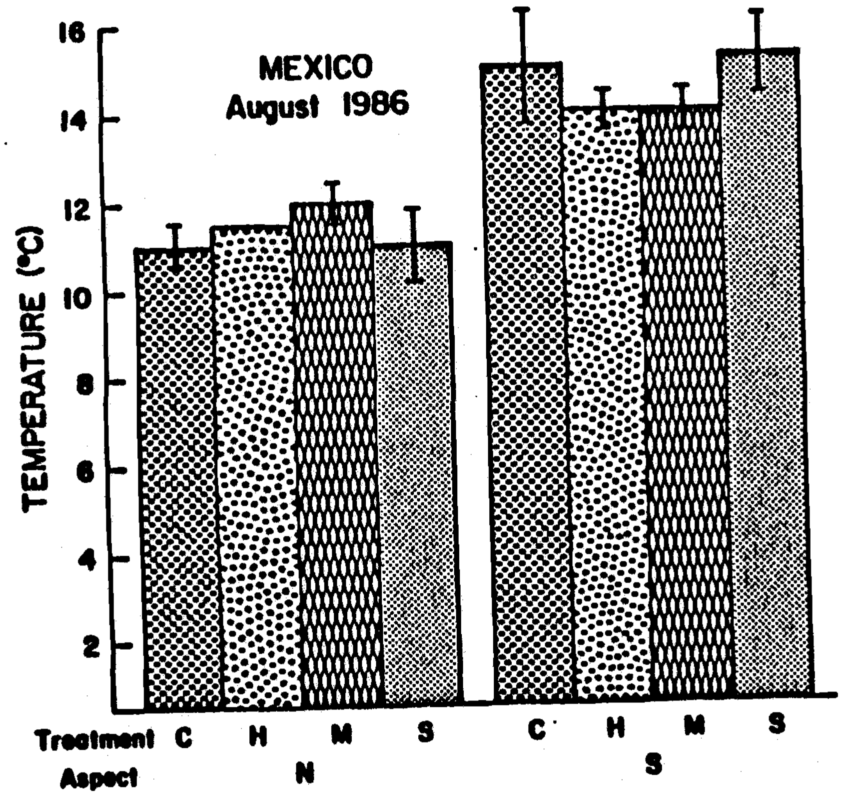


Figure 4.2 (c). Soil temperature at 30 cm depth, Mexico, August, 1986. Means of four replications.

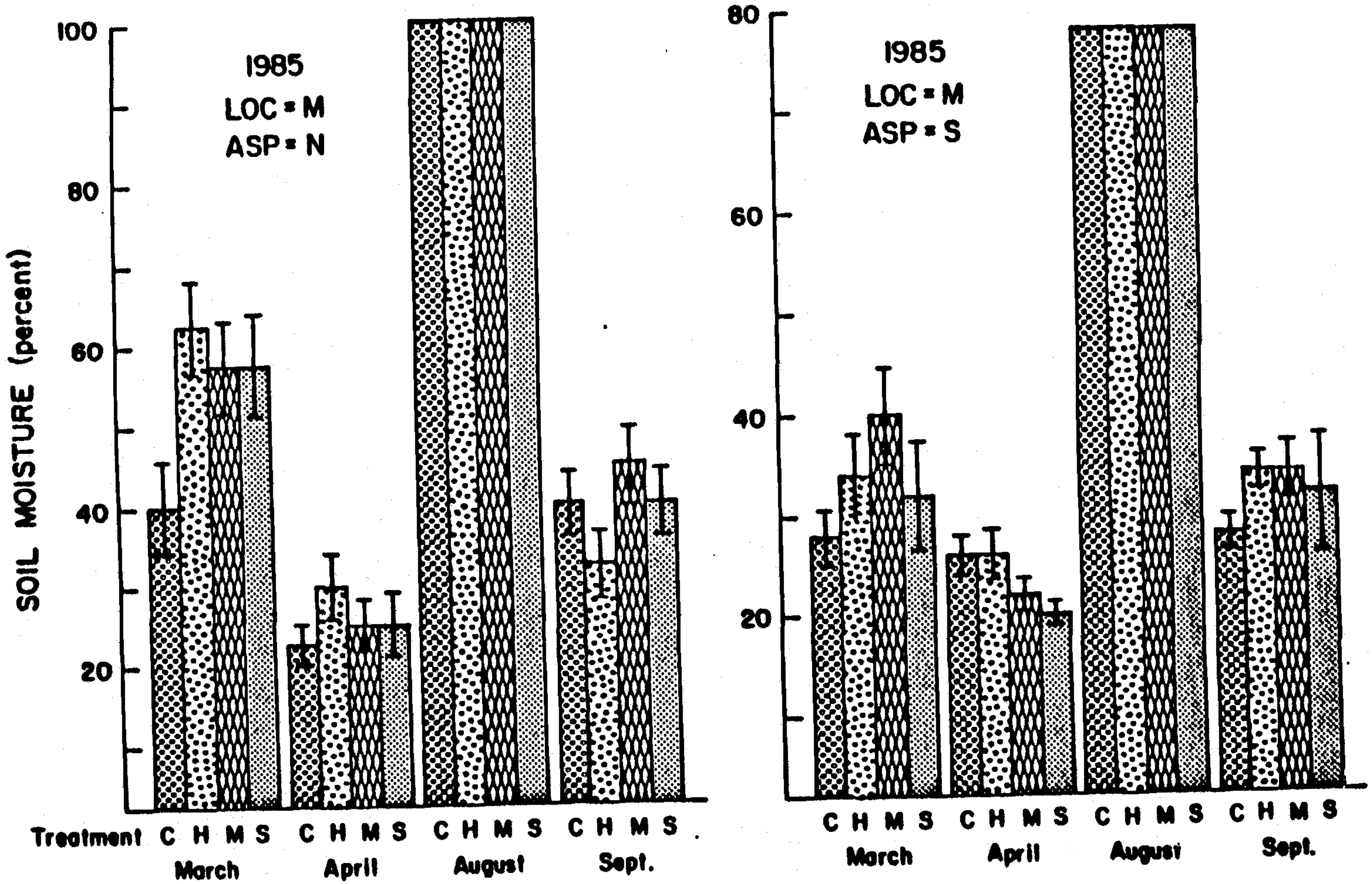


Figure 4.3 Percent Soil Moisture, as indicated by the resistance of the gypsum blocks, by aspect and treatment, in Mexico, during 1985. Values represent means of four replications.

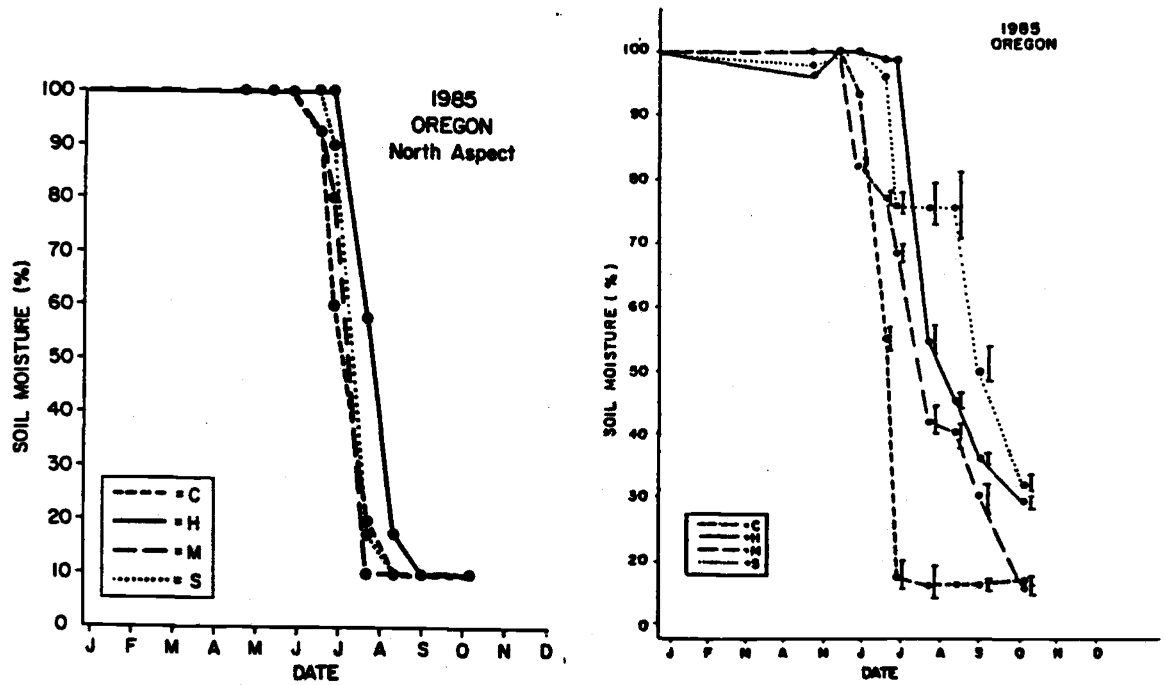


Figure 4.4 Percent Soil Moisture content, as indicated by the resistance of the gypsum blocks, by aspect and treatment, in Oregon during 1985. Values represent means of four replications.

percent) for Mexico, by aspect and treatment for the different dates of 1985. Figure 4.4 shows the same for Oregon. Results from the ANOVA and Tukey's test indicate that, in Oregon during 1985, significant differences among treatments were detected through June, July and August <see Tables A-6 (d),(e) and(f). By June 14, the control treatment had separated from the rest(June 14) and by July 24, the H and S treatments retained significantly more moisture, while moisture in the M treatment was at an intermediate level. The control had the least soil moisture throughout the growing season. The statistical differences by August 9, showed that the S and H treatments appeared to conserve moisture more effectively than C or M. In the second year, the ANOVA test for the Oregon data showed that significant differences among treatments existed at June 04 and July 08, when the Control and Manual treatments were separated from the H and S. Eventually all soils dried so that differences decreased by the end of the summer. See figure 4.5.

At the Mexican location, aspect had a significant effect on soil moisture in March and September, but treatments did not produce detectable difference at any date, reflecting the rains during the growing season <see Table A-6 (a), (b) and (c)>.

In Mexico, no detectable second year difference was attributable to treatments within the data available. On both June 15 and August 18, the soil was at its field capacity in all plots in both aspects. During 1986 the general tendency is repeated in Oregon, according to data summarized by figure 4.5.

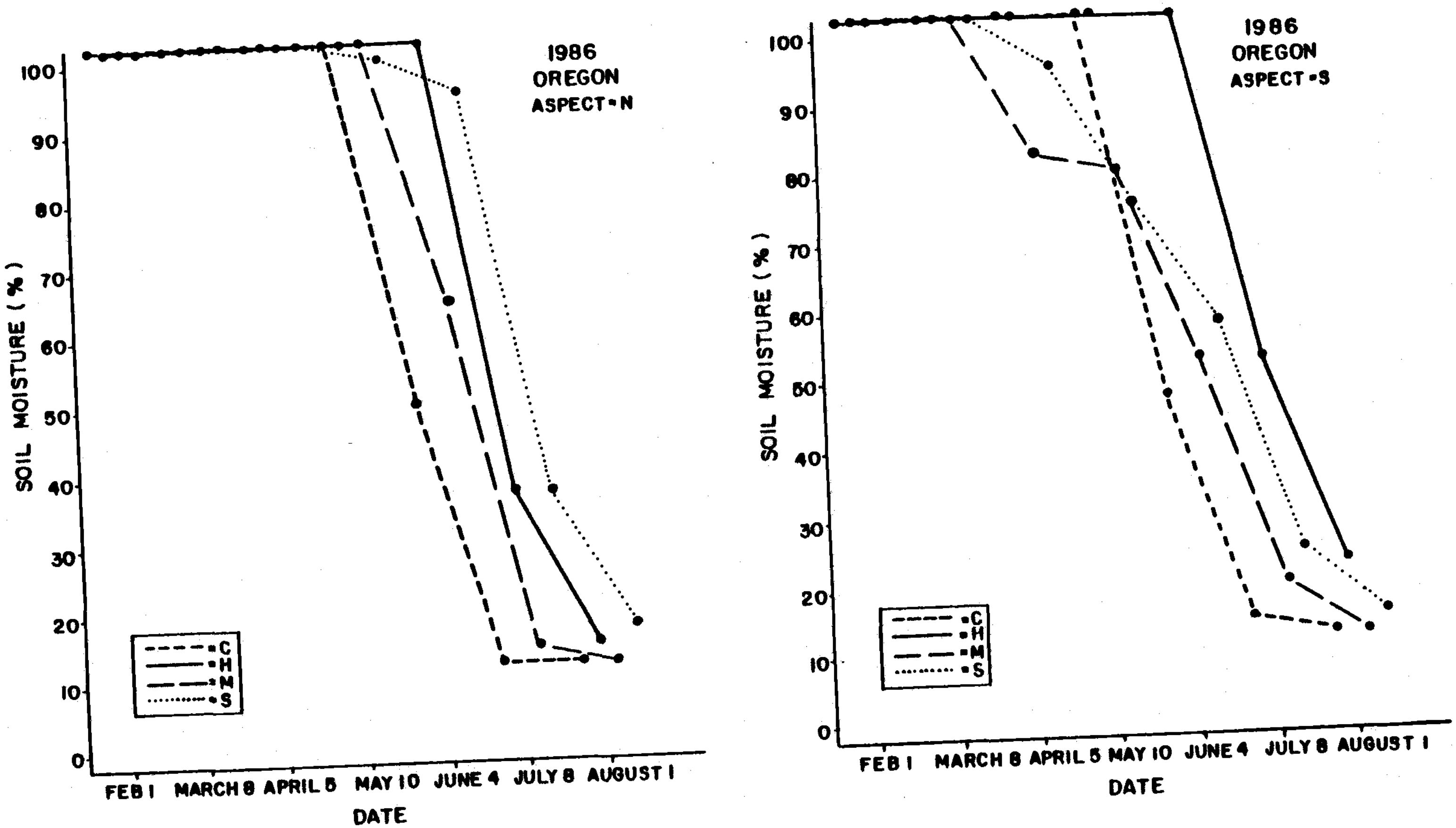


Figure 4.5 Soil moisture as indicated by the electric resistance of the gypsum blocks in Oregon, during 1986.

For the Oregon data, an averaged SCI Index was calculated for the dryest months of each year. Table 4.2 summarizes the results.

Table 4.2. Averaged soil conditions index (SCI) for the driest months of both years, in Oregon.

ASP	TMT	SCI 1985	STDERR	SCI 1986	STDERR
N	C	2.357	0.2598	1.891	0.2210
N	H	2.565	0.0717	2.413	0.0804
N	M	2.251	0.1427	1.898	0.2107
N	S	2.378	0.0241	2.279	0.1102
S	C	1.318	0.1670	1.847	0.1981
S	H	2.661	0.1664	2.649	0.2904
S	M	1.806	0.3830	1.541	0.3275
S	S	2.323	0.3409	1.645	0.5038

The index is highest in the Herbicide treatment whereas control is the lowest. Manual and Simazine remained intermediate. In 1986, Herbicide is still the highest, but Control is not different from S, while M is the lowest.

An ANOVA test for the data of the Oregon Location for both years showed that the differences are significant and attributable to both aspect and treatments <see Table A-9 (a) and (b)>.

4.1.4 Period of Moisture Availabilty

The number of days that the gypsum blocks in the soil remained with more than fifty percent of moisture (indicated values) in Oregon is presented in table 4.3.

The ANOVA tests for both years detected a significant effect of treatment. The Tukey's test formed three groups: H and S in one, M in a intermediate group, C the dryest. Treatments H and S had 32 to 37 more days than treatment C, and 23 to 28 more days than treatment M. See Table A-8 (a) and (b).

Table 4.3. Number of days with more than fifty percent of soil moisture (indicated values), for 1985 and 1986, Oregon.

ASP	TMT	MDAYS85	STDERR	MDAYS86	STDERROR
N	C	183.25	7.215	154.75	5.793
N	H	200.50	3.662	186.75	9.086
N	M	186.75	2.015	165.00	6.442
N	S	193.50	2.533	179.75	5.647
S	C	173.50	11.608	154.25	6.712
S	H	219.50	19.098	188.00	9.380
S	M	188.75	22.350	148.25	12.120
S	S	238.00	24.355	150.75	16.350

In 1986, treatments again are separated but now into two groups: H and S versus M and C. The wetter group had 11 to 33 more days with soil moisture above fifty percent than the drier group.

4.1.5.- Evaporation potential.

The means of potential evaporation by location, aspect and treatment are shown in figure 4.6.

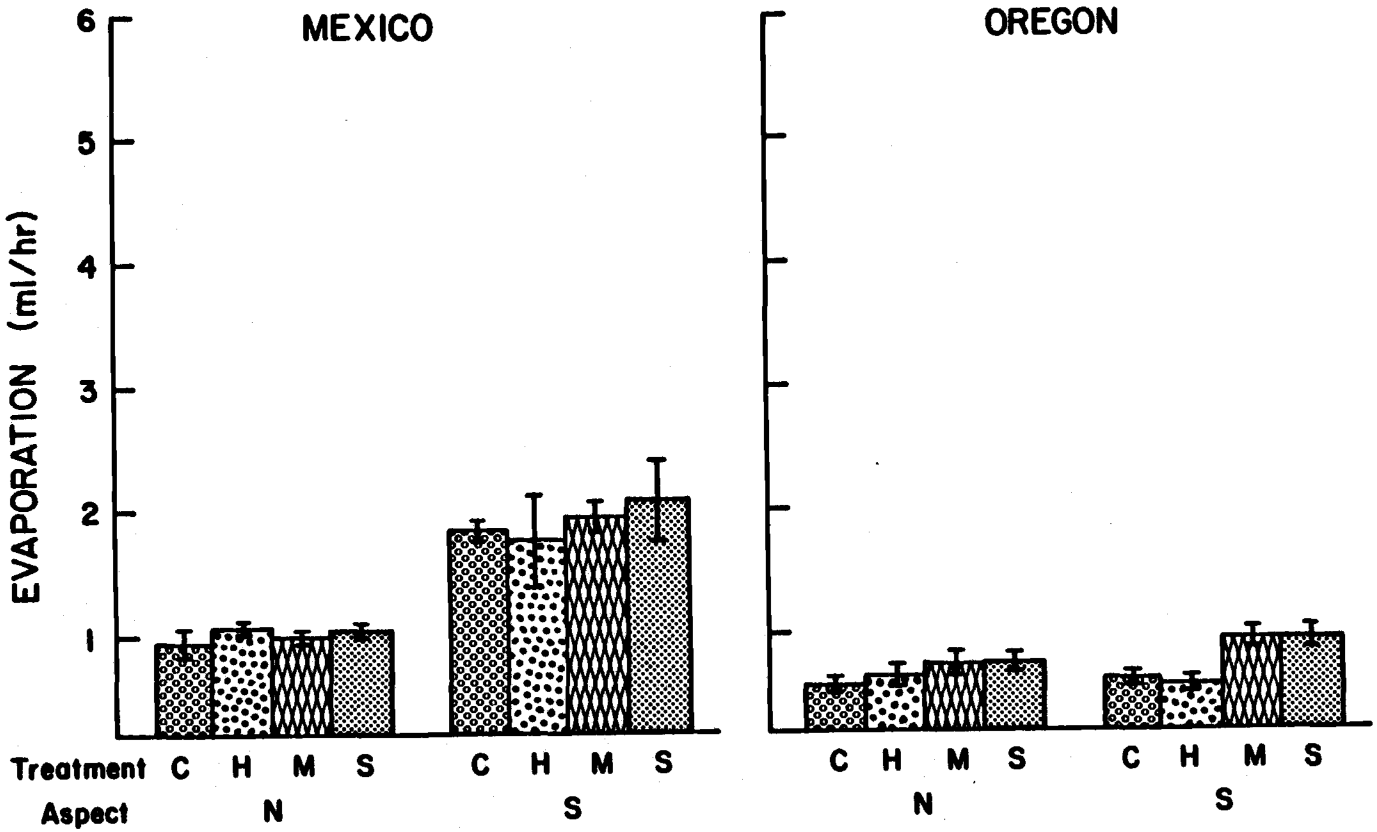


Figure 4.6 Potential evaporation in Mexico and Oregon. Values are means of four replications. Units= Milli meters per hour.

4.1.5.1 Oregon

The ANOVA <Table A-7 (b)> indicates that in Oregon the interaction aspect by treatment is significant. In both aspects, two groups were formed: M and S versus C and H.

The greatest differences between the same treatments in opposite aspects is between the treatments in the cleared area.

4.1.5.2 Mexico

The ANOVA <Table A-7 (a)> indicates that treatments and aspects had significantly different effects on evaporative potential. Tukey's test separated the means of treatments in the order manual- simazine - control - herbicide. The potential evaporation on the south slope was double that of the north slope.

4.2. Survival.

4.2.1 Animal damage

During the first two months after planting, a highly selective rate of mortality resulting from foraging by wood rats was detected in the Oregon location. In view of the degree of the damage, most affected seedlings were replaced. Those planted underneath brush (C and H treatments) were protected with plastic Vexar tubes to prevent further damage.

In Mexico, animal damage was apparent only by June, 1986. No protective measures were taken.

The means per location, aspect and treatment are presented in Figure 4.7.Table B-1 (a) contains the correspondent

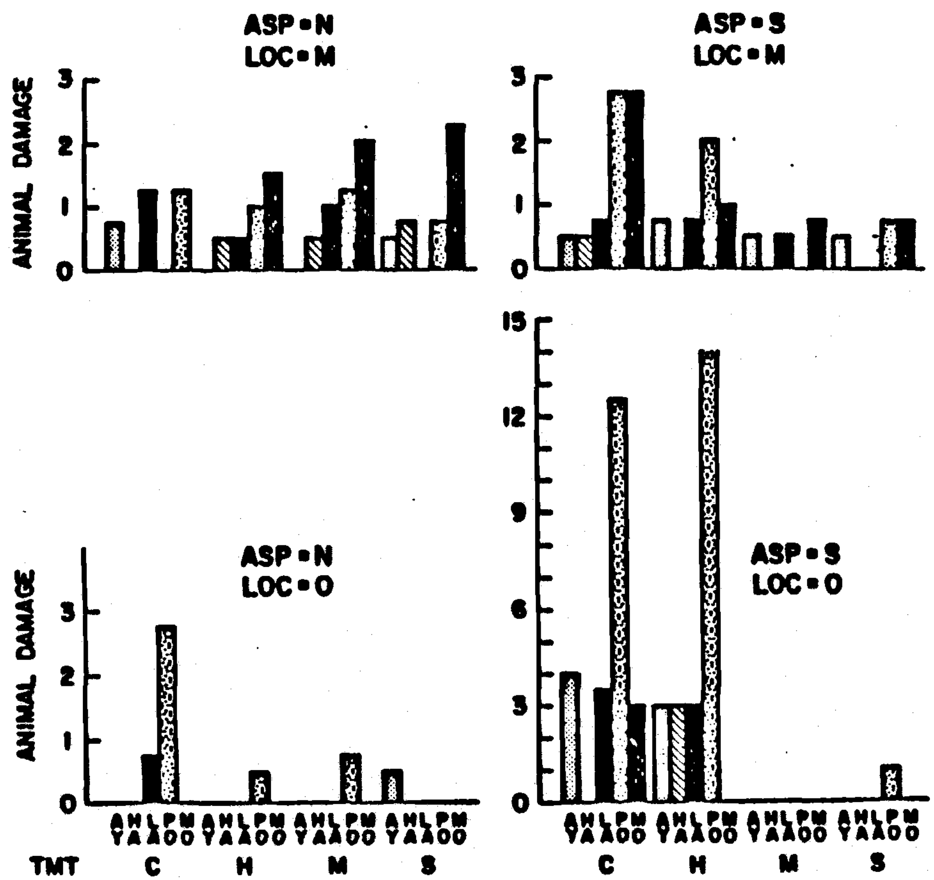


Figure 4.7 Animal damage in both locations, by aspect, treatment and species. Values are means of four replications. Number of damaged seedlings per row.

data. The ANOVA results are in table B-1 (b).

For the Oregon data, the Tukey's test separated the aspects, the cleared versus non-cleared treatments, and ponderosa pine as different from other species in being vulnerable to animal damage.

Ponderosa pine was largely damaged by animals in the treatments herbicide and control in the south slope of Oregon, ten times more than in the north; almost all of the 14 seedlings per row were severely damaged, while the damage to the rest of the seedlings was negligible.

This concentration of damage was absent in the Mexican plots. There was no difference among treatments or aspects, and the damage was minor, if any.

4.2.2 Total survival

For the two year period of this experiment, the average survival across locations, species etc. was 70 percent. In 1985 it was 82.5 percent; 60 percent of the total mortality ocurred the first year.

The general mean of survival in Oregon was 66 percent; in Mexico it was 73.8 percent. Considering aspects in each location, the means are:

LOC	ASP	SURVTO	STDERR
M	N	86.69	2.1703
M	S	60.98	3.1765
O	N	75.89	2.9001
O	S	56.37	4.3025

The survival on the north aspect of Mexico is the highest, followed by the north slope of Oregon, while the differences between south aspects among locations are smaller than their north slope counterparts.

The results are presented graphically in figure 4.8.

The ANOVA test detected significance ($P<.01$) for the interaction species*treatment, meaning that the responses of species varied significantly among treatments. See Table B-2.

The interaction location*species*aspect is significant, meaning that the survival of at least one species was different depending on the aspect-location combination. This is more clear when we see that the interaction of aspect with treatment is significant, as well as the location*treatment interaction ($P<.01$).

Figure 4.8 (b) shows survival in Oregon, by treatment and aspect. Here, the best survival was achieved in the herbicide treatment, followed by the simazine treatment.

In both aspects, the highest mortality was in untouched cover.

In Mexico, the highest mortality also occurred in the control, but there was no difference among the rest of the treatments.

Over all, effects of aspect were similar in the two locations, but location influenced the degree of mortality and of difference between aspects.

Considering the species separately, the following is a general view of their responses, based on Table 4.4

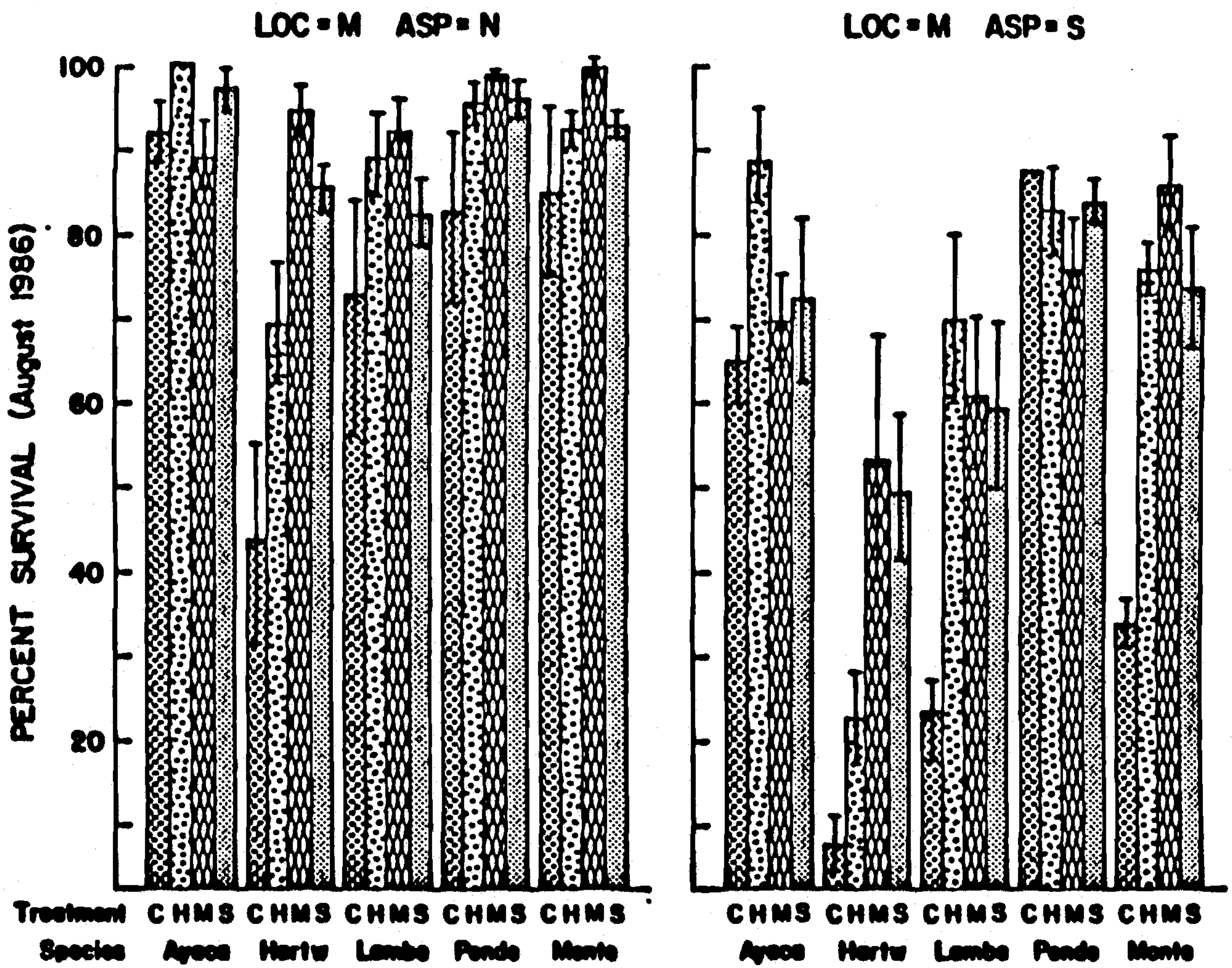


Figure 4.8 (a). Percent survival after two growing seasons
in Mexico by aspect, treatment and species.

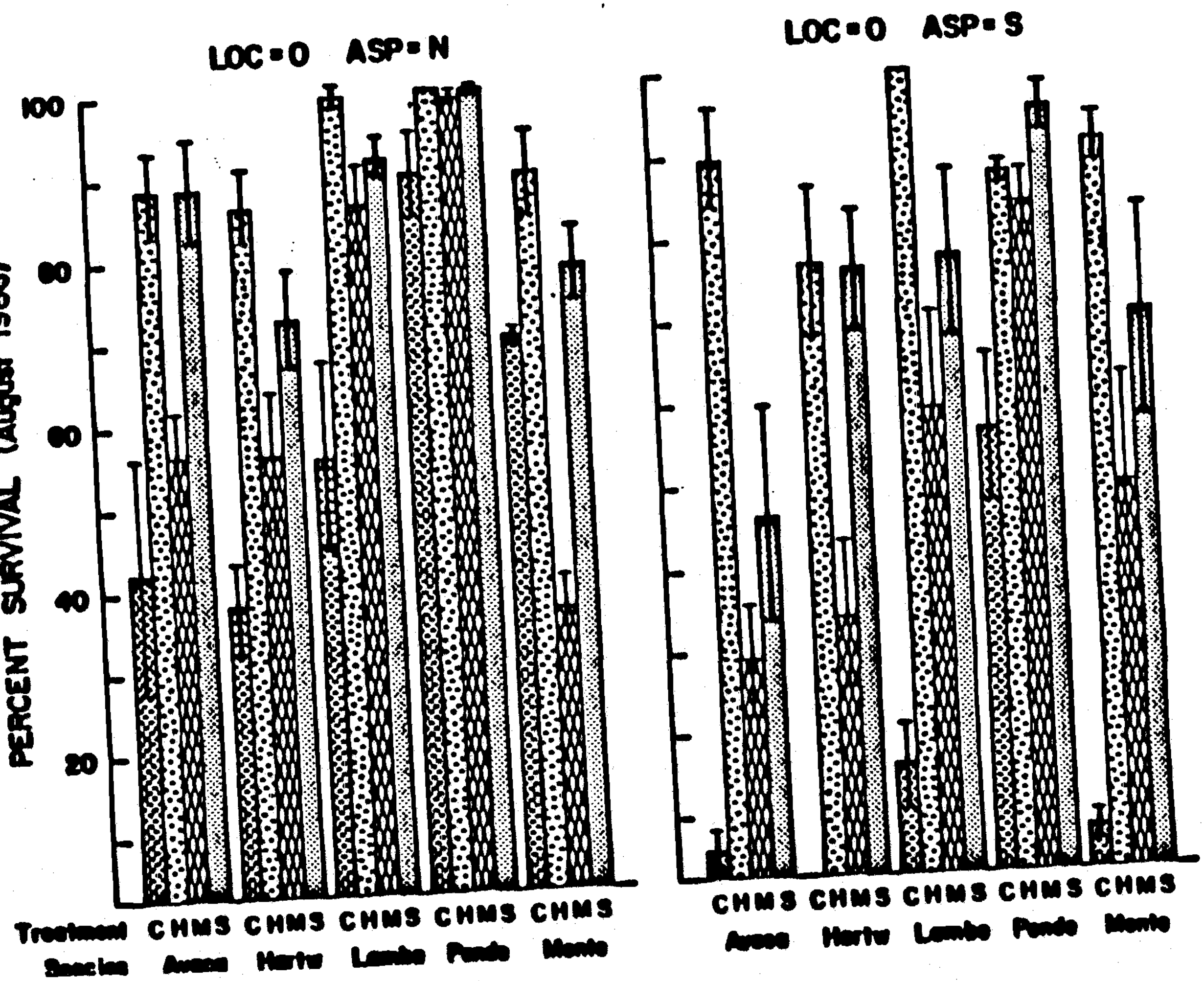


Figure 4.8 (b). Percent survival after two growing seasons
in Oregon by aspect, treatment and species.

Table 4.4 Total survival (average) by species, location, aspect and treatment.

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN TMT(ASP)
M	N	C	91.1	5.4	42.9	18.9	71.4	16.2	82.1	11.8	85.7	12.0	74.6
M	N	H	100.0	0.0	67.9	11.1	87.5	7.9	94.6	3.4	92.9	2.9	88.6
M	N	M	87.5	8.4	92.9	5.1	91.1	4.5	98.2	1.8	98.2	1.8	93.6
M	N	S	96.4	3.6	83.9	3.4	80.4	5.4	96.4	3.6	92.9	2.9	90.0
M	S	C	64.3	5.1	5.4	5.4	23.2	7.9	83.9	9.4	32.1	4.6	41.8
M	S	H	87.5	7.9	21.4	6.5	69.6	12.2	82.1	6.8	75.0	3.6	67.1
M	S	M	69.6	8.9	51.8	17.6	58.9	12.2	75.0	9.4	85.7	7.1	68.2
M	S	S	71.4	10.5	48.2	11.4	57.1	12.7	83.9	3.4	73.2	8.9	66.8
O	N	C	41.1	16.1	37.5	7.9	55.4	15.3	89.3	6.8	69.2	0.0	58.5
O	N	H	87.5	6.1	83.9	5.4	98.2	1.8	100.0	0.0	89.7	3.6	91.9
O	N	M	55.4	7.9	55.4	10.7	85.7	7.7	96.4	2.1	35.2	3.9	65.6
O	N	S	87.5	6.1	72.5	7.1	91.1	3.4	98.2	1.8	77.3	3.4	85.3
O	S	C	3.6	3.6	0.0	0.0	10.7	6.2	55.1	13.3	5.1	3.6	14.9
O	S	H	89.3	6.8	76.8	10.3	100.0	0.0	87.6	2.2	90.3	4.4	88.8
O	S	M	28.6	10.1	32.1	11.1	57.1	15.2	83.9	6.1	47.4	15.7	49.8
O	S	S	46.4	15.6	75.0	15.6	76.8	13.8	94.6	3.4	69.4	16.4	72.5
Mean species			69.2		53.8		70.7		87.6		71.4	Great Mean=70	

Mexico. The north aspect in Mexico generally showed excellent potential for survival. P.ayacahuite, P. ponderosa, and P. montezumae registered high survival, P. hartwegii the lowest. The best treatment for P. ayacahuite is herbicide (100 percent), but this was only a few points above the rest of the treatments. The lowest is control (90 percent). This differences are probably non-significant, taken by themselves. P. lambertiana survived best in the H and M treatments (89 percent) and again, the lowest is in the control (71 percent). P.ponderosa survived most poorly (82 percent) under the C treatment, but the rest of the treatments are equally good among themselves (around 96 percent). The same tendency is shown by P. montezumae. P.hartwegii had its best survival in the cleared treatments and the lowest in the control.

The south aspect in Mexico displayed over-all poorer survival than the Mexican North slope. All species except ponderosa pine have the lowest survival in the control treatment.

For P. ponderosa the worst treatment was Manual, with 75 percent survival. The poorest- surviving species was P.hartwegii, for which survival in the control treatment was only 5 percent. P. ayacahuite and P. lambertiana reached the highest survival in the Herbicide treatment. The manual treatment was the best for P. hartwegii and P. montezumae, followed by simazine and herbicide, respectively.

Oregon. The above general pattern of survival was repeated in Oregon. In the North aspect, for all species (except for P. montezumae) the poorest survival was in control plots. All species demonstrated maximum survival in the herbicide treatment. For P.ayacahuite, the S treatment had also the highest survival (87.5 percent). For P.lambertiana, P.ayacahuite and P. hartwegii, M was the third best treatment. Again, P. ponderosa does not show important differences among the best treatments other than control. Again, P. hartwegii has the lowest survival of all species in all treatments.

In general the relative effects of treatments were similar among species other than P. ponderosa. The highest survival for a single species is for P. ponderosa. The second best was P.lambertiana.

The south aspect in Oregon had the harshest summer microclimates of the entire study. For all species except for P. ponderosa, the best survival rate was under the herbicide treatment, the worst under Control.P. ponderosa survived well in the Simazine (95 percent) Herbicide (87 percent) and Manual(84 percent) treatments, and showed no differences among them. Among the five species,P. ponderosa has the highest survival for the control treatment (55 percent) but the control was clearly the poorest of the environments.

Simazine is the second best treatment for P.ayacahuite (46 percent). The same is true for P. montezumae (69 percent), P.lambertiana (77 percent) and P. hartwegii (75 percent).

In general, the differences between treatments increased in the harshest summer conditions.

4.2.3.-Correlating Survival with environment.

The Soil Conditions Index developed for the

Oregon data was significantly correlated with survival.

The correlations (R) between overall survival in Oregon and SCI are as follows:

	Surv85	Survtot
SCI'85	0.717	0.672
SCI'86	..	0.398

BY SPECIES:		Surv 85	Surv 86
P.ayacahuite	SCI'85	0.872	0.813
P.ayacahuite	SCI'86		0.590
P. hartwegii	SCI'85	0.854	0.802
P. hartwegii	SCI'86		0.488
P.lambertiana	SCI'85	0.810	0.773
P.lambertiana	SCI'86		0.462
P. ponderosa	SCI'85	0.298	0.324
P. ponderosa	SCI'86		0.069
P. montezumae	SCI'85	0.839	0.850
P. montezumae	SCI'86		0.456

It is apparent that first year conditions influence over-all survival much more than second-year conditions, regardless of species. Ponderosa pine is less sensitive to SCI than the other species, explaining its better performance in the extreme environments.

4.3 Growth responses to treatment.

4.3.1 Relative height growth.

Figure 4.9 (a) and (b). shows the means of relative height growth by species and treatments, grouped by aspects, for each of the locations. In all cases P. montezumae shows the highest relative growth, since it went from a grass stage to an average of 12.7 cm. P.lambertiana consistenly had the lowest relative growth.

The ANOVA test <Table B-3 (b).> detected a significant effect of the interactions location*species and species*aspect indicating that the growth of the seedlings depends not only on species but also on the location and aspect.

The relation between the Mexican and Oregon pine species was moderately consistent; the Mexican pines tend to have higher relative growth rates under a variety of conditions in the field. See Table B-3 (a).

The preferences of species for treatments are different depending on location and aspect. For example, P. ponderosa and P.ayacahuite in Oregon grew better under simazine and herbicide treatment than under Control or Manual in both aspects, but P.lambertiana did so only on the south aspect, while in the north aspect herbicide promoted more its growth in height.

On the north aspect in Mexico, all species, except P. montezumae, grew more in the cleared treatments than in the standing cover. In the south aspect of Mexico, P. montezumae and

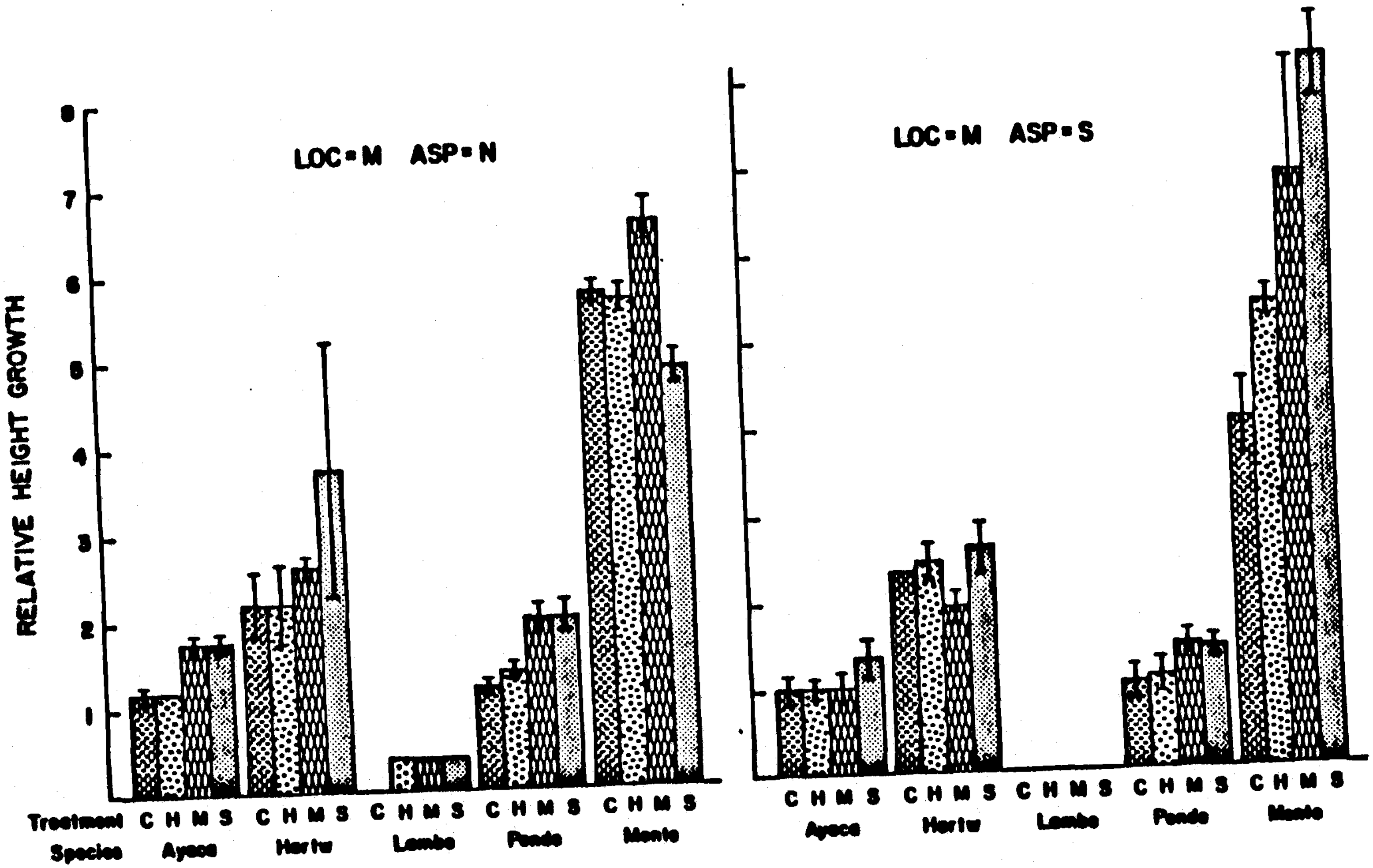


Figure 4.9 (a) Means of relative height growth by species, aspect and treatment for the Mexican plots.

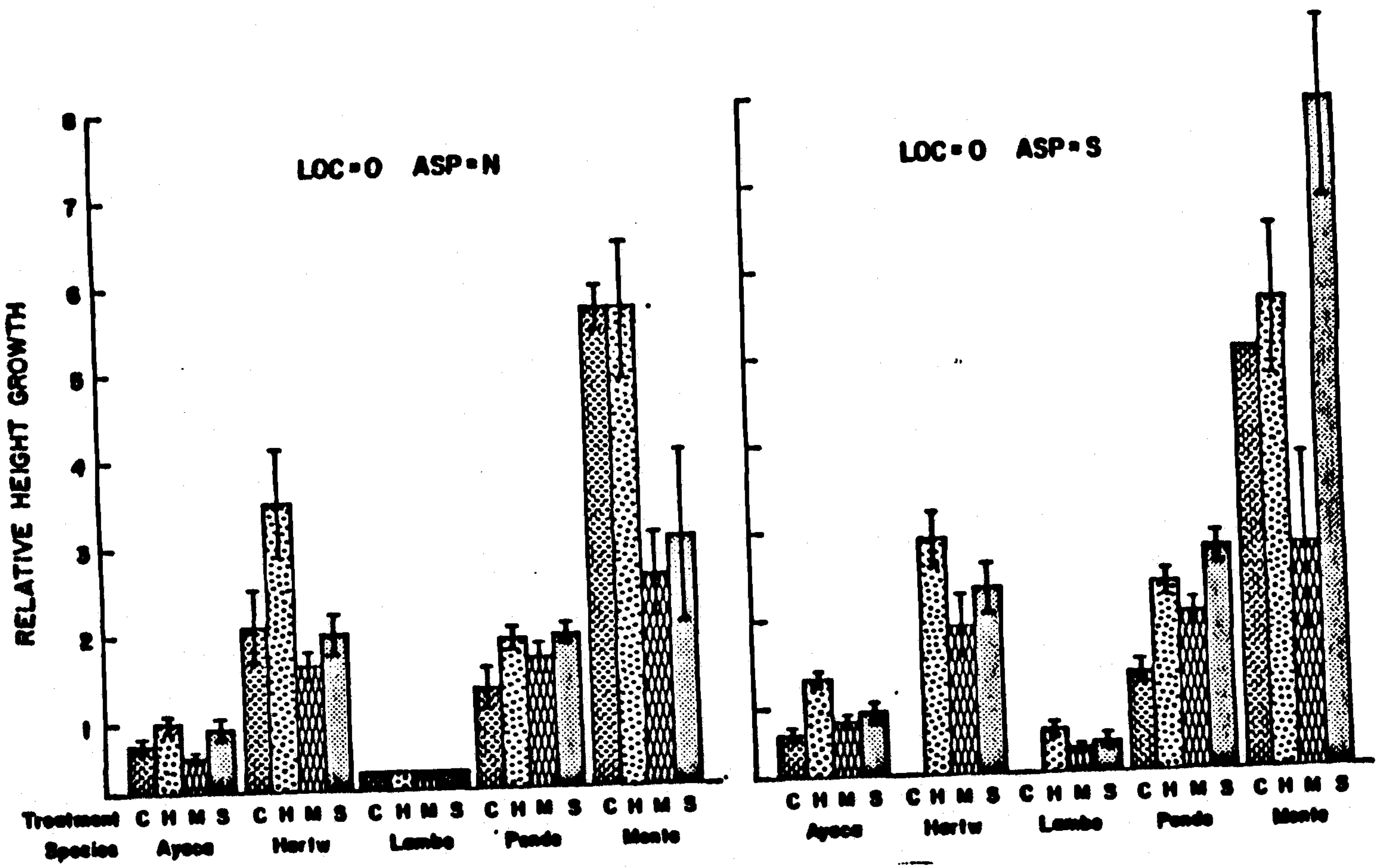


Figure 4.9 (b) Means of relative height growth by species, aspect and treatment for Oregon.

P. ponderosa show a tendency to grow more in the cleared than where cover remained standing. P.lambertiana performed very poorly in all treatments on south slopes in Mexico.

The correlations between relative growth and Soil Conditions Index were very low: for 1985=0.168, for 1986=0.056.

4.3.2 Absolute growth

The actual growth in millimeters will be called absolute growth. Table 4.5 lists mean net growth values for each species, by location, aspect and treatment. Figure 4.10 shows the same results graphically.

On north slopes in Mexico, the tendency of most species is to grow more where cover was removed than in the Control-Herbicide treatments. The exception is P. montezumae which apparently prefers the environment created by the Manual and Control treatments. Ponderosa pine and P. hartwegii are the least sensitive to treatment, aspect or location.

In the south slopes of Mexico P. ponderosa and P. montezumae grow better where cover is cleared. P.ayacahuite does better in the S treatment. P. hartwegii shows no preference for any of the environments. Sugar pine has its worst performance on this slope.

On the north slope of Oregon, P.ayacahuite and P. ponderosa grew better in the H-S combination, P.lambertiana and P. hartwegii did better in the S, but they do not show differences for the Control-Simazine. P. montezumae prefered the H-C group of treatments.

TABLE 4.5. Absolute or Net height growth in millimeters.

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN TMT(ASP)
M	N	C	152.9	9.9	44.8	5.3	11.7	4.3	126.3	13.4	110.6	8.6	89.3
M	N	H	163.4	6.5	42.1	8.7	28.4	4.1	143.9	12.6	108.4	21.2	97.2
M	N	M	219.0	7.1	53.6	4.7	41.2	9.0	212.5	15.6	128.8	6.7	131.0
M	N	S	222.2	7.7	72.1	29.7	41.7	6.7	212.0	12.0	93.9	19.0	128.4
M	S	C	131.9	22.5	43.3		-41.2	5.8	99.0	18.8	78.7	12.1	62.3
M	S	H	128.6	9.5	45.4	6.4	-39.2	17.4	110.3	28.0	103.8	6.0	69.8
M	S	M	138.1	20.1	36.6	4.5	-28.3	9.8	136.1	12.0	137.1	20.0	83.9
M	S	S	169.8	10.7	48.7	6.4	-11.8	11.9	127.2	5.9	165.5	9.7	99.9
O	N	C	77.2	16.5	39.8	7.1	33.6	20.3	137.4	38.4	113.3		80.3
O	N	H	132.9	11.6	68.0	17.2	66.6	20.6	190.5	16.7	113.8	17.9	114.3
O	N	M	63.3	14.2	29.7	6.7	24.8	17.4	154.0	25.5	47.6	11.2	63.9
O	N	S	97.5	15.7	38.3	8.0	27.7	17.2	202.6	7.6	59.9	19.4	85.2
O	S	C	63.0	.	.	.	-19.5	9.5	116.6	19.6	100.0	.	65.0
O	S	H	168.7	7.8	56.2	7.4	123.1	9.9	228.0	25.7	110.2	17.5	137.2
O	S	M	79.4	11.8	34.2	9.1	37.7	21.5	193.8	17.0	54.0	28.0	79.8
O	S	S	102.5	12.7	45.9	14.4	83.7	18.4	266.9	18.6	159.0	19.6	131.6
MEAN SPECIES			131.9		46.6		23.8		166.1		105.3		

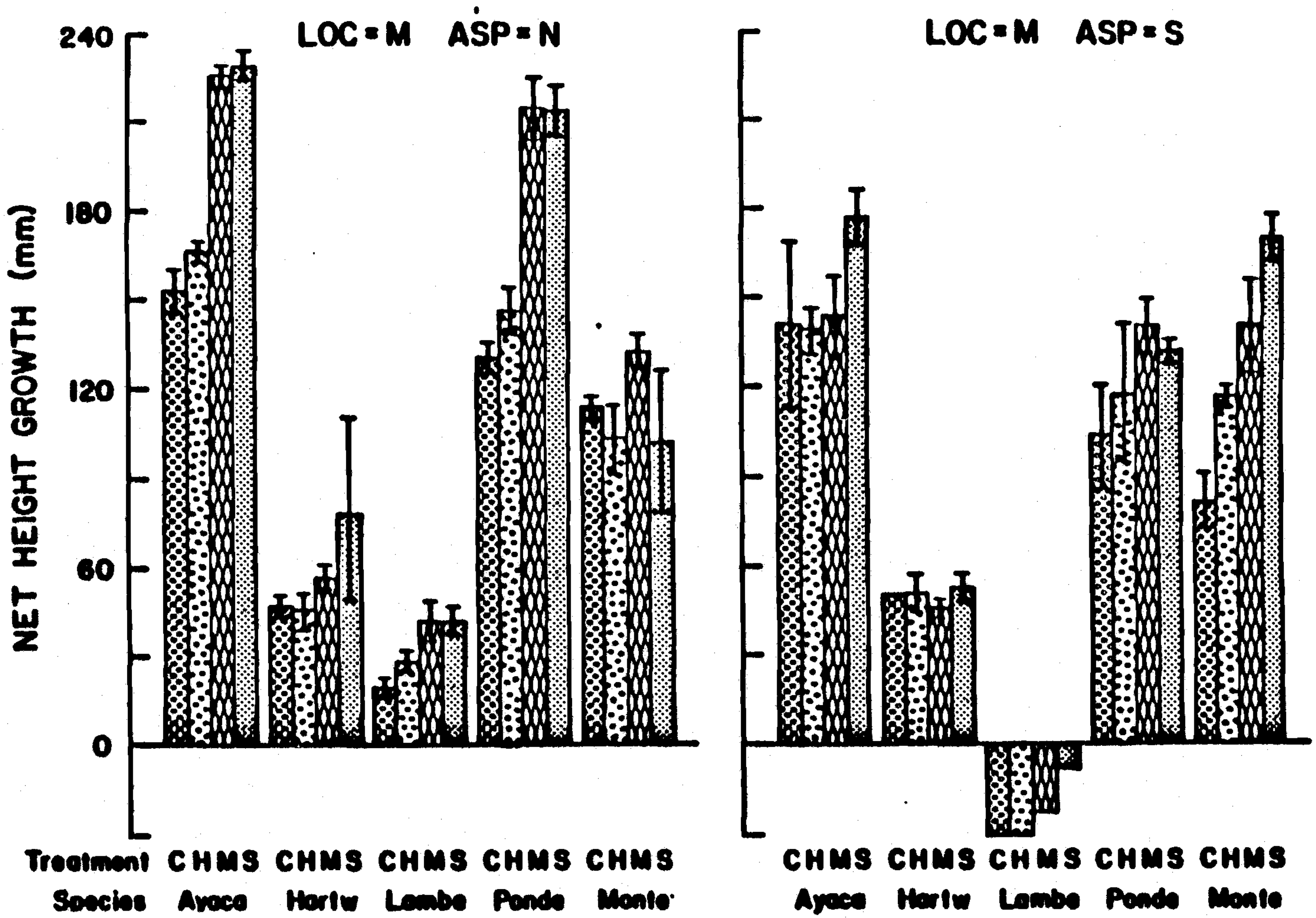


Figure 4.10 (a) Net height growth (mm) by species, aspect and treatments. Mexico.

In the south slope of Oregon H and S were the best for all species. Control the worst for all, except for P. montezumae.

4.4 Diameter increment.

4.4.1 Relative diameter increment.

Figure 4.11 shows the means of relative diameter increment. In all environments for all species, the conditions in the slashed area (M-S) stimulated diameter growth. In all cases, Control has the lowest increment.

In all environments, P. hartwegii and P. montezumae grew the least in relative diameter. P. ponderosa grew more in all cases. The general tendencies, representing the averages across species are presented in Figure 4.12.

4.4.2 Absolute diameter increment

The values of Absolute or Net diameter increment, in tenths of millimeters are presented in Table 4.6.

The tendencies are the same as with the relative diameter increment.

4.5 Ratio height:diameter

The values corresponding to the ratio height: diameter are shown in table 4.7. In general, the shaded seedlings have a higher ratio than those that received full sunlight.

4.6.- Height growth season and bud activity.

Most of the growth in Oregon was observed between March and June with no further increments until the following spring.

In Mexico, most of the increment was registered between March and June but some increment ocurred between September and December (9.9 mm).

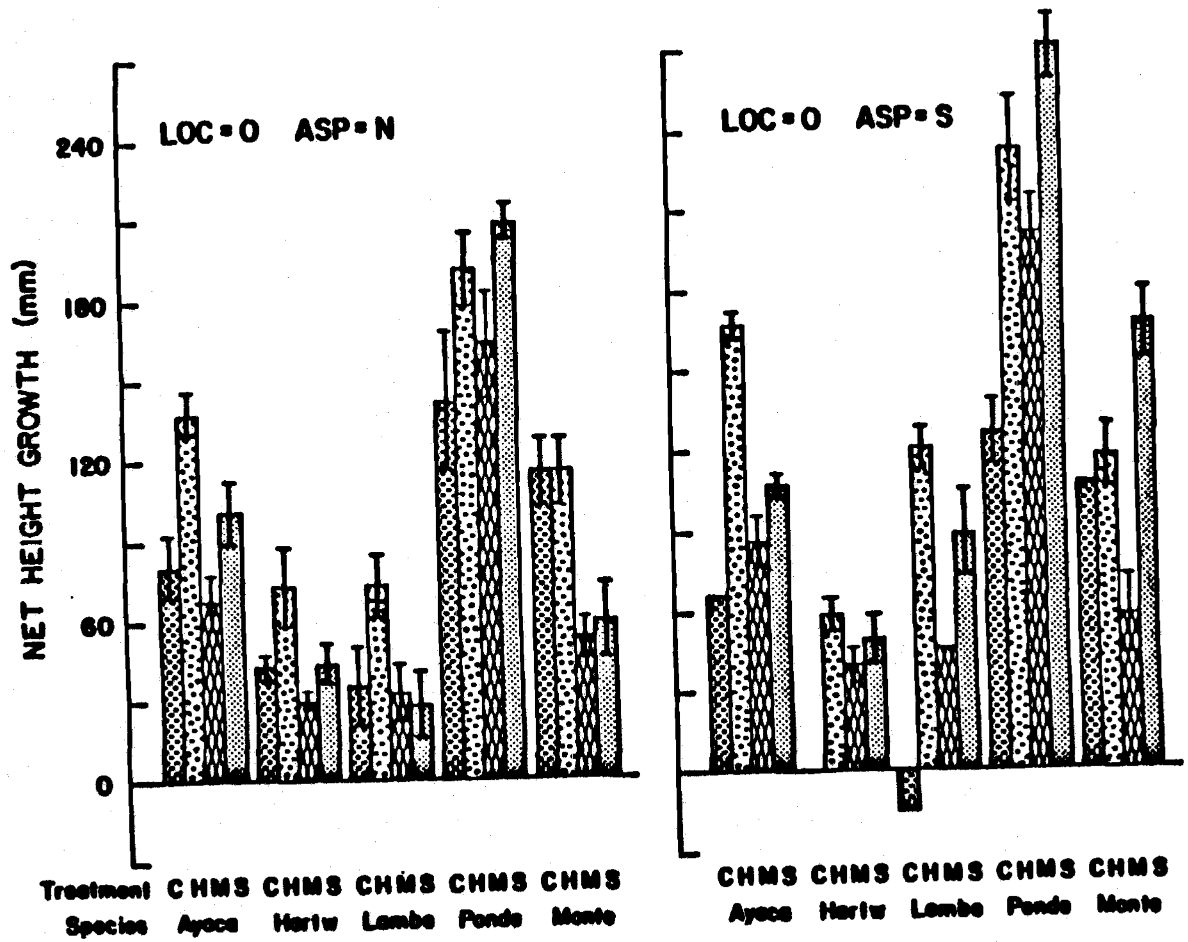


Figure 4.10 (b) Net height growth (mm) by species, aspect and treatments. Oregon.

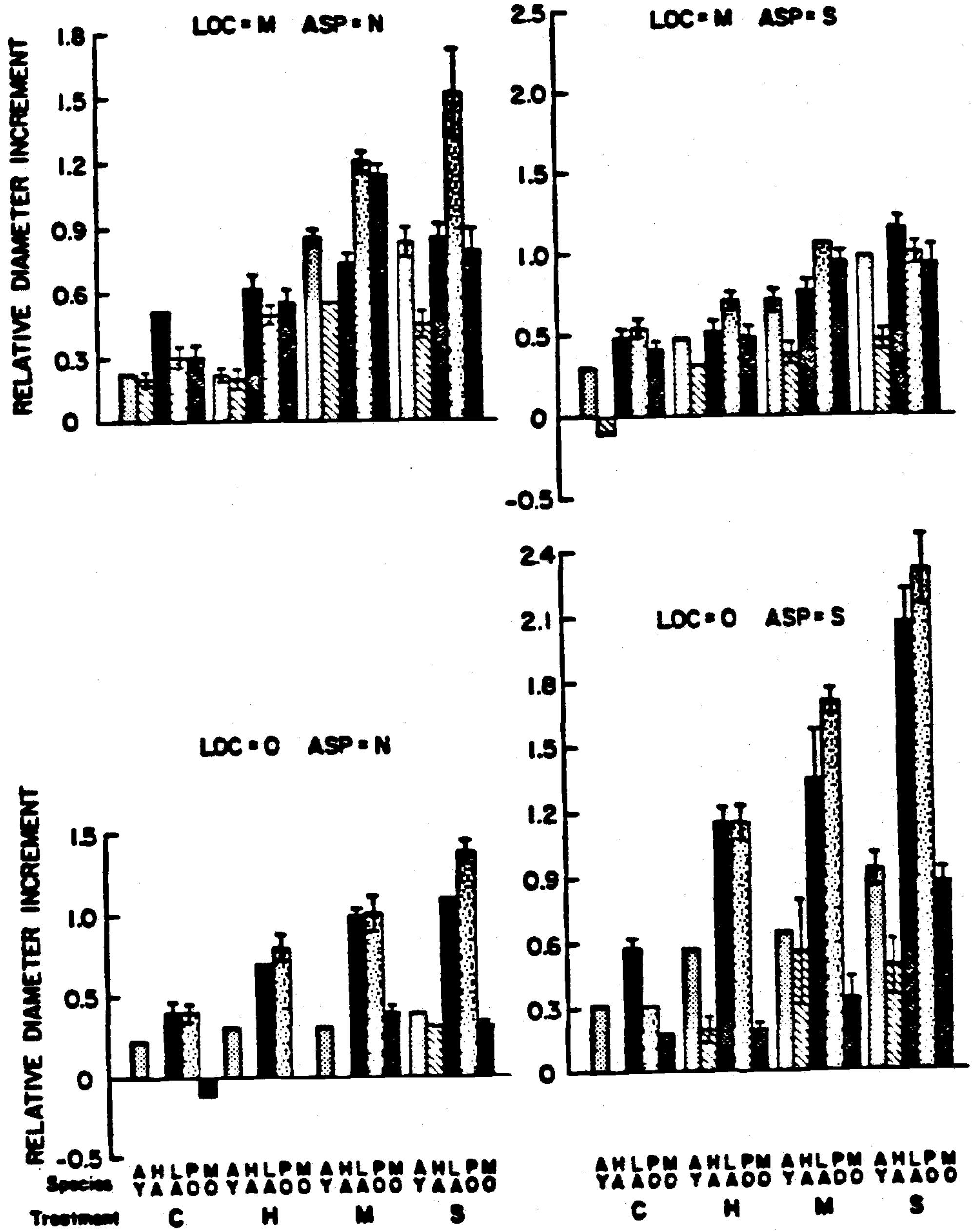


Figure 4.11. Relative Diameter increment for each species, by aspect and treatment for both locations.

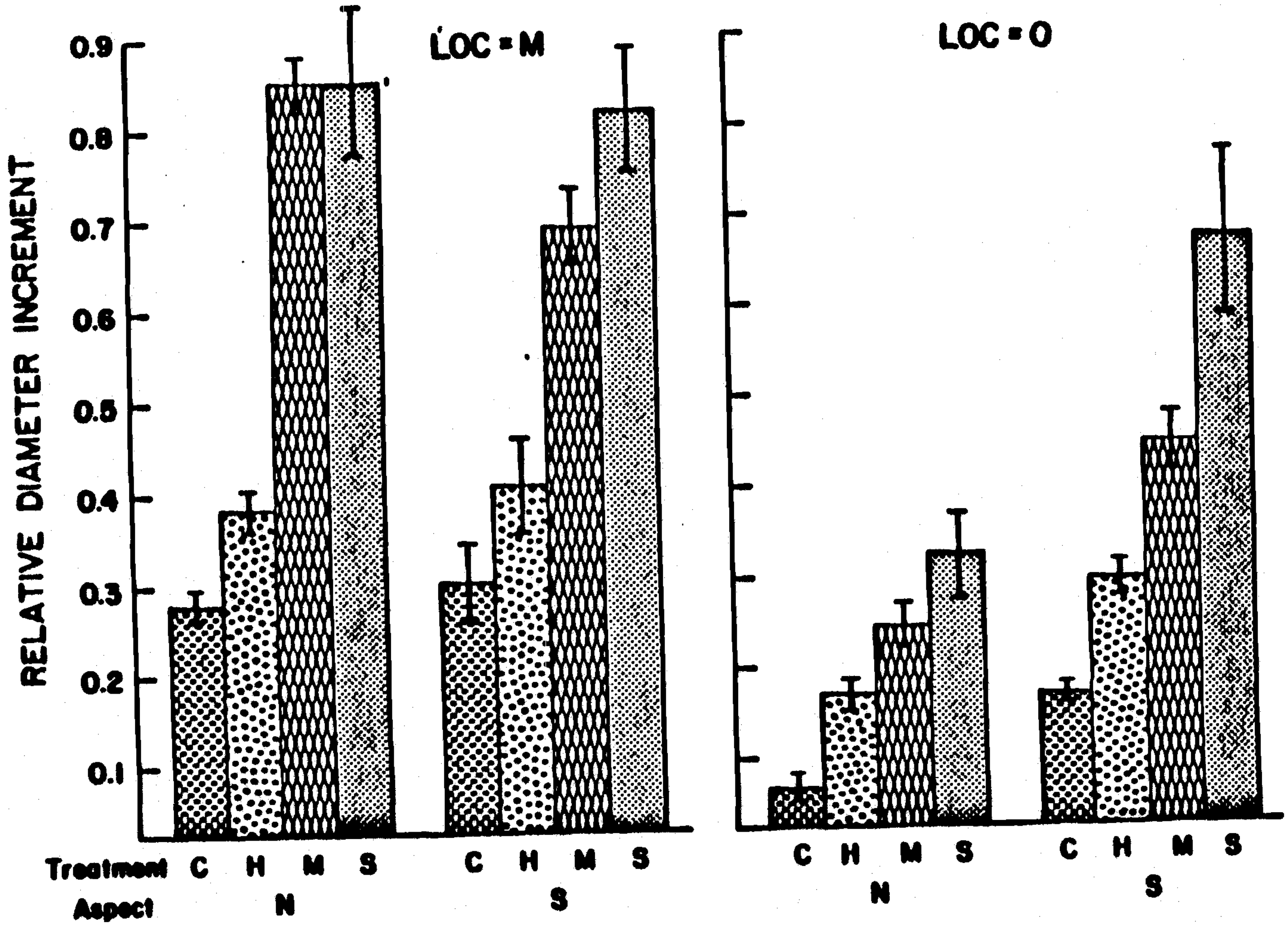


Figure 4.12. Relative Diameter increment, average of all species, by location, aspect and treatment.

The sum of days that the average seedling remained open during the year was called "BUDAYS". The numbers for 1985 are presented in Table B-5 (a) and for 1986 in Table B-5 (d).

(For the 1986 Mexican data it was not posible to compute this value due to the discontinuity of observations).

The ANOVA results (Tables B-5 b, c.) detected significant effects of the species by aspect interaction. In Oregon during 1985 P. ayacahuite shows a tendency to increase the period of bud activity under shade. The shaded treatments increased the period of P. lambertiana in the north slope of Oregon. The other species are not sensitive to treatments.

In Mexico during 1985, P.ponderosa have the shorter period of bud activity under shade in both slopes, while P. ayacahuite shows that tendency only in the north slope. The control treatment caused a reduction of days for P.hartwegii and P. lambertiana in the south slope of mexico, while the shaded treatments increased the period in the north slope for P. lambertiana. The general tendency of P. lambertiana appears to be longer periods under shade, except when the live brush has exhausted the soil moisture.

For 1986, the ANOVA test <Table B-5 (e) >indicated significance for the species*aspect and species*treatment interactions regarding BUDAYS.

In each aspect, the pattern was different. For the south slope, P. ayacahuite had its greatest number of BUDAYS in the control treatment, while the north slope control had the least number of BUDAYS.

The control treatment increased the number of BUDAYS for P.montezumae in the north slope , but the reverse effect is seen for P. lambertiana and P.hartwegii in both aspects.

P. ponderosa was very consistent, registering very similar numbers for all plots.

4.7 Root Growth Capacity Test and morphology.

The means of Root Growth Capacity (RGC) are contained in Figure 4.11. Table B.6 (a) presents RGC results and some morphological characteristics at planting time.

The ANOVA results (table B-6 b) showed a significant effect of species. Both P. ponderosa and P.montezumae are in the group with the highest values (107.5 and 98.2, respectively P. hartwegii is intermediate (73.3) and P.ayacahuite forms a group with P. lambertiana having the lowest values (around 28 cm.) for total root growth potential.

Table 4.6. Absolute Diameter Increment.
(units= 0.10 mm).

LOC	ASP	TMT	P.AYA	SE	P.MAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN Tmt(asp)
M	N	C	6.5	1.9	6.1	3.9	11.6	0.7	9.7	1.6	11.1	3.5	9.0
M	N	H	8.4	1.6	6.0	1.8	14.7	1.9	12.6	1.6	20.7	3.3	12.5
M	N	M	32.4	2.5	23.9	2.1	18.1	1.4	35.7	2.9	44.0	5.5	30.8
M	N	S	30.0	3.4	19.6	4.6	22.1	2.1	45.1	13.6	29.5	6.2	29.2
M	S	C	7.0	1.8	-11.3	.	9.6	2.9	14.0	1.8	12.6	4.5	6.4
M	S	H	14.5	1.0	7.8	4.7	12.8	2.1	17.7	2.3	17.4	3.3	14.0
M	S	M	26.2	2.0	14.6	4.9	18.6	2.6	28.6	1.3	31.6	2.4	23.9
M	S	S	34.1	1.1	20.3	2.4	27.6	6.1	28.0	2.1	33.1	6.3	28.6
O	N	C	2.9	1.1	-3.2	2.2	8.3	2.4	9.0	2.3	-8.9	.	1.6
O	N	H	7.7	1.1	-4.6	3.3	16.4	0.7	22.3	5.2	1.0	3.0	8.6
O	N	M	9.6	0.9	1.9	1.5	22.2	2.7	26.9	4.6	12.6	4.5	14.6
O	N	S	10.9	0.8	7.3	2.0	26.9	1.2	40.5	1.6	11.1	2.9	19.3
O	S	C	11.0	.	.	.	12.7	3.1	9.9	0.7	2.5	.	9.0
O	S	H	18.6	0.9	6.9	6.7	28.9	1.7	31.6	4.2	3.4	2.7	17.9
O	S	M	24.1	1.5	19.9	12.2	32.7	4.2	49.8	4.4	14.6	8.7	28.2
O	S	S	33.7	2.0	20.8	7.6	52.1	4.6	68.5	7.4	36.2	5.5	42.3
MEAN Sps			17.4		9.1		21.0		28.1		17.0		

Table 4.7 Ratio Height/Diameter (mm/.1mm), two growing seasons after planting. Compare to initial ratios in Table B.7 (a).

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN (TMT(ASP)
M	N	C	6.3	0.1	1.2	0.1	6.9	0.1	5.8	0.2	2.6	0.3	4.5
M	N	H	6.2	0.1	1.1	0.1	6.8	0.3	5.9	0.5	2.1	0.3	4.4
M	N	M	4.9	0.1	1.0	0.1	6.6	0.3	4.8	0.2	1.8	0.1	3.8
M	N	S	5.2	0.2	1.4	0.4	6.0	0.3	4.5	0.6	1.7	0.4	3.8
M	S	C	5.7	0.4	1.6	0.1	5.9	0.5	4.6	0.3	1.9	0.2	3.9
M	S	H	4.9	0.2	1.2	0.1	5.3	0.2	4.4	0.4	2.1	0.0	3.6
M	S	M	4.1	0.3	1.0	0.1	4.9	0.2	4.1	0.2	2.2	0.3	3.3
M	S	S	4.1	0.1	1.0	0.1	4.5	0.5	4.0	0.1	2.6	0.3	3.2
O	N	C	5.0	0.4	1.4	0.2	8.3	0.8	6.1	0.9	3.3	0.2	4.8
O	N	H	5.7	0.1	2.0	0.3	7.4	0.6	5.7	0.4	3.0	0.4	4.8
O	N	M	4.0	0.4	1.0	0.1	5.6	0.2	4.5	0.2	1.1	0.2	3.3
O	N	S	4.6	0.3	1.1	0.1	5.2	0.2	4.4	0.2	1.4	0.3	3.3
O	S	C	4.0	0.0	1.3	0.2	6.0	0.3	5.5	0.5	2.5	0.2	3.9
O	S	H	5.2	0.2	1.4	0.1	6.7	0.1	5.4	0.2	2.6	0.2	4.3
O	S	M	3.3	0.2	1.1	0.3	4.9	0.2	3.7	0.1	1.3	0.4	2.9
O	S	S	3.2	0.1	0.9	0.1	4.3	0.3	3.8	0.2	2.3	0.3	2.9
MEAN SPECIES			4.8		1.2		6.0		4.8		2.2		

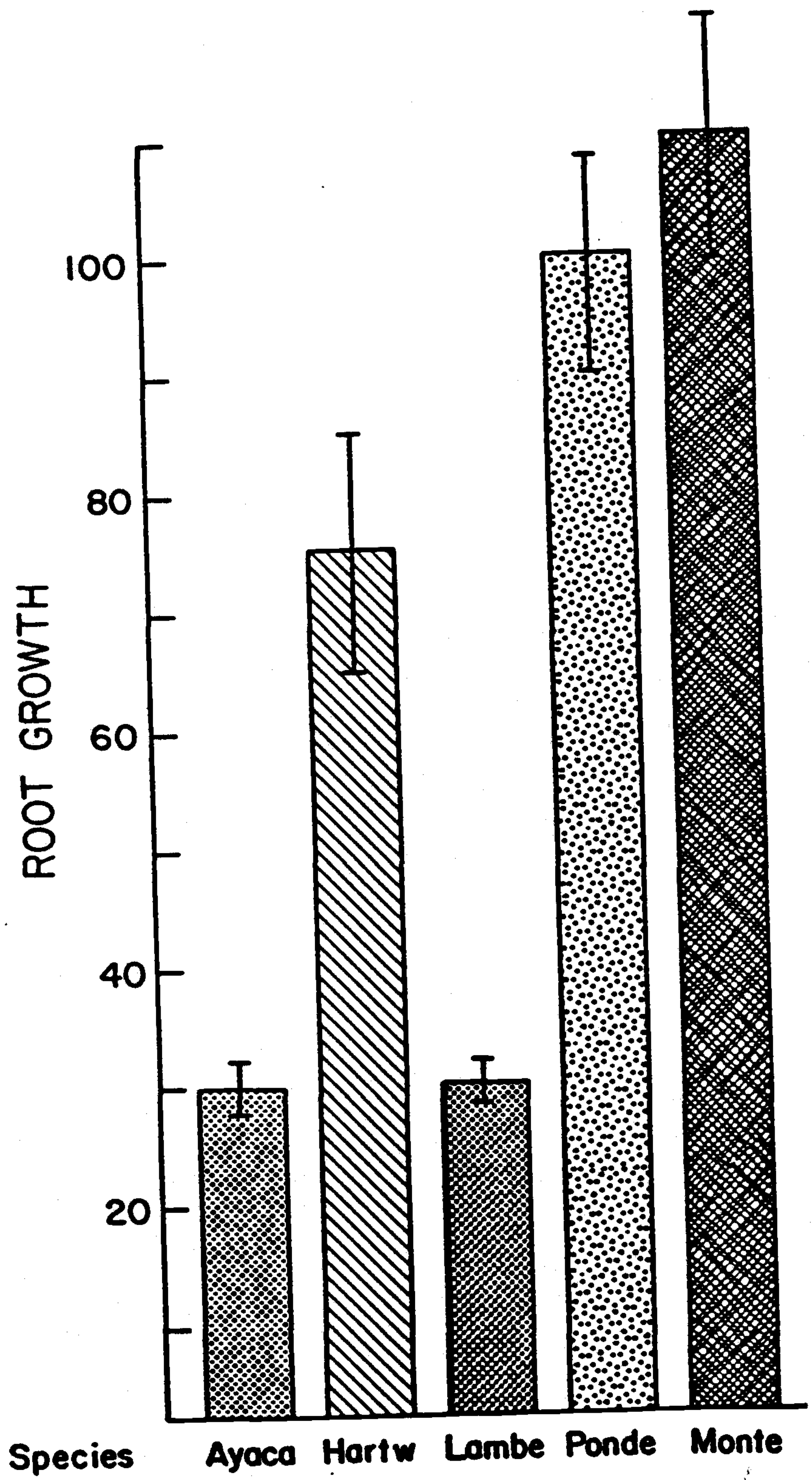


Figure 4.13 Root growth capacity of the different species at planting time. Values are means of 24 seedlings.

5.- DISCUSSION AND CONCLUSIONS

5.1.- General

Successful regeneration is the most important single operation in sustained-yield forest management. The existence of brush-covered areas on forest land is an indication of non-productivity resulting from past regeneration failures. Reforestation or afforestation of potentially productive brushlands depends on methods that are most fitting in a given climate, soil and social situation.

The data reported here help to describe more fully how pines, in general, respond to resources and limitations on them and how certain treatments help to qualify, in a general way, the importance of moisture limitations according to distribution during the year. Finally, they show key interactions useful in prescribing for a range of conditions. Of particular importance are the consistent way five species responded to freedom from shrub competition and the variable way all responded to herbs, depending on rainfall distribution and initial composition.

5.2.- Location, aspect and cover

Location and aspect are not subject to manipulation but have a major role on effects of treatments. The location factor provided differences in season of moisture availability and temperature extremes in which maximum growing-season water and heat stress were observed in Oregon. The tendency for herbs to create lethal moisture stress was substantially reduced by summer rainfall. Additionally, location had a bearing on whether mechanical removal of shrub cover led to different shifts in competitor type, to herbs in Oregon and to resprouting shrubs in Mexico. the herbs created lethal stress in Oregon, but, although present in Mexico, were not a major problem.

The differences among treatments showed similar trends in conifer response in both locations; aspect affected the degree of differences, sometimes obscuring them, sometimes emphasizing them, depending on season. Radiation is one of two key factors being manipulated with changes in location and is the one major environmental variable responding to aspect. The amount of potential incoming radiation for a particular slope on a yearly basis depends on the latitude of the site and the angle and azimuth of the slope. (Garnier and Ohmura, 1968; Swift and Knoerr, 1973).

The slope angle and aspect of the land has been recognized as an important climatological factor causing differences in site quality and a wide array of silvicultural practices, from reforestation to logging and transportation. (Lee and Baumgartner,1966; Stoeckler and Curtis,1960). Solar radiation, as the principal force accounting for most of the differences in heat, evaporative potential and oxidation processes, is a critical control on physical and biological processes. A description of radiation patterns follows.

The annual net radiation income on north and south facing slopes with an angle of 15 degrees at Latitudes of 20, 30, 40 and 50 degrees was obtained from the tables published by Buffo, Fritschen and Murphy (1972). They calculated these values assuming a standard atmospheric transmission coefficient of 0.9.

The values were then linearly extrapolated to obtain an approximate value of yearly averages of direct radiation on the planting sites. The results are as follows (in Cal/ square cm):

Latitude North	North aspect	South aspect
25^{o}	205416	256758
42^{o}	151789	226250

The differences between opposite aspects on the same location are larger than between similar slopes of the same azimuth on different locations. The difference between aspects in Mexico is smaller than that in Oregon because of differences in solar declination.

The annual march of the incoming solar radiation is another important variable to consider. Figure 5.1 (a) shows the typical pattern of this march for a 16 degree slope at 37^{o} latitude, (from Swift and Knoerr, 1973) showing a general picture of north versus south slopes. Figure 5.1 (b) shows the annual march of solar radiation at 25 and 42 degrees north, for a flat surface (from Brown, 1973). The differences between aspects in the same location and between locations are least during the summer and greatest during the winter. Under conditions of similar rainfall, soil temperatures would be nearly comparable during the growing season.

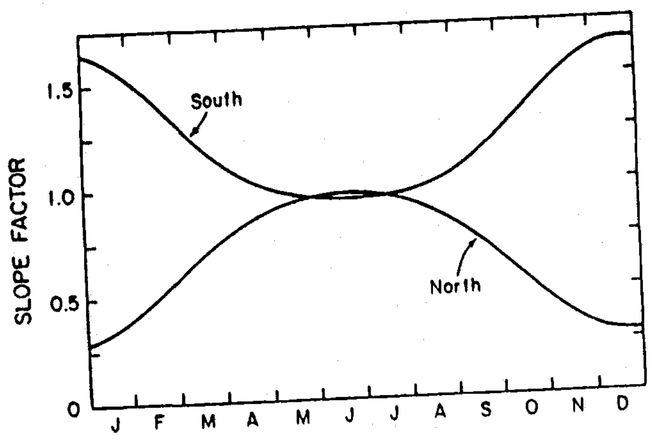


Figure 5.1 (a) Annual march of radiation for a 33 percent slope at 37 degrees latitude, aspects north and south. From Swift and Knoerr, 1973. Slope factor indicates relative differences between aspects.

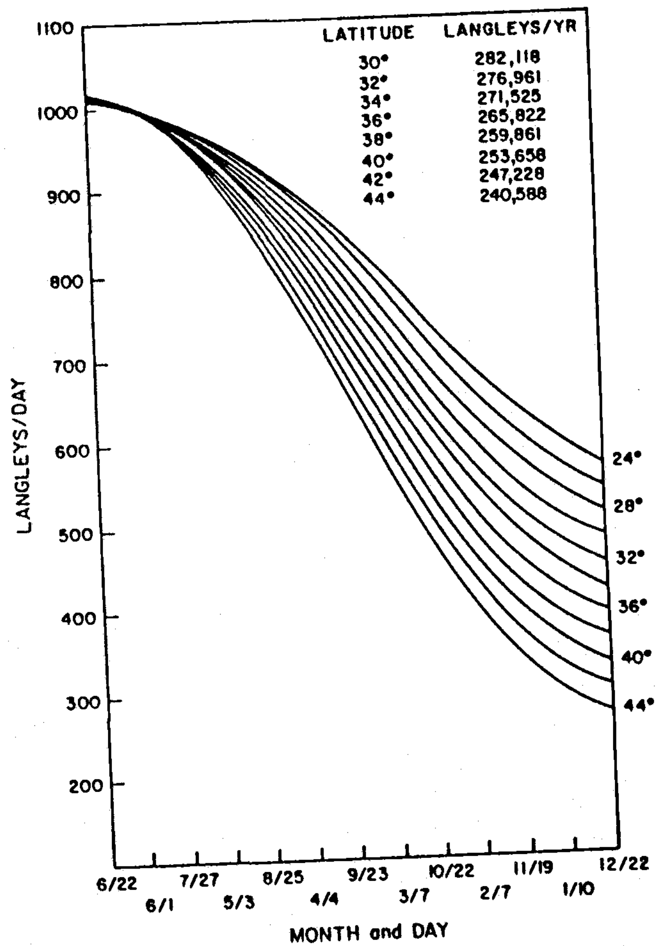


Figure 5.1 (b) Annual march of solar radiation for different latitudes. Adapted from Brown, 1973.

In Oregon, soil temperature differences between aspects increased toward the summer. In Mexico the maximum differences between aspects are recorded during March. The differences caused by the treatments are significant during April and September in Mexico and from May to October in Oregon. The importance of the dry season in stressing differences can not be overlooked: the amount of soil moisture in general, and current rate of precipitation in particular, are the main factors controlling soil temperature. This emphasizes the importance of rainfall distribution and also of those treatments which conserve soil moisture.

5.3 Treatments.-

Plants respond to the combined effect of those components of the environment that directly affect their physiology. The environmental changes brought about by the manipulation of vegetation affected, in the short run, the level of at least the following factors:

Factor	Effect in relation to Control Treatment Herbicide	Simazine		Manual	
Radiant Energy	+	+++	(+)	++	(+)
Evaporation Potential	=	+++	(++)	+++	(++)
Soil Temperature	=	+++	(= or +)	+++	(= or +)
Soil Moisture Availabilty in dry season	+++	+++		++	

Numbers between brackets indicate response in Mexico during the second year.

Eliminating competing vegetation, all or in part, conserved soil moisture effectively, increased the radiation load on the seedlings and on the ground, and increased air temperature, hence evaporation demand. The lack of treatment kept the radiation load on conifers to a minimum, reducing potential evaporation and temperature but strongly reducing the soil moisture availability. Live shade reduced photosynthetically active light below the minimum survival threshold of most pines, especially where aspect and location aggravate the drought. High survival but reduced growth suggest that dead shade reduced photosynthesis significantly.

A proportional increase in photosynthesis results when radiant energy increases if soil moisture and temperature are not limiting. The limit to this relationship is the light saturation point, which is the upper asymptote of photosynthetic rate. This was apparently reached only with complete clearing. Local evaporation potential is the resultant effect of relative humidity, temperature, wind movement and radiation load. These appear to be strongly influenced by differences in location, aspect and degree of overstory removal. The total gain for the seedling (net photosyntesis) is the result of a dynamic equilibrium between photosynthesis and respiration that is mediated by availability and use of soil water. (Larcher, 1977). In this experiment, increments of removal of live cover clearly improved the metabolic environment of all species of pine. This is evidence that the increased availability of soil moisture and radiant energy more than compensated for the increased transpirational demand on the seedlings.

The empirical evidence of environmental change varied with treatment. The cleared sites increased tree growth in general, and increased growth most if further reductions in competition were conducted. Where hand slashing was complemented with simazine, the effect on herb competition was favourable and significant. In those situations where lack of maintenance allowed vigorous shrub resprouting, the effect of the simazine was cancelled. Reflecting the combined effect of location and aspect, differences in conifer mortality and growth between live and dead shade environments reached a maximum on south slopes of Oregon. The differences between the Simazine and the Manual treatment were similarly large. Dead shade in herbicide treatments ameloriated the temperature-related stress, and competition reduction ameloriated the soil-water related stress. In Mexico, under the inluence of surplus summer rainfall, the north slope showed the smallest differences among treatments, and neither north nor south slopes showed differences between the Simazine and manual treatments through year 2. Herb competition appears not to be a major problem where a)- woody species are fully dominant and b).- moisture stress is low during the growing season.

The north aspect of the Mexican site appears to be the coolest and wettest of the four site types during the growing season. The coincidence of rain with summer keeps temperature well below the extremes observed on the south slope of Oregon, which is also the harshest planting site. Conditions of bright sunshine during the early summer season in Oregon raised the soil surface temperatures to extremes for seedling survival. On August 4, 1986, the soil surface in the cleared areas in the south slope was 55 ^{o}C at 14:00 hs.

All treatments were effective in reducing plant cover for 1985 in both locations. The S and H treatments had the least live cover, hence the lowest level of total competition, one year after the treatments were applied. Due to the maintenance applied in Simazine treatments after planting in the Oregon site, the initial differences were still present during the second growing season. The Herbicide treatment did not need maintenance, and it was highly effective in controlling both brush and herbs for two years. In Mexico, brush resprouted vigorously in cleared treatments during the spring of 1985, but aggregate shading in cleared plots was still less than in uncleared. Because of that, the Simazine and Manual treatments formed a single group apart from herbicide and control in which radiation radiation limitation appear to account for differences in observed results Summer rains nearly eliminated competitive differences due to herbs when all cleared plots were under strong influence of shrubs. At the end of the second year it evident that resprouting shrubs are surpassing shading and competition in herbicide plots and that continued control of sprouts will be required in hand cleared operations.

To summarize, each treatment created a unique set of micro-environments for the seedlings planted on them. Factors that modified radiation load and/or transpiration influenced differences among treatments. Occurrence of rainfall during the season of active growth sharply reduced variability among treatments in the first two years.

In relative terms it is possible to qualify each treatment within its location and aspect as follows:

Control.- For each location and aspect, we can conclude that this treatment is characterized in relative terms as having the driest soil, lowest temperature, lowest evaporative demand and lowest photosynthetically active light intensity, and highest probability of mortality and poor growth. Failure was universal.

Herbicide.- This treatment had the least live plant cover, and lowest competition stress for the planted seedlings. SCI was always the highest.

During the first two years of the experiment this was a relatively moist, cool environment, with almost no competition, but excesive dead shade. Survival was near maximum, but early growth less than maximum.

Manual.- This was a hot dry environment, with a high evaporative potential and intermediate competition. It was ineffective on south slopes except for ponderosa pine in Oregon, and reasonably effective where summer rains precluded high moisture stress in Mexico. This treatment usually requires maintenance.

Simazine.- Sparse herb cover, high temperature, moderately moist soil and high evaporative demand characterize this treatment. The SCI was high in 1985 but intermediate in 1986 in Oregon. The level of shrub recovery masked effects of reduced herb cover in the Mexican site.

The treatments were conceptually separated by abiotic and biotic factors. Among the abiotic factors, temperature and evaporation (based on Oregon results) formed two groups: treatments in the cleared area and treatments in the shade. Regarding moisture, Herbicide and Simazine were grouped together, with manual intermediate and control in a third group. Density and type of competition determined rate and depth of moisture loss. It has been documented elsewhere that shrubs consume water faster and for a longer period than herbs and that even shrub cover as low as 25% affects seedling performance in this climatic zone (Oliver,1984). But in Mexico, summer rains negate effects of summer transpiration, bringing shading to preeminence in competitive roles.

The findings reported here for soil moisture trends, evaporation rate and soil temperature in the Oregon sites coincide in a general way with findings by others. Petersen, (1980) found similar trends in soil moisture availabilty and evaporation rates; Stoeckeler and Curtis, (1960) reported the same type of differences between north and south aspects regarding soil moisture; Tappeiner and Helms, (1971), found similar differences in potential evaporation between shady and sunny plots.

Regarding conifer responses to the above factors, two tendencies are clear:

1.- Oregon survival tends to separate Herbicide and Simazine treatments into a high-survival group, with manual in an intermediate and Controls in a third one, that is generally poorer than others.

2.- The increment in height, diameter and volume is higher in the treatments entailing clearing than in standing vegetation in Oregon, Simazine is separated as the treatment with greatest growth by year two.

The high mortality registered for the control treatment indicates that the water stress imposed on the seedlings by the soil moisture deficit was the main factor causing mortality. Reduction of temperature and evaporative demand under the shade of the live cover was not adequate to compensate for low soil moisture. The relatively high survival under the live brush in Mexico suggests that the seedlings can survive for an extended period in deep shade in the absence of high moisture stress.

The correlation of the highest survival rates with the maximum growth can be explained in part by intolerance of the pines. They are among the least tolerant conifer species, and their net photosynthesis rate increases as light and temperature increases in a wide range of conditions (Mirov, 1967). It is evident that the amount of shade they experienced under dead shrubs was enough to decrease growth, despite favorable water balance. The layout of the experiment plus the small size of the treated area may have contributed to reduction of growth in the herbicide plots. Live brush in three sides of each small plot may have caused some depletion of moisture through unsaturated flow because the closest rows were only three meters away from live cover. Although shade from the side and root competition may have accounted for part of this reduction, moisture conditions were still most favorable in this treatment, and no explanation of growth losses other than light limitation appears likely. Indirect evidence would be that on the North slopes, were shrub cover is taller and original leaf area is larger, the differences between control and herbicide treatments will be minimum while in the south slopes, with shorter brush, the differences will be larger. The relative growth means for each treatment and aspect in Table B-3 (a) follow this pattern. Those in Table 4.11 for relative diameter show the same tendency.

Two years is not long enough to show the long-term effects of treatments. When six site preparation treatments were ranked by their values in survival and growth eight years after planting, the ranking order was the same for both parameters on two of three sites for ponderosa pine. Lodgepole pine (P. contorta) presents the same tendency on the only site of that particular study. The statistical separation of treatments started at 3 years after planting. (Ross, 1985). Distinct separation of treatments at year two in this experiment suggests that differences will continue to increase rapidly.

5.4 Species.-

A variety of microenvironments was created in this experiment that offered a "menu" of conditions to a diversity of genotypes represented by the five species. The analysis of variance for survival, relative height growth, and relative diameter increment were run twice: once with the reduced model involving locations, aspects, treatments and replications plus their interactions; the second time with the full model including species and interactions plus those factors in the reduced model, to test for species significance. In all cases, the inclusion of species to the model strongly increased the explanation of variance, indicating that species alone accounted for much of the variation. The increments were :

Variable	R-square	
	Reduced model	Full model
Survival	.57	.84
Rel Ht. Growth	.066	.85
Rel. Vol. Incr.	.34	.80

The initial parameters of the seedlings influenced the outcome of the experiment in a variety of ways. Species that did or did not enlongate accounted for much variation in growth. Those seedlings passing trough a grass stage, for example, were often partly covered by litter and soil reducing their photosynthetic area. Additionally, the proximity to the ground of foliage and buds put them under stronger temperature stress.

Shading tended to reduce the period of bud activity. Deviations from this pattern can be explained largely by the diversity of developmental patterns in pine shoots represented in this experiment. P. ayacahuite belongs to the subgenus strobus, which shows a tendency to extend its annual shoot growth by both free and fixed growth. The spring shoot (fixed) represents most of the terminal enlongation, while summer shoots (free) usually are a minor part. (Lanner, 1976).

Grass-stage species (P.hartwegii and P. montezumae) have little fixed growth and no free growth in their first two years.

P. ponderosa and P. lambertiana have monocyclic spring shoots; winter buds elongate during the first part of the growth season, and then another winter bud is formed which will elongate next spring; all growth is fixed (Kozlowski, 1962; Lanner, 1976).

Growth of P.lambertiana was affected by location; in Mexico, height growth was poor even where survival was good. The poor growth of P.lambertiana may have been associated with its performance in the root growth capacity test and also with day length.

In areas where spring soil moisture is deficient, as in Mexico, height growth is correlated with current-season rainfall or soil moisture content (Kozlowski, 1962). In Arizona, for example, ponderosa pines make their height growth during the dry season and are strongly influenced by stored soil moisture and occasional spring rains. In this experiment, spring soil moisture was augmented by treatment in both locations.

In Oregon, early spring soil moisture is abundant. Height growth and bud activity are largely dependent on the moisture conditions of the previous growing season and the temperature conditions of the current spring. Treatments that prolong soil moisture availability late in the summer and increase radiation early in the spring will give the seedlings the best conditions for growth. This entails transpiration reduction in spring and summer.

In Mexico, spring soil moisture is generally deficient and height growth is correlated with current moisture availabilty. Conserving moisture through winter is neccesary for strong height growth early in the season if light is not limiting. Transpiration reduction in summer is not important here, but moisture conservation in fall, winter and spring is needed.

According to Cannell et al (1976), the times when shoots elongate differ greatly between years and site irrespective of genotype; the relative differences among genotypes are maintained, however, and depend both on inherited differences in responsiveness to environmental conditions and number of stem units (histologically speaking) present in the winter buds. The more stem units accumulated in the winter buds, the stronger the need to enlongate faster or longer. These two forces are acting simultaneously, but depend on different events. Current responses to environment depend on present conditions, while the number of stem units is determined by the conditions prevalent during the past year. This probably explains in part why, maximum survival and maximum growth did not often coincide.

Diameter growth depends primarly on current-year conditions. An early bud setting will allow the seedlings to fully take advantage of remaining moisture for other uses i.e. diameter growth, bud formation and root growth. This seems to be more important where soil moisture and temperature conditions are rapidly deteriorating, like in Oregon. Here, P. ponderosa showed the shortest period of shoot activity and it grew more Than P. ayacahuite in absolute diameter and height.

In the Mexican sites, an opportunistic height growth pattern will allow seedlings to fully take advantage of the climate, since dry spells are not uncommon even in the middle of the rainy season. Here, P. ayacahuite grew more than P. ponderosa in absolute height.

The large increase in height reported here for P. montezumae in cleared plots agrees with findings by Pessin (1944) and Walker and Wiant,(1966) for P. palustris, which also responded vigorously in plots free of competing vegetation. More intense and longer exposure to light appears to stimulate the seedlings to break the grass stage.

Differences among species appart from those with grass stages reflect differences in strategies adapted to native environments. The purpose of this section is to integrate the relevant information on this topic and to offer consistent explanations about the response of each species as expressed in height growth. Figure 4.10 provides evidence that P.ayacahuite switches places with P. ponderosa in the two locations. Ponderosa pine has a wide range of tolerance for drought and heat damage. Despite its general intolerance it was able to handle shade relatively well in this experiment, according to its mortality and growth rates. Its best growth performance was in Oregon on a weeded south slope that offered good spring conditions but harsh summer conditions. Having all that potential, reflected also in the results from the Root Growth Capacity Test, what kept it from growing more in the mild, wet summer offered by the North slope in Mexico? It is postulated that the the inflexibility of its spring shoot growth pattern is a key factor. In the Mediterranean-type climate of Oregon, the predictability of soil moisture content and temperature for the spring season is high. It was in this condition that this provenance of P. ponderosa evolved. Fast enlongation followed by budset and building of a new bud is the only strategy with reasonable probabiltiy of success without silvicultural intervention. When transported to a summer-rain climate, it cannot express its normal tendencies because of the dry spring. This condition limits early-season growth and its innate habit prevents summer season elongation. It may divert photosyntate allocation to other processes, perhaps storing carbohydrates for the next spring. When the next spring comes, the limiting soil moisture may again reduce its potential growth. The short period of height growth, on the other hand, was translated into the largest diameter increment, a factor that may have a later positive influence on total growth (Newton,M. and E.C. Cole, 1986. Unpublished data, O.S.U., Dept. of Forest Science).

P. ayacahuite combines the security of the fixed-growth spring shoot pattern with the opportunistic free growth of summer shoot. This seems to be an advantageous strategy in a climate where two growing seasons are separated by two unfavourable periods: one dry and warm, the other one frosty. As pointed out by Lanner (1966), the duration of winter bud formation determines the potential length of the next year's growth.

The same characteristics that give P. ayacahuite its best performance in Mexico harms it in Oregon. By remaining "open" to growth, the seedlings are more easily subjected to late season heat and drought damage, as corroborated by its altitudinal distribution. P. ayacahuite bud-formation timing is somewhat out of phase in oregon. Survival and growth of this species suffered more in Oregon than in Mexico, under comparable treatments.

Sugar pine posseses the same type of inflexible spring shoot- growth discussed above for ponderosa pine. In addition, it shows the least drought resistance (Pharis, 1966) and the poorest root growth capacity. The three combined factors were devastating for sugar pine. in the Mexican plots, the soil is at field capacity by the end of September,. Then, a short dry period, accompanied by transpiration on the evergreen shrub and conifers, occurs during October-November. During the cold December and January period, occasional snowfall and rain help to maintain the soil moisture, but at less than complete recharge. By March, after the short winter, the rapid drying process starts, reducing the spring water availabilty in the surface soil where transpirational depletion is unchecked. If seedlings are to survive, their roots must grow fast and early (i.e. during fall and winter), in order to keep pace with the rapidly falling moisture availability. Sugar pine was unable to meet those requirements at least in part, because of its original low root growth capacity. Studies by others, have shown that P. lambertiana in its original area of distribution has a very short enlongation period (Fowells,1941). If this tendency has persisted in the Mexican location, then the opportunities for finding or creating appropiate conditions in Mexico are much less for this species than for others.

5.5 Silvicultural implications.-

The correct anticipation of planting success is fundamental to the task of prescribing vegetation management practices for forest regeneration. Here, woody plant removal was associated consistenly with maximum growth; Herb removal was tied to survival under conditions of summer moisture stress. If maximum timber production is the goal, then maximum survival can be achieved by herb and woody plant suppression to produce regularly stocked, fast-growing stands. If they are not growing at maximum potential rate, they can be managed to do so. A poorly or erraticaly stocked stand does not offers this option, nor does a stand with adequate survival but chronic woody competition.

Despite the current growth rates, it is predicted that the herbicide treatment, applied in areas larger than those used in this experiment, will produce maximum timber production on south slopes in the long run. Clearing is likely to improve performance on north slopes if brush is treated first with systemic herbicides. Figure 5.2 anticipates the projected trajectories for competitive plant cover and pine plant cover, assuming no corrective measures are taken after initial site preparation.

In places with a long dry season, where the soil is relatively shallow, the topography steep and the rain falls as thunderstorms, like in Mexico, a site preparation method is required which, while controlling long-term competing (i. e. woody) vegetation, also reduces the risk of erosion, leaching and and fire. Removal of all non-coniferous cover is the principal component of success in this circumstance. Each specific combination of climate, topography and vegetation will qualify the merits of each approach. The major constraints for seedling survival and growth must be identified and the possible outcomes of practices evaluated in terms of biological and economic considerations, along with those of the local work force and availability of tools such as herbicides.

In summary, several findings here may improve reforestation success in one or both countries:

1) Dense woody cover is incompatible with seedlings of all pines, regardless of distribution of seasonal rain or aspect.

2) Dead woody cover reduces growth of pine seedlings in the first two years, despite having excellent moisture conservation properties.

3) Clearing all woody cover leads to best seedling growth, regardless of rainfall distribution, but herb control is also essential where summers are dry.

4) Were woody species sprout vigorously, the improvement in environment provided by cutting is temporary unless complemented by herbicidal treatment or repeated cutting.

5) A soil conditions index, based on soil moisture and temperature is significantly correlated with survival of all five pine species.

6) Combinations of herbicides and manual clearing methods can provide for environmental needs for five species of *Pinus* under a wide variety of conditions.

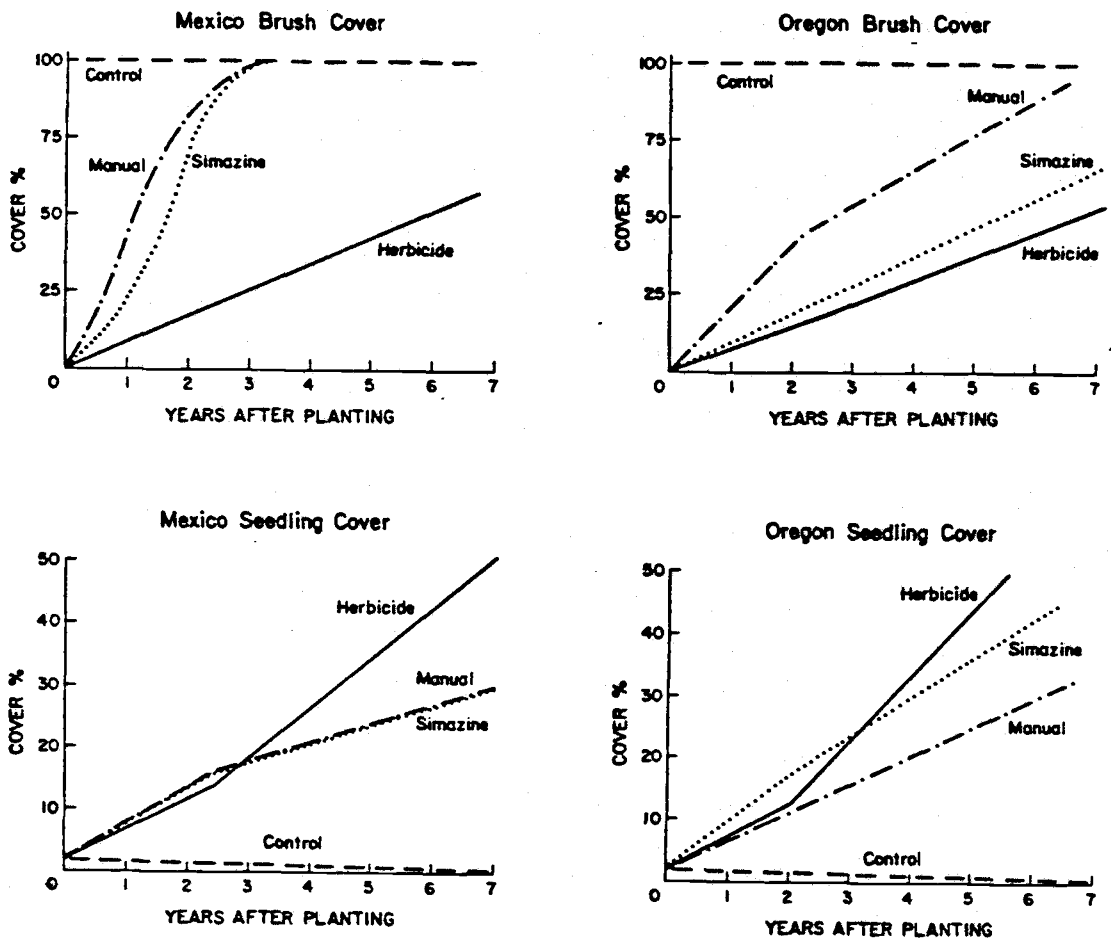


Figure 5.2 Projected trajectories of plant cover for the different treatments and locations. Conifer cover based on 700 planted trees per acre (1750 per ha).

BIBLIOGRAPHY

Anonymous, 1955. California's Forest Regeneration Problems. Calif. State Board of Forestry. Prepared by The Forest Regeneration Committee, F.S. Baker Chairman. Sacramento.

Atzet, T. 1981. Operational Environment and Factors Limiting Reforestation in the Siskiyou Mountains. IN: Reforestation of Skeletal Soils. Ed. by S.D. Hobbs and D.T. Helgerson, Forest Research Laboratory. O.S.U. Corvallis.

Baker, F.S. and Korstian, C.F. 1931. Suitability of Brush Lands in the Intermountain Region for the Growth of Natural or planted Western Yellow Pine Forests. Tech. Bull. No. 256. USDA. 83.P.

Baron, F.J. 1962. Effects of different grasses on ponderosa pine seedling establishment. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Research Note 199, 8p.

Barrett, J.W., and C.T. Youngberg. 1964. Effect of tree spacing and understory vegetation on water use in a pumice soil. Soil Science Society of America Proceedings 29:472-475.

Bentley, J.R., S.B. Carpenter, and D.A. Blakeman, 1971. Early brush control promotes growth of ponderosa pine planted on bulldozed sites. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Research Note PSW-238. 6 pp.

Billings, W. D., 1974. Environment: concept and reality. In Handbook of Vegetation Science, part VI: Vegetation and Environment. B.R. Strain and W.D. Billings, eds. Dr. W. Junk B.V. Publishers. The Hague.

Brender, E.V. and T.C. Nelson. 1952. Re-establishing pine on piedmont cut-over land. USDA Forest Service Station Paper No. 18, South-Eastern Forest Experiment Station.

Brown, James M., 1973. Tables and conversions for microclimatology. USDA For. Ser. North Central For. Exp. Sta. General Technical Report NC-8.

Bonilla B.R. and Avila, H.M. 1980. Aspectos Politicos de las Plantaciones Forestales. In Memoria de la Segunda Reunion Nacional. Plantaciones Forestales. Publicacion Especial No. 33. INIF Mexico.

Burns, R.M. and Hebb, E.A. 1972. Site preparation and reforestation of droughty, acid sands. USDA Forest Service Agriculture Handbook No. 426, 61pp.

Buffo, John, Leo Fritschen, and James Murphy. Preparation and reforestation. 1972. Direct solar radiation on various slopes from 0 to 60 north latitude. USDA Forest Serv. Res. Pap. PNW-152, 74p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, OR. Handbook No. 426, 61pp.

Cain, M.D. and W.F. Mann, Jr. 1980. Annual Brush Control Increases Early Growth of Loblolly Pine. South Jour. Appl. For. 4 (2): 67-70.

Capo-Arteaga, M.A. 1972. Observaciones Sobre la Taxonomia y Distribucion de la Coniferas de Nuevo Leon, Mexico. Tesis. U.A.N.L. Monterrey, Mexico.

Cannell, M.G.R., S. Thompson and R. Lines 1976. An analysis of inherent differences in shoot growth within some north temperate conifers. In: Tree Physiology and Field Improvement. Ed. by M.G.R. Cannell and F.T. Last. Academic Press.

Cleary, Brian D., Robert D. Greaves and Richard K. Hermann. 1978. Ecological Principles. In: Regenerating Oregon's Forests. Oregon State University Extension Service. Corvallis, OR.

Conrad, S.G., A.E. Jaramillo, K. Cromack, Jr., and S. Rose. 1985. The role of the genus Ceanothus in western forest ecosystems. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. General Technical Report PNW-182. 72 p.

Crouch, Glenn L. 1979. Atrazine improves survival and growth of ponderosa pine threatened by vegetative competition and pocket gophers. Forest Service; 25 (1): 99-111 p.

Dajoz, R. 1974. Tratado de Ecologia. Ediciones Mundi-Prensa, Madrid.

Debazac. E.F., 1964. Note sur le comportement en France de quelques Pins Mexicains. Revue Forestiere Francaise 16(12): 929-935.

Durland, W.D. 1931. Mexico's Pine Forests. American Forest 37:348-364.

Eguiluz, P., Teobaldo. 1978. Ensayo de Integracion de los Conocimieutos sobre el Genero Pinus en Mexico. Tesis. U.A.C.H. Chapingo, Mexico.

Flint, Lorraine E., 1985. Effects of soil surface shading, mulching and vegetation control on douglas-fir seedlings growth and microsite water partitioning. M.S. Thesis Oregon State University.

Fowells, H. A., 1941. The period of seasonal growth of ponderosa pine and associated species. J. For. 39:601-608.

Ganguli, B.N., 1967. Mexican Pines and their possibilities in India. Indian Forester 93 (9): 633-645.

Gonzalez, H. 1978. Evaluacion del Crecimiento en las pantaciones forestales de la Cuenca de Cointzio Thesis. UACH. Chapingo, Mexico.

Gottfried, G.J. 1980. Control of New Mexican Locust and the effect on planted Ponderosa pine in Central Arizona. USDA Forest Service REs. Note. Rm-386. 6p.

Gratkowski, H.J. 1967. "Ecological Considerations in Brush Control. IN: Herbicides and Vegetation Management." M. Newton (ed). School of Forestry, Oregon State Univers., Corvallis.

Griffith, A.L. and W.G. Dyson. 1962. Plantation and Management. IN: Seminar and Study Tour of Latin-American Conifers S.A.G. - I.N.I.F. - F.A.O., Mexico.

Grime, J.P., 1981. Plant strategies of vegetation processes. John Wiley & Sons, Ltd.

Grubb, P.J. 1977. The Maintenance of species-richness in plant communities: the importance of the regeneration niche. Biol. Rev. 52:107-145.

Harper, John L. 1977. Population Biology of Plants. Academic Press. London, New York, San Francisco.

Heidmann, L.J. 1969. Use of herbicides for planting site preparation in the southwest. Journal of Forestry 67:506-509.

Heidmann, L.J., Johnsen Jr., T.N., Cole, Q.N. and Cullum, G. 1982. Establishing natural regeneration of ponderosa pine in Central Arizona. Journal For. 80 (2): 77-79.

Helgerson, O.T., and J.D. Bunker. 1985. Alternate Types of artificial shade increase survival of Douglas Fir <u>Pseudotsuga menziesii</u> (Mirb.) Franco seedlings in clearcuts. Tree Planter's Notes Vol. 36(4):7-12.

Hermann, R.K. 1968. A watering Experiment with sown ponderosa pine in central Oregon. Northwest Science, 42(2): 47-52.

Hernandez, C. 1974. Comparacion de tres metodos de preparacion al terreno con fines forestales. Thesis. ENA Chapingo, Mexico.

Hobbs, J.D., John C. Gordon and G. W. Brown. 1983. Research and Technology transfer in southwest Oregon. J.For 81(8): 534-536.

Knowe, S.A.; Nelson, L.; Gjerstad, D.H.; Zutter, B.R.; Glover, G.R.; Minogue, P.J. and James H. Dukes Jr. 1985. Four-year Growth and Development of planted Loblolly Pine on sites with competition control. South. Journal Appl. For. 9(1): 11-14.

Kozlowski, T.T., 1962. Photosynthesis, climate and tree growth. <u>In</u>: Tree Growth. Edited by T.T. Kozlowski. The Ronald Press Company.

Lanner, R.M. 1976. Patterns of shoot development in <u>Pinus</u> and their relationship to growth potential. In: Tree Physiology and Yield Improvement. Edited by M.G.R. Cannell and F.T. Last. Academic Press.

Lanini, W.T., and S.R. Radosevich. 1986. Response of three conifer species to site preparation and shrub control. Forest Science 32:61-77.

Larcher, W.T. 1977. Ecofisiologia vegetal. Ediciones Omega, Barcelona.

Larson, M.M. and G.H. Schubert. 1969. Effect of Osmotic Water Stress on Germination and Initial Development of Ponderosa Pine Seedlings. For. Sci., 15(1):30-36.

Larson, M.M. and G.H. Schubert. 1969. Root Competition Between Ponderosa Pine Seedlings and Grass. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Missoula, Montana. Research Paper RM-54. 12 p.

Lavender, D.P. 1981. Environment and Shoot Growth of Woody Plants. Forest Research Laboratory, Oregon State University Corvallis. Research Paper 45. 47p.

Lee, Richard and Albert Baumgartner, 1966. The topography and insolation climate of a mountanous forest. For.Sci.12(3): 258-267.

Little Jr., E.L. 1962. Variation and Evolution in Mexican Pines. Seminar and Study Tour of Latin-American Conifers. S.A.G.-I.N.I.F.-F.A.O. Mexico.

McClain, Keith M.,1985. Water relations and associated morphology of conditioned Douglas-fir and Jack-pine seedlings subjected to periods of drought stress. Ph. D. Thesis, O.S.U.

Marx, D.H. 1975. Mycorrhizae of Exotic Trees in the Peruvian Andes and Synthesis of Ectomycorrhizae on Mexican Pines. Forest Sci., 21(4):353-358.

Mason, H.L. and Jean H. Langenheim. 1957. Language Analysis and the Concept Environment. Ecol., 38:325-340.

Mathus, M.A. 1978. Aspectos Tecnicos de la Plantacion de Pinos Tropicales en la Sabana, Distrito Mixe, OAXACA. In: Memoria

Primera Reunion Nacional. Plantaciones Forestales. S.A.R.H. F.F., D.G.I.F. Pub. Esp. No.13. Mexico.

Meagher, G.S. 1943. Reaction of Pinyon and Juniper Seedlings to Artificial Shade and Supplemental Watering. J. For., 41(7): 480-482.

Merril, S., and W.W. Kilby. 1952. Effect of cultivation, irrigation, ferilization and other cultural treatments on growth of newly planted Tung trees. Proc. Amer. Soc. Hort. Sci., 59:69-81.

Michael, S.L. 1980. Long-Term impact of aerial application of 2,4,5-T to Longleaf Pine (Pinus Palustris). Weed Sci., 28(4):255-257.

Minckler, L.S. and Russell A. Ryker. 1959. Partial conversion of poor hardwood stands to Conifers by planting. U.S.D.A. For. Ser. Technical Paper No.159.

Minore, D. 1971. Shade benefits Douglas-Fir on South Western Oregon cutover areas. Tree Planters' Notes, 22(1):22-23.

Minore, D. 1971. The dead Indian plateau: A Historical summary of forestry observations and research in a severe Southwestern Oregon environment. U.S.D.A. For. Serv. Pacific Northwest Forest and Range Exp. Sta. General Technical Report PNW-72. 23 p.

Mirov, N.T. 1967. The Genus Pinus. Ronald Press. New York. 602 p.

Mirov, N.T. 1954. Composicion de las Trementinas de los Pinos Mexicanos. Unasylva, 8(4):186-192.

Montenegro, Mejia, E. 1957. Possibilities for introducing some Conifers from Mexico and Central America into Colombia. Tesis Mag. Agr. Turrialba, Costa Rica. IICA.

Muelder, D.W., John C. Tappeiner and Jack H.Hausen. 1963. Measurement of potential evaporation rates in ecology and silviculture with particular reference to the piche Atmometer. J. For., 61:840-846.

Nelson, Larry R., Richard C. Petersen, Larry L. Autry, S. Dudley and S.D. Walstad. 1981. Impacts of herbaceous weeds in young Loblolly Pine Planations. South. J. Appl. For., 5:153-158.

Newton, M. 1964. The influence of herbaceous vegetation on Coniferous seedling habitat in old field plantations. Ph.D. Thesis. Oregon State University. Corvallis.

Newton, M. 1973. Forest rehabilitation in North America: Some simplifications. J. For., 71(3):159-162.

Newton, M. 1981. (a) Chemical Management of Herbs and Sclerophyll brush. In: Reforestation of skeletal soils. Edited by S.D. Hobbs and O.T. Helgerson. Oregon State University. FRL. Corvallis.

Newton, M. 1981. (b) Ecological principles of weed control in forestry. Proceedings of the 1981 John S. Wright Forestry Conference Weed Control in Forestry Management. Purdue University.

Oliver, W.W. 1984. Brush reduces growth of thinned Ponderosa pine in northern California. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California. Research Paper PSW-172. 7p.

Outcalt, Kenneth W. and R.H. Brendemuehl. 1984. Sand pine survival and growth on prepared and unprepared sites. Southern J. of Appl. For., 8(2):96-99.

Patino V., F. and L. Vela. 1981 (criteria for the establishment of forest plantations by ecological area) In: Plantaciones Forestales. Memoria. Segunda Reunion Nacional. Publicacion Especial No.33. I.N.I.F. Mexico.

Pearson, G.A.. 1934. Grass, pine seedlings and grazing. J. For., 32:545-555.

Pearson, G.A.. 1942. Herbaceous vegetation as a factor in the natural regeneration of Ponderosa pine in the Southwest. Ecol. Monogr., 12:315-338.

Pessin, L.J.. 1944. Stimulating the early height growth of Longleaf pine seedlings. J. For., 42(2):95-98.

Petersen, T.D. 1980. First year response of Douglas fir after release from snowbrush Ceanothus. M.S. Thesis. Oregon State University. Corvallis.

Pienaar, L.V., John W. Rheney and B.D. Shiver. 1983. Response to control of competing vegetation in site-prepared pine plantations. South J. Appl. For., 7(1):38-45.

Pimentel B., Luis. 1978. Preparacion de Terreno en plantaciones forestales. Memoria de la primera reunion nacional de plantaciones forestales. Pub. Esp. No.13. INIF. Mexico.

Preest, David S. 1975. Effects of herbaceous weed central on young Douglas-fir moisture stress and growth. Ph.D. Thesis. Oregon State University. Corvallis.

Preest, David S. 1973. Summer soil moisture dynamics in a young Douglas-fir plantation as influenced by three herbaceous weed communities. M.S. Thesis. Oregon State University. Corvallis.

Radosevich, Steven R. and Jodie S. Holt. 1984. Weed ecology-Implications for vegetation management. Wiley-Interscience.

Ramirez, M., H., and J.M. Torres Rojo. 1984. Analisis del desarrollo y Estado actual de las experiencias practicas y tecnicas en la evaluacion de plantaciones. In: Plantaciones forestales. Tercera Reunion Nacional, August, 1984. Mexico.

Ross, D.W. 1985. The effects of mechanical and chemical site preparation on Ponderosa pine (Pinus Ponderosa Douglas Ex Laws.) and Lodgepole Pine (Pinus Contorta Couglas ex Loud.) Performance, associated vegetation, and soil properties in

Southcentral Oregon eight years after planting. M.S. Thesis. Oregon State University. Corvallis.

Ross, D.W. and J.D. Walstad. 1986. Vegetative competition, site-preparation, and pine performance: a literature review with reference to Southcentral Oregon. FRL. Oregon State University. Corvallis. Res. Bull. 58. 21 pp.

Rzedowski, J. 1978. Vegetacion de Mexico. Ed. Limusa, S.A. Mexico D.F. 431 pp.

Schubert, G.H., L.J. Heidmann and M.M. Larson. 1970. Artificial reforestation practices for the Southwest. USDA For. Ser. Agri. Hdbk. No.370. 25 pp.

Schubert, G.H., and R.S. Adams. 1971. Reforestation practices for conifers in California. State of California, Department of Conservation, Div. of Forestry, Sacramento. 359 pp.

Schubert, Gilbert, H. 1974. Silviculture of Southwestern ponderosa pine: the status of our knowledge. USDA For. Serv. Res. Pap. RM-123. 71p. Rocky Mt. For. and Range Exp. Stn; Fort Collins, Colorado.

Spurr, Stephen H. and Burton V. Barnes. 1973. Forest Ecology. The Ronald Press Co. New York.

Stein, W.I. 1955. Some lessons in artificial regeneration from Southwestern Oregon. Northwest Sci., 29(1):10-22.

Stoeckler, J.H. and Willie R. Curtis, 1960. Soil moisture regime in Southwestern Wisconsin as affected by aspect and forest type. J. For.58:892-896.

Stone, E. C. and Edward A. Norberg. 1979. Use of Root growth capacity in developing propagation regimes, storage criteria and nursery stock certification. Presented at Symposium on regeneration and management of young True Fir Stands. Redding, California.

Stewart, R.E., L.L. Gross, and B.H. Honkala. 1984. Effects of competing vegetation on forest trees: a bibliography with abstracts. USDA Forest Serv., Washington, DC. General Technical Report WO-43.

Stewart, R.E., and T.Beebe. 1974. Survival of ponderosa pines following control of competing grasses. Western Society of Weed Sci. Proc., 27:55-58.

Swift, Lloyd W. and Kenneth R. Knoerr, 1973, Estimating solar radiation on Mountain slopes. Agricultural Meteorology 12:329-336.

Tappeiner, J.C.,II, and John A. Helms. 1971. Natural regeneration of Douglas-fir and white fir on exposed sites in the Sierra Nevada of California. The American Midland Naturalist. 86(2):358-370.

Tappeiner, J.C., II, and S.R. Radosevich. 1982. Effect of bear-mat (Chamaebatia foliolosa) on soil moistrue and ponderosa pine (Pinus ponderosa) growth. Weed Sci., 30:98-101 pp.

U.S.D.A. Soil Conservation Service. 1986. State of Oregon General Soils Map.

Valdez Tamez, V. 1981. (contribution to the knowledge of the vegetation types, its chartography and notes Floristic-Ecological of the Municipio Santiago, N.L. Mexico) Thesis. Universidad Autonoma de Nuevo Leon. F.C.B. Mexico. (Spanish).

Verduzco, J. 1962. Artificial establishment of forest stands. In: Seminar and study tour of Latin-American Conifers. S.A.G.-I.N.I.F.-F.A.O. Mexico.

Wakeley, P.C. 1954. Planting Southern Pines. USDA For. Serv. Agric. Mono. No. 18.

White, E. Diane. 1986. Effects of whiteleaf manzanita on Douglas-fir and Ponderosa Pine: water use strategy and growth. Proceedings 7th Annual Forest vegetation Management Conference.

Walker, L.C. and Harry V. Wiant, Jr. 1966. Silviculture of Longleaf Pine. Stephen F. Austin State College, School of Forestry. Nacogdoches, Texas. Bull. No. 11.

Waring, R.H. and R.K. Hermann. 1966. A modified piche evaporimeter. Ecol., 47(2):308-310.

Weaver, J. and Clements. 1944. Ecologia Vegetal. Acme Agency. Buenos Aires.

Zahner, R. and F.W. Withmore. 1960. Early growth of radically thinned Loblolly Pine. J. For., 58(8):628-634.

Zavitkovski, J., M. Newton and B. El-Hassan. 1969 Effects of snowbrush on growth of some conifers. J. Forestry 67: 242-246.

Zavitkovski, J., and E.S. Woodard. 1970. Role of brush in Ponderosa pine establihsment. In: Regeneration of ponderosa pine. Ed. by R.K. Hermann. O.S.U. School of Forestry, Corvallis.

Zerecero L. R.E., 1978. Preparacion de Terrenos con especial interes en "Maquinaria Pesada." Memoria de la Primera Reunion Nacional de Plantaciones Forestales. Pub. Esp. No. 13. INIF. Mexico.

Zobel, B.J. 1961. Pines in the tropics and sub-tropics, Proc. IUFRO, 13th Congress Vienna, Austria, Vol. 1 (22/10), pp.1-9.

APPENDIX A

Table A-1.Climatological Data from Stations near the Planting Sites.

Station	Coordinates	Years Recording		J	F	M	A	M	J	J	A	S	O	N	D	Aver.
Saltillo Coah. Mexico	25o 25' 101o 0' El 1589 m	T 31	T (oC)	12.1	13.5	15.9	19.0	21.4	22.7	22.2	22.2	20.0	17.5	14.2	12.1	17.7
		P 35	P (mm)	10.3	10.6	6.0	14.6	25.1	41.0	51.9	45.9	47.7	24.4	12.3	14.1	303.9
San Antonio LasAlazanas, Coah. Mexico	25o 15' 100o 35' El 2138 m		T (oC)	NO RECORDS												
		P 15	P (mm)	28.8	17.2	16.7	17.8	30.9	50.3	61.1	65.9	58.5	39.0	19.4	12.6	418.1
Arteaga, Coah. Mexico	25o 27' 100o 51' El 1610 m	T 5	T (oC)	18.5	20.6	21.4	25.3	26.9	27.6	25.2	26.5	25.4	25.3	21.4	19.6	23.6
		P 18	P 18	4.1	13.1	6.4	16.9	25.1	37.3	48.4	50.1	61.4	37.7	12.3	6.5	319.3
Exp. Station, Medford, OR U.S.A.		T 23	T (oC)	2.8	5.0	7.2	10.6	13.9	16.9	20.7	19.6	16.9	11.3	6.1	3.5	11.2
		P 23	P (mm)	81.0	66.2	49.0	24.2	40.7	27.7	7.2	6.0	18.7	53.0	68.2	86.0	528.0
WB Station, Medford, OR U.S.A.		T 31	T (oC)	2.9	5.7	7.9	11.4	14.7	17.9	22.4	21.7	18.3	12.5	6.6	3.9	12.2
		P 31	P (mm)	78.0	59.4	43.5	26.5	36.7	25.5	5.2	4.5	15.0	48.5	65.0	84.5	494.0

Table A-2 Results of Soil Analysis from Samples Taken at Sykes Creek and Arteaga sites, 10-30 cm depth.

Soil Property	Oregon South	Oregon North	Mexico South	Mexico North
Organic matter	01.00%	2.8%	4.17%	1.7%
Available N	23.5 kg/ha	68 kg/ha	101.2 kg/ha	16.4 kg/ha
Available P	23.0 kg/ha	78.5 kg/ha	13.6 kg/ha	16.4 kg/ha
Available K	275.0 kg/ha	290 kg/ha	134.23 kg/ha	135 kg/ha
pH	6.8	7.1	6.97	7.2
Total carbonates	0.005%	0.005%	11.57	4.5%
Electric conductivity	.25 mmhos/cm	.38 mmhos/cm	.86 mmhos/cm	.617 mmhos/cm
Sand/silt/clay	64/22/14%	58/25/17%	33/16/50%	19/30/51%

Table A-3 Percent Plant Cover after Treatments.

TMT	Oregon 1985		Oregon 1986		Mexico 1985		Mexico 1986	
	N	S	N	S	N	S	N	S
Simazine	20.00	7.50	16.8	28.25	15.5	6.94	80	68
Manual	26.67	31.25	31.2	52.4	33.5	17.64	84	73
Herbicide	18.33	9.17	25	16	7.5	4.44	16.5	20.5
Control	112.5	100	108	102	107.5	104.75	100	104

Table A4.- Plant Cover: ANOVA results.

General Linear Models Procedure

Dependent Variable: COVER

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	101186.3385	4216.0974	42.06	0.0001
Error	39	3909.6267	100.2468		
Corrected Total	63	105095.9653			

R-Square	C.V.	Root MSE	COVER Mean
0.962799	25.706983	10.01233	38.94791667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
LOC	1	191.36111	191.36111	1.91	0.1749
ASP	1	895.00694	895.00694	8.93	0.0048
TMT	3	99267.54427	33089.18142	330.08	0.0001
REP	3	97.17535	32.39178	0.32	0.8086
LOC*ASP	1	0.11111	0.11111	0.00	0.9736
LOC*TMT	3	122.64844	40.88281	0.41	0.7482
ASP*TMT	3	58.23872	19.41291	0.19	0.9001
TMT*REP	9	554.25260	61.58362	0.61	0.7773

Tukey's Studentized Range (HSD) Test for variable: COVER

NOTE: This test controls the type I experimentwise error rate, but generally has a higher type II error rate than REGWQ.

Alpha= 0.05 df= 39 MSE= 100.2468
Critical Value of Studentized Range= 3.795
Minimum Significant Difference= 9.4988

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	106.188	16	C
B	27.260	16	M
C	12.484	16	S
C			
C	9.859	16	H

Table A-5(a).- Soil temperature in Mexico, March of 1985

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	302.8515625	23.2962740	24.64	0.0001
Error	18	17.0156250	0.9453125		
Corrected Total	31	319.8671875			

R-Square	C.V.	Root MSE	TEMP1 Mean
0.946804	7.4166146	0.9722718	13.10937500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	291.007812	291.007812	307.84	0.0001
TMT	3	1.023437	0.341146	0.36	0.7820
REP(ASP)	6	8.171875	1.361979	1.44	0.2537
ASP*TMT	3	2.648437	0.882813	0.93	0.4447

Tukey's Studentized Range (HSD) Test for variable: TEMP1

Alpha= 0.05 df= 18 MSE= .9453125
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 1.374

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	13.375	8	M
A			
A	13.125	8	S
A			
A	13.062	8	H
A			
A	12.875	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .72219

Tukey Grouping	Mean	N	ASP
A	16.125	16	S
B	10.094	16	N

Table A5(b).- Soil temperature in Mexico, April, 1985

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	64.75000000	4.98076923	5.24	0.0008
Error	18	17.12500000	0.95138889		
Corrected Total	31	81.87500000			

R-Square	C.V.	Root MSE	TEMP2 Mean
0.790840	7.5392592	0.9753917	12.93750000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	32.000000	32.000000	33.64	0.0001
TMT	3	24.625000	8.208333	8.63	0.0009
REP(ASP)	6	6.375000	1.062500	1.12	0.3914
ASP*TMT	3	1.750000	0.583333	0.61	0.6153

Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 1.3784

Tukey Grouping	Mean	N	TMT
A	13.875	8	M
A			
A	13.750	8	S
B	12.125	8	H
B			
B	12.000	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .72451

Tukey Grouping	Mean	N	ASP
A	13.937	16	S
B	11.937	16	N

Table A5(c).- Soil temparature in Mexico, September, 1985

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	69.65625000	5.35817308	7.24	0.0001
Error	18	13.31250000	0.73958333		
Corrected Total	31	82.96875000			

R-Square	C.V.	Root MSE	TEMP3 Mean
0.839548	6.1565302	0.8599903	13.96875000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	57.781250	57.781250	78.13	0.0001
TMT	3	7.093750	2.364583	3.20	0.0483
REP(ASP)	6	4.437500	0.739583	1.00	0.4552
ASP*TMT	3	0.343750	0.114583	0.15	0.9251

Tukey's Studentized Range (HSD) Test for variable: TEMP3

Alpha= 0.05 df= 18 MSE= .7395833
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 1.2153

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	14.500	8	M
A			
A	14.375	8	S
A			
A	13.500	8	C
A			
A	13.500	8	H

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .63879

Tukey Grouping	Mean	N	ASP
A	15.312	16	S
B	12.625	16	N

Table A5(d).- Soil temperature in Oregon, april 04, 1986

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	30.87500000	2.37500000	2.50	0.0368
Error	18	17.12500000	0.95138889		
Corrected Total	31	48.00000000			

R-Square	C.V.	Root MSE	TEMP13 Mean
0.643229	10.544775	0.9753917	9.25000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	3.125000	3.125000	3.28	0.0866
TMT	3	10.250000	3.416667	3.59	0.0341
REP(ASP)	6	16.375000	2.729167	2.87	0.0385
ASP*TMT	3	1.125000	0.375000	0.39	0.7587

Tukey's Studentized Range (HSD) Test for variable: TEMP13
Alpha= 0.05 df= 18 MSE= .9513889
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 1.3784

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	9.875	8	M
A			
A	9.750	8	S
A			
A	8.750	8	H
A			
A	8.625	8	C

Alpha= 0.05 df= 18 MSE= .9513889
Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .72451

Tukey Grouping	Mean	N	ASP
A	9.562	16	S
A	8.937	16	N

Table A5(e).- Soil temperature in Oregon, May 10, 1986, ANOVA results.

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	17.12500000	1.31730769	1.09	0.4234
Error	18	21.75000000	1.20833333		
Corrected Total	31	38.87500000			

R-Square	C.V.	Root MSE	TEMP14 Mean
0.440514	10.659318	1.099242	10.31250000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	3.125000	3.125000	2.59	0.1252
TMT	3	9.125000	3.041667	2.52	0.0908
REP(ASP)	6	4.250000	0.708333	0.59	0.7370
ASP*TMT	3	0.625000	0.208333	0.17	0.9136

Tukey's Studentized Range (HSD) Test for variable: TEMP14

Alpha= 0.05 df= 18 MSE= 1.208333
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 1.5534

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	11.000	8	S
A	10.625	8	M
A	10.000	8	H
A	9.625	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 0.8165

Tukey Grouping	Mean	N	ASP
A	10.625	16	N
A	10.000	16	S

Table A5(f).- Soil temperature in Oregon, June 4, 1986

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	120.4062500	9.2620192	0.89	0.5809
Error	18	188.3125000	10.4618056		
Corrected Total	31	308.7187500			

R-Square	C.V.	Root MSE	TEMP15 Mean
0.390019	15.333791	3.234471	21.09375000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	30.03125	30.03125	2.87	0.1074
TMT	3	64.84375	21.61458	2.07	0.1406
REP(ASP)	6	19.93750	3.32292	0.32	0.9193
ASP*TMT	3	5.59375	1.86458	0.18	0.9098

Tukey's Studentized Range (HSD) Test for variable: TEMP15

Minimum Significant Difference= 4.5709

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	22.500	8	S
A			
A	21.875	8	M
A			
A	21.250	8	H
A			
A	18.750	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 2.4025

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	ASP
A	22.062	16	S
A			
A	20.125	16	N

Table A5(g).- Soil temperature in Oregon, July 8, 1986

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	185.5000000	14.2692308	2.57	0.0326
Error	18	100.0000000	5.5555556		
Corrected Total	31	285.5000000			

R-Square	C.V.	Root MSE	TEMP16 Mean
0.649737	11.711914	2.357023	20.12500000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	0.50000	0.50000	0.09	0.7676
TMT	3	77.25000	25.75000	4.64	0.0143
REP(ASP)	6	41.50000	6.91667	1.25	0.3303
ASP*TMT	3	66.25000	22.08333	3.98	0.0246

Tukey Grouping		Mean	N	TMT
	A	21.750	8	S
	A			
	A	21.000	8	M
	A			
B	A	20.125	8	H
B				
B		17.625	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 1.7508

Tukey Grouping	Mean	N	ASP
A	20.250	16	S
A			
A	20.000	16	N

Table A5(h). Soil temperature in Oregon, August 01, 1986

General Linear Models Procedure

Dependent Variable: SOIL TEMPERATURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	354.1562500	27.2427885	2.79	0.0229
Error	18	176.0625000	9.7812500		
Corrected Total	31	530.2187500			

R-Square	C.V.	Root MSE	TEMP17 Mean
0.667944	13.116641	3.127499	23.84375000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	175.78125	175.78125	17.97	0.0005
TMT	3	110.84375	36.94792	3.78	0.0290
REP(ASP)	6	45.68750	7.61458	0.78	0.5974
ASP*TMT	3	21.84375	7.28125	0.74	0.5395

Alpha= 0.05 df= 18 MSE= 9.78125
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 4.4197

Tukey Grouping		Mean	N	TMT
	A	26.250	8	M
	A			
B	A	25.000	8	S
B	A			
B	A	22.500	8	H
B				
B		21.625	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 2.3231

Tukey Grouping	Mean	N	ASP
A	26.187	16	S
B	21.500	16	N

Table A6(a).- Soil moisture in Mexico, March 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	5248.125000	403.701923	3.00	0.0163
Error	18	2423.750000	134.652778		
Corrected Total	31	7671.875000			

R-Square	C.V.	Root MSE	MOIST1 Mean
0.684073	27.919395	11.60400	41.56250000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	3321.12500	3321.12500	24.66	0.0001
TMT	3	1115.12500	371.70833	2.76	0.0722
REP(ASP)	6	538.25000	89.70833	0.67	0.6779
ASP*TMT	3	273.62500	91.20833	0.68	0.5772

Tukey's Studentized Range (HSD) Test for variable: MOIST1

Alpha= 0.05 df= 18 MSE= 134.6528
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 16.399
Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	46.625	8	M
A	45.250	8	H
A	42.750	8	S
A	31.625	8	C

Alpha= 0.05 df= 18 MSE= 134.6528
Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 8.6193

Tukey Grouping	Mean	N	ASP
A	51.750	16	N
B	31.375	16	S

Table A6(b).- Soil moisture in Mexico, April, 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	594.9062500	45.7620192	0.91	0.5621
Error	18	907.3125000	50.4062500		
Corrected Total	31	1502.2187500			

R-Square	C.V.	Root MSE	MOIST2 Mean
0.396018	32.043942	7.099736	22.15625000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	30.03125	30.03125	0.60	0.4502
TMT	3	149.59375	49.86458	0.99	0.4201
REP(ASP)	6	323.93750	53.98958	1.07	0.4154
ASP*TMT	3	91.34375	30.44792	0.60	0.6208

Tukey's Studentized Range (HSD) Test for variable: MOIST2

Alpha= 0.05 df= 18 MSE= 50.40625
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 10.033
Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	25.875	8	H
A			
A	21.125	8	C
A			
A	21.125	8	M
A			
A	20.500	8	S

Minimum Significant Difference= 5.2736

Tukey Grouping	Mean	N	ASP
A	23.125	16	N
A			
A	21.187	16	S

Table A6(c).- Soil moisture in Mexico, September 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	828.1562500	63.7043269	1.54	0.1941
Error	18	743.3125000	41.2951389		
Corrected Total	31	1571.4687500			

R-Square	C.V.	Root MSE	MOIST4 Mean
0.526995	19.344886	6.426129	33.21875000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	413.28125	413.28125	10.01	0.0054
TMT	3	144.09375	48.03125	1.16	0.3512
REP(ASP)	6	129.93750	21.65625	0.52	0.7825
ASP*TMT	3	140.84375	46.94792	1.14	0.3608

Tukey's Studentized Range (HSD) Test for variable: MOIST4

Alpha= 0.05 df= 18 MSE= 41.29514
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 9.0813

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	36.500	8	M
A			
A	33.625	8	S
A			
A	31.750	8	C
A			
A	31.000	8	H

Minimum Significant Difference= 4.7733

Tukey Grouping	Mean	N	ASP
A	36.812	16	N
B	29.625	16	S

Table A6(d).-Soil moisture in Oregon, June 14, 1985

General Linear Models Procedure

Dependent Variable:SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	10173.50000	782.57692	2.46	0.0390
Error	18	5724.50000	318.02778		
Corrected Total	31	15898.00000			

R-Square	C.V.	Root MSE	MOIST4 Mean
0.639923	20.037453	17.83333	89.00000000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	1800.0000	1800.0000	5.66	0.0286
TMT	3	4080.7500	1360.2500	4.28	0.0191
REP(ASP)	6	2288.0000	381.3333	1.20	0.3511
ASP*TMT	3	2004.7500	668.2500	2.10	0.1358

Tukey's Studentized Range (HSD) Test for variable: MOIST4

Alpha= 0.05 df= 18 MSE= 318.0278
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 25.202

Tukey Grouping		Mean	N	TMT
	A	100.000	8	H
	A			
	A	98.125	8	S
	A			
B	A	86.125	8	M
B				
B		71.750	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 13.246

Tukey Grouping	Mean	N	ASP
A	96.500	16	N
B	81.500	16	S

Table A6(e).- Soil moisture in Oregon, June 26, 1985

General Linear Models Procedure

Dependent Variable:SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	26769.65625	2059.20433	3.25	0.0110
Error	18	11400.56250	633.36458		
Corrected Total	31	38170.21875			

R-Square	C.V.	Root MSE	MOIST5 Mean
0.701323	34.401347	25.16674	73.15625000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	2363.2813	2363.2813	3.73	0.0693
TMT	3	18119.8437	6039.9479	9.54	0.0005
REP(ASP)	6	3968.1875	661.3646	1.04	0.4301
ASP*TMT	3	2318.3437	772.7812	1.22	0.3311

Tukey's Studentized Range (HSD) Test for variable: MOIST5

Alpha= 0.05 df= 18 MSE= 633.3646
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 35.565

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	100.00	8	H
A			
A	83.50	8	S
A			
A	73.87	8	M
B	35.25	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 18.694

Tukey Grouping	Mean	N	ASP
A	81.750	16	N
A			
A	64.562	16	S

Table A6(f).- Soil moisture in Oregon, July 24, 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	27391.62500	2107.04808	3.57	0.0069
Error	18	10632.25000	590.68056		
Corrected Total	31	38023.87500			

R-Square	C.V.	Root MSE	MOIST6 Mean
0.720380	68.341429	24.30392	35.56250000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	3160.12500	3160.12500	5.35	0.0328
TMT	3	8961.62500	2987.20833	5.06	0.0103
REP(ASP)	6	8800.75000	1466.79167	2.48	0.0628
ASP*TMT	3	6469.12500	2156.37500	3.65	0.0324

Tukey's Studentized Range (HSD) Test for variable: MOIST6

Alpha= 0.05 df= 18 MSE= 590.6806
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 34.346
Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	56.00	8	H
	A			
B	A	46.88	8	S
B	A			
B	A	25.62	8	M
B				
B		13.75	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 18.053

Tukey Grouping	Mean	N	ASP
A	45.500	16	S
B	25.625	16	N

Table A6(g).- Soil moisture in Oregon, September 2, 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	10185.65625	783.51202	4.50	0.0019
Error	18	3133.56250	174.08681		
Corrected Total	31	13319.21875			

R-Square	C.V.	Root MSE	MOIST8 Mean
0.764734	67.124685	13.19420	19.65625000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	2983.78125	2983.78125	17.14	0.0006
TMT	3	1542.34375	514.11458	2.95	0.0604
REP(ASP)	6	4117.18750	686.19792	3.94	0.0108
ASP*TMT	3	1542.34375	514.11458	2.95	0.0604

Tukey's Studentized Range (HSD) Test for variable: MOIST8

Alpha= 0.05 df= 18 MSE= 174.0868
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 18.646

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	29.250	8	S
	A			
B	A	21.625	8	H
B	A			
B	A	17.750	8	M
B				
B		10.000	8	C

Minimum Significant Difference= 9.8005

Tukey Grouping	Mean	N	ASP
A	29.312	16	S
B	10.000	16	N

Table A6(h). Soil moisture in Oregon, August 9, 1985

General Linear Models Procedure

Dependent Variable:SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	24822.65625	1909.43510	3.77	0.0052
Error	18	9120.31250	506.68403		
Corrected Total	31	33942.96875			

R-Square	C.V.	Root MSE	MOIST7 Mean
0.731305	83.272668	22.50964	27.03125000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	7350.78125	7350.78125	14.51	0.0013
TMT	3	4683.59375	1561.19792	3.08	0.0537
REP(ASP)	6	8123.43750	1353.90625	2.67	0.0493
ASP*TMT	3	4664.84375	1554.94792	3.07	0.0543

Tukey's Studentized Range (HSD) Test for variable: MOIST7

Alpha= 0.05 df= 18 MSE= 506.684
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 31.81

Tukey Grouping		Mean	N	TMT
	A	43.75	8	S
	A			
B	A	30.00	8	H
B	A			
B	A	24.37	8	M
B				
B		10.00	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= 16.72

Tukey Grouping	Mean	N	ASP
A	42.188	16	S
B	11.875	16	N

Table A6(i).- Soil moisture in Oregon, October 5, 1985

General Linear Models Procedure

Dependent Variable: SOIL MOISTURE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	3364.656250	258.819712	6.11	0.0003
Error	18	762.062500	42.336806		
Corrected Total	31	4126.718750			

R-Square	C.V.	Root MSE	MOIST9 Mean
0.815335	43.108399	6.506674	15.09375000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	830.281250	830.281250	19.61	0.0003
TMT	3	533.093750	177.697917	4.20	0.0204
REP(ASP)	6	1468.187500	244.697917	5.78	0.0017
ASP*TMT	3	533.093750	177.697917	4.20	0.0204

Tukey's Studentized Range (HSD) Test for variable: MOIST9

Alpha= 0.05 df= 18 MSE= 42.33681
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 9.1951

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	20.875	8	S
	A			
B	A	16.625	8	H
B	A			
B	A	12.875	8	M
B				
B		10.000	8	C

Minimum Significant Difference= 4.8331

Tukey Grouping	Mean	N	ASP
A	20.187	16	S
B	10.000	16	N

Table A7(a).- Potential evaporation in Mexico

General Linear Models Procedure

Dependent Variable: EVAPORATION POTENTIAL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	98.56201461	5.47566748	5.60	0.0001
Error	24	23.47890167	0.97828757		
Corrected Total	42	122.04091628			

R-Square	C.V.	Root MSE	EVAP Mean
0.807615	28.248287	0.9890842	3.50139535

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	71.6244399	71.6244399	73.21	0.0001
TMT	3	15.4640872	5.1546957	5.27	0.0062
REP(ASP)	11	9.6938871	0.8812625	0.90	0.5534
ASP*TMT	3	1.7796004	0.5932001	0.61	0.6173

Tukey's Studentized Range (HSD) Test for variable: EVAP

Comparisons significant at the 0.05 level are indicated by '***'.

TMT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
M - S	-1.004	0.143	1.291	
M - H	0.163	1.310	2.458	***
M - C	0.357	1.504	2.652	***
S - M	-1.291	-0.143	1.004	
S - H	-0.053	1.167	2.387	
S - C	0.141	1.361	2.581	***
H - M	-2.458	-1.310	-0.163	***
H - S	-2.387	-1.167	0.053	
H - C	-1.026	0.194	1.414	
C - M	-2.652	-1.504	-0.357	***
C - S	-2.581	-1.361	-0.141	***
C - H	-1.414	-0.194	1.026	

Table A7(b).- Potential evaporation in Oregon

General Linear Models Procedure

Dependent Variable: EVAPORATION POTENTIAL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	0.66682559	0.05129428	17.03	0.0001
Error	13	0.03916026	0.00301233		
Corrected Total	26	0.70598585			

R-Square	C.V.	Root MSE	EVAP Mean
0.944531	9.7672445	0.0548847	0.56192593

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	0.26449334	0.26449334	87.80	0.0001
TMT	3	0.32116281	0.10705427	35.54	0.0001
REP(ASP)	6	0.02690026	0.00448338	1.49	0.2569
ASP*TMT	3	0.05426918	0.01808973	6.01	0.0085

Tukey's Studentized Range (HSD) Test for variable: EVAP

Alpha= 0.05 Confidence= 0.95 df= 13 MSE= .0030123
Critical Value of Studentized Range= 4.151

Comparisons significant at the 0.05 level are indicated by '***'.

TMT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit	
M - S	-0.0204	0.0657	0.1518	
M - C	0.1839	0.2700	0.3561	***
M - H	0.1812	0.2708	0.3604	***
S - M	-0.1518	-0.0657	0.0204	
S - C	0.1182	0.2043	0.2904	***
S - H	0.1155	0.2051	0.2947	***
C - M	-0.3561	-0.2700	-0.1839	***
C - S	-0.2904	-0.2043	-0.1182	***
C - H	-0.0888	0.0008	0.0904	
H - M	-0.3604	-0.2708	-0.1812	***
H - S	-0.2947	-0.2051	-0.1155	***
H - C	-0.0904	-0.0008	0.0888	

Table A8 (a).- Number of days above fifty percent of soil moisture, 1985: ANOVA results.

General Linear Models Procedure

Dependent Variable: MDAYS85

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	18818.81250	1881.88125	2.89	0.0194
Error	21	13674.15625	651.15030		
Corrected Total	31	32492.96875			

R-Square	C.V.	Root MSE	MDAYS85 Mean
0.579166	12.889735	25.51765	197.9687500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ASP	1	1554.031	1554.031	2.39	0.1373
TMT	3	7594.094	2531.365	3.89	0.0235
REP	3	6344.094	2114.698	3.25	0.0423
ASP*TMT	3	3326.594	1108.865	1.70	0.1970

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ASP	1	1554.031	1554.031	2.39	0.1373
TMT	3	7594.094	2531.365	3.89	0.0235
REP	3	6344.094	2114.698	3.25	0.0423
ASP*TMT	3	3326.594	1108.865	1.70	0.1970

General Linear Models Procedure

Tukey's Studentized Range (HSD) Test for variable: MDAYS85

NOTE: This test controls the type I experimentwise error rate, but generally has a higher type II error rate than REGWQ.

Alpha= 0.05 df= 21 MSE= 651.1503
Critical Value of Studentized Range= 3.942
Minimum Significant Difference= 35.563

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	TMT
A	215.75	8	S
B A	210.00	8	N
B A	187.75	8	M
B	178.37	8	C

Table A8 (b).- Number of days above fifty percent of soil moisture, 1986: ANOVA results.

General Linear Models Procedure

Dependent Variable: MDAYS86

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	8930.000000	893.000000	2.50	0.0369
Error	21	7499.875000	357.136905		
Corrected Total	31	16429.875000			

R-Square	C.V.	Root MSE	MDAYS86 Mean
0.543522	11.388665	18.89807	165.9375000

Source	DF	Type III SS	Mean Square	F Value	Pr > F
ASP	1	1012.5000	1012.5000	2.84	0.1070
TMT	3	5420.6250	1806.8750	5.06	0.0086
REP	3	1262.6250	420.8750	1.18	0.3417
ASP*TMT	3	1234.2500	411.4167	1.15	0.3514

Tukey's Studentized Range (HSD) Test for variable: MDAYS86

NOTE: This test controls the type I experimentwise error rate, but generally has a higher type II error rate than REGWQ.

Alpha= 0.05 df= 21 MSE= 357.1369
Critical Value of Studentized Range= 3.942
Minimum Significant Difference= 26.338

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	187.375	8	H
	A			
B	A	165.250	8	S
B				
B		156.625	8	M
B				
B		154.500	8	C

Table A-9 (a).- Soil Conditions Index 1985: ANOVA results.

Analysis of Variance Procedure

Dependent Variable: SCI ' 85

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	7.87861614	0.60604740	4.41	0.0022
Error	18	2.47456747	0.13747597		
Corrected Total	31	10.35318361			

R-Square	C.V.	Root MSE	SCI85 Mean
0.760985	16.793339	0.3707775	2.20788451

Source	DF	Anova SS	Mean Square	F Value	Pr > F
ASP	1	1.0399256	1.0399256	7.56	0.0132
TMT	3	2.8289503	0.9429834	6.86	0.0028
REP(ASP)	6	2.4714105	0.4119018	3.00	0.0329
ASP*TMT	3	1.5383297	0.5127766	3.73	0.0303

Tukey's Studentized Range (HSD) Test for variable: SCI85

Alpha= 0.05 df= 18 MSE= 0.137476
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= .52398

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	2.613	8	H
	A			
B	A	2.351	8	S
B				
B		2.029	8	M
B				
B		1.836	8	C

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .27541

Tukey Grouping	Mean	N	ASP
A	2.388	16	N
B	2.028	16	S

Table A-9 (b).- Soil Conditions Index 1986: ANOVA results.

Analysis of Variance Procedure

Dependent Variable: SCI '86

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	6.16476847	0.47421296	1.64	0.1620
Error	18	5.19097563	0.28838754		
Corrected Total	31	11.35574410			

R-Square	C.V.	Root MSE	SCI86 Mean
0.542877	26.571079	0.5370173	2.02105927

Source	DF	Anova SS	Mean Square	F Value	Pr > F
ASP	1	0.3185889	0.3185889	1.10	0.3071
TMT	3	3.0223532	1.0074511	3.49	0.0372
REP(ASP)	6	1.9689665	0.3281611	1.14	0.3806
ASP*TMT	3	0.8548598	0.2849533	0.99	0.4206

Tukey's Studentized Range (HSD) Test for variable: SCI86

Alpha= 0.05 df= 18 MSE= .2883875
Critical Value of Studentized Range= 3.997
Minimum Significant Difference= 0.7589

Means with the same letter are not significantly different.

Tukey Grouping		Mean	N	TMT
	A	2.532	8	H
	A			
B	A	1.963	8	S
B	A			
B	A	1.870	8	C
B				
B		1.720	8	M

Critical Value of Studentized Range= 2.971
Minimum Significant Difference= .39889

Tukey Grouping	Mean	N	ASP
A	2.121	16	N
A			
A	1.921	16	S

APPENDIX B

Table B1(a). Animal damage by location aspect treatment and species. Number of damaged seedlings per row (average).

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN TMT (ASP)
M	N	C	0.5	0.5	0.0	0.0	1.0	0.4	0.3	0.3	1.0	0.4	0.6
M	N	H	0.0	0.0	0.3	0.3	0.3	0.3	0.8	0.5	1.3	1.3	0.5
M	N	M	0.0	0.0	0.3	0.3	0.8	0.5	1.0	0.6	1.7	0.6	0.8
M	N	S	0.3	0.3	0.5	0.5	0.0	0.0	0.5	0.5	2.0	0.0	0.7
M	S	C	0.3	0.3	0.3	0.3	0.5	0.3	2.5	0.9	2.5	0.5	1.2
M	S	H	0.5	0.5	0.0	0.0	0.5	0.5	1.7	0.6	0.8	0.8	0.7
M	S	M	0.3	0.3	0.0	0.0	0.3	0.3	0.0	0.0	0.5	0.3	0.2
M	S	S	0.3	0.3	0.0	0.0	0.0	0.0	0.5	0.3	0.6	0.4	0.3
O	N	C	0.0	0.0	0.0	0.0	0.5	0.5	2.5	2.5	0.0	.	0.6
O	N	H	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.1
O	N	M	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.1
O	N	S	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
O	S	C	3.2	1.6	0.5	0.5	3.0	1.7	12.0	1.4	2.3	0.7	4.2
O	S	H	2.2	0.3	2.2	0.3	2.5	0.6	13.7	0.3	0.0	0.0	4.2
O	S	M	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
O	S	S	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.0	0.0	0.1
MEAN SPECIES			0.49		0.25		0.59		2.3		0.79 GRAND MEAN =.88		

Table B1 (b).- Animal damage : ANOVA results.

Dependent Variable: ANIMAL DAMAGE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	63	617.9667681	9.8089963	2.39	0.0001
Error (£ 1)	258	1059.8286667	4.1078630		
Corrected Total	321	1677.7954348			

R-Square	C.V.	Root MSE	DAMAGE Mean
0.368321	229.07168	2.026786	0.88478261

Source	DF	Anova SS	Mean Square	F Value	Pr > F
LOC	1	25.7921632	25.7921632	6.28	0.0128
ASP	1	73.0533736	73.0533736	17.78	0.0001
TMT	3	129.0358201	43.0119400	10.47	0.0001
REP(LOC*ASP)	12	29.6217452	2.4684788	0.60	0.8407
LOC*ASP	1	74.4548750	74.4548750	18.12	0.0001
LOC*TMT	3	74.1166702	24.7055567	6.01	0.0006
ASP*TMT	3	114.0564180	38.0188060	9.26	0.0001
LOC*ASP*TMT	3	39.7803765	13.2601255	3.23	0.0231
TMT*REP(LOC*ASP)	36	58.0553263	1.6126480	0.39	0.9994

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	139	1255.598971	9.033086	3.89	0.0001
Error (£ 2)	182	422.196463	2.319761		
Corrected Total	321	1677.795435			

R-Square	C.V.	Root MSE	DAMAGE Mean
0.748362	172.14128	1.523076	0.88478261

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	167.0610030	41.7652507	18.00	0.0001
LOC*SPECIES	4	113.7236657	28.4309164	12.26	0.0001
SPECIES*ASP	4	97.4501458	24.3625364	10.50	0.0001
LOC*SPECIES*ASP	4	53.9495876	13.4873969	5.81	0.0002
SPECIES*TMT	12	152.0204254	12.6683688	5.46	0.0001
SPECIES*REP(LOC*ASP)	48	53.4273757	1.1130703	0.48	0.9982

Table B-2.- Survival: ANOVA results.

Analysis of Variance Procedure

Dependent Variable: SURVIVAL

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	63	167085.0662	2652.1439	5.44	0.0001
Error (ℓ 1)	254	123800.0000	487.4016		
Corrected Total	317	290885.0662			

R-Square	C.V.	Root MSE	SURVTOT Mean
0.574402	31.590237	22.07717	69.88606400

Source	DF	Anova SS	Mean Square	F Value	Pr > F
LOC	1	5032.599	5032.599	10.33	0.0015
ASP	1	39844.385	39844.385	81.75	0.0001
TMT	3	53780.857	17926.952	36.78	0.0001
REP(LOC*ASP)	12	14515.537	1209.628	2.48	0.0044
LOC*ASP	1	1044.800	1044.800	2.14	0.1444
LOC*TMT	3	14833.116	4944.372	10.14	0.0001
ASP*TMT	3	6314.722	2104.907	4.32	0.0054
LOC*ASP*TMT	3	1779.607	593.202	1.22	0.3040
TMT*REP(LOC*ASP)	36	29939.441	831.651	1.71	0.0101

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	139	245809.7708	1768.4156	6.98	0.0001
Error (ℓ 2)	178	45075.2954	253.2320		
Corrected Total	317	290885.0662			

R-Square	C.V.	Root MSE	SURVTOT Mean
0.845041	22.770298	15.91326	69.88606400

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	31907.555	7976.889	31.50	0.0001
LOC*SPECIES	4	14957.468	3739.367	14.77	0.0001
SPECIES*ASP	4	1124.969	281.242	1.11	0.3531
LOC*SPECIES*ASP	4	3573.301	893.325	3.53	0.0085
SPECIES*TMT	12	15002.126	1250.177	4.94	0.0001
SPECIES*REP(LOC*ASP)	48	12159.285	253.318	1.00	0.4818

TABLE B-3 (a).- Means of relative height growth, by location, aspect and treatment, for each species.

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN TMT (ASP)
M	N	C	1.2	0.1	2.2	0.3	0.0	0.0	1.2	0.1	5.5	0.4	2.0
M	N	H	1.2	0.0	2.1	0.4	0.1	0.0	1.4	0.1	5.4	1.1	2.1
M	N	M	1.7	0.1	2.7	0.2	0.2	0.0	2.0	0.2	6.4	0.3	2.6
M	N	S	1.7	0.1	3.6	1.5	0.2	0.0	2.0	0.1	4.7	1.0	2.4
M	S	C	1.0	0.2	2.1	0.1	-0.2	0.0	1.0	0.2	3.9	0.6	1.6
M	S	H	1.0	0.1	2.3	0.3	-0.2	0.1	1.1	0.3	5.2	0.3	1.9
M	S	M	1.0	0.2	1.8	0.2	-0.1	0.0	1.3	0.1	6.9	1.0	2.2
M	S	S	1.3	0.1	2.4	0.3	-0.0	0.0	1.2	0.1	8.3	0.5	2.6
O	N	C	0.6	0.1	2.0	0.4	0.1	0.1	1.3	0.4	5.5	0.2	1.9
O	N	H	1.0	0.1	3.4	0.9	0.3	0.1	1.8	0.2	5.6	0.6	2.4
O	N	M	0.5	0.1	1.5	0.3	0.1	0.1	1.5	0.2	2.4	0.4	1.2
O	N	S	0.7	0.1	1.9	0.4	0.1	0.1	1.9	0.1	3.0	0.7	1.5
O	S	C	0.5	0.1	2.2	0.2	-0.1	0.0	1.1	0.2	4.6	0.2	1.7
O	S	H	1.3	0.1	2.8	0.4	0.5	0.0	2.2	0.2	5.6	0.6	2.5
O	S	M	0.6	0.1	1.7	0.3	0.2	0.1	1.9	0.2	3.0	1.0	1.5
O	S	S	0.8	0.1	2.3	0.7	0.3	0.1	2.6	0.2	8.0	0.7	2.8
Means species			1.0		2.3		0.09		1.6		5.2		

Grand Mean= 2.05

TABLE B-3(b).- Relative height Growth: ANOVA results.

Analysis of Variance Procedure

Dependent Variable: Relative height Growth

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	63	89.57414740	1.42181186	0.29	1.0000
Error (£ 1)	254	1261.9030848	4.96812238		
Corrected Total	317	1351.4772322			

R-Square	C.V.	Root MSE	RELGT4 Mean
0.066279	108.49824	2.228929	2.05434535

Source	DF	Anova SS	Mean Square	F Value	Pr > F
LOC	1	4.670945	4.670945	0.94	0.3332
ASP	1	0.290607	0.290607	0.06	0.8091
TMT	3	17.159975	5.719992	1.15	0.3290
REP(LOC*ASP)	12	5.173213	0.431101	0.09	1.0000
LOC*ASP	1	5.981047	5.981047	1.20	0.2736
LOC*TMT	3	25.809451	8.603150	1.73	0.1610
ASP*TMT	3	13.030617	4.343539	0.87	0.4549
LOC*ASP*TMT	3	2.333206	0.777735	0.16	0.9254
TMT*REP(LOC*ASP)	36	15.125087	0.420141	0.08	1.0000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	139	1155.369538	8.312011	7.54	0.0001
Error	178	196.107695	1.101729		
Corrected Total	317	1351.477232			

R-Square	C.V.	Root MSE	RELGT4 Mean
0.854894	51.093289	1.049633	2.05434535

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	990.622018	247.655504	224.79	0.0001
LOC*SPECIES	4	21.587273	5.396818	4.90	0.0009
SPECIES*ASP	4	12.711561	3.177890	2.88	0.0240
LOC*SPECIES*ASP	4	0.585937	0.146484	0.13	0.9701
SPECIES*TMT	12	11.374708	0.947892	0.86	0.5884
SPECIES*REP(LOC*ASP)	48	28.913893	0.602373	0.55	0.9922

Table B4.- Net Growth: ANOVA Results.

Analysis of Variance Procedure

Dependent Variable: NET GROWTH

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	63	260032.3510	4127.4976	0.79	0.8684
Error (£ 1)	255	1333582.9625	5229.7371		
Corrected Total	318	1593615.3134			

R-Square	C.V.	Root MSE	NETGRWT Mean
0.163171	76.807673	72.31692	94.15325079

Source	DF	Anova SS	Mean Square	F Value	Pr > F
LOC	1	373.803	373.803	0.07	0.7894
ASP	1	5561.999	5561.999	1.06	0.3034
TMT	3	74297.132	24765.711	4.74	0.0031
REP(LOC*ASP)	12	21519.314	1793.276	0.34	0.9803
LOC*ASP	1	46750.181	46750.181	8.94	0.0031
LOC*TMT	3	63236.176	21078.725	4.03	0.0080
ASP*TMT	3	12635.074	4211.691	0.81	0.4919
LOC*ASP*TMT	3	12710.361	4236.787	0.81	0.4893
TMT*REP(LOC*ASP)	36	22948.309	637.453	0.12	1.0000

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	139	1417989.663	10201.364	10.40	0.0001
Error (£ 2)	179	175625.650	981.149		
Corrected Total	318	1593615.313			

R-Square	C.V.	Root MSE	NETGRWT Mean
0.889794	33.268417	31.32330	94.15325079

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	898389.816	224597.454	228.91	0.0001
LOC*SPECIES	4	145558.854	36389.713	37.09	0.0001
SPECIES*ASP	4	14970.958	3742.740	3.81	0.0053
LOC*SPECIES*ASP	4	22466.783	5616.696	5.72	0.0002
SPECIES*TMT	12	33734.143	2811.179	2.87	0.0012
SPECIES*REP(LOC*ASP)	48	42836.758	892.432	0.91	0.6417

Table B-5 (a) Number of days that Bud remained open during 1985.

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P.PON	SE	P.MON	SE	MEAN TMT (ASP)
M	N	C	35.3	4.2	45.8	2.7	71.9	4.5	48.8	11.0	51.2	5.5	50.6
M	N	H	35.7	10.3	42.4	6.0	68.7	9.5	47.5	9.8	42.5	13.7	47.3
M	N	M	53.1	7.9	43.9	9.9	62.2	7.7	55.8	4.5	50.7	8.0	53.1
M	N	S	52.4	17.5	47.2	14.8	60.3	4.2	63.6	13.0	43.3	6.8	53.4
M	S	C	43.9	5.5	35.1	3.3	49.5	4.3	58.7	8.5	57.8	8.9	49.0
M	S	H	49.7	6.3	51.9	3.7	60.4	7.1	69.4	11.1	50.7	5.6	56.4
M	S	M	42.5	9.6	48.2	1.1	72.2	10.6	77.7	13.0	39.7	5.7	56.1
M	S	S	39.9	7.2	51.0	4.2	53.9	5.3	95.4	6.4	59.2	8.4	59.9
O	N	C	88.4	7.8	75.7	3.5	84.0	7.3	69.4	7.0	83.6	.	80.2
O	N	H	80.4	6.2	76.0	7.0	85.2	9.0	71.1	4.2	84.3	6.5	79.4
O	N	M	74.5	4.3	73.3	3.0	72.7	2.6	72.8	2.4	82.6	5.2	75.2
O	N	S	61.6	6.4	76.5	6.3	74.8	3.5	71.5	1.9	82.9	2.0	73.5
O	S	C	105.5	4.5	77.7	3.9	75.3	4.7	85.2	7.4	92.7	8.9	87.3
O	S	H	93.3	10.4	76.5	3.9	85.4	7.0	77.3	10.3	82.9	1.6	83.1
O	S	M	86.2	8.8	88.0	8.6	75.9	2.8	85.6	11.1	86.1	1.8	84.3
O	S	S	89.6	9.7	83.4	6.6	70.2	4.2	70.3	19.0	85.1	3.1	79.7
MEANS SPECIES			65.6		62.3		69.8		70.1		67.9		GRAND MEAN =53

Table B-5 (b). BUDAYS Mexico 1985: ANOVA Results

Analysis of Variance Procedure

Dependent Variable: BUDAYS MEXICO '85

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	6760.729964	218.088063	0.59	0.9568
Error (#1)	122	45395.850617	372.097136		
Corrected Total	153	52156.580580			

R-Square	C.V.	Root MSE	BUDAYS Mean
0.129624	36.396405	19.28982	52.99924469

Source	DF	Anova SS	Mean Square	F Value	Pr > F
ASP	1	637.9075	637.9075	1.71	0.1929
TMT	3	940.8985	313.6328	0.84	0.4729
REP(ASP)	6	2463.9116	410.6519	1.10	0.3642
ASP*TMT	3	561.9363	187.3121	0.50	0.6806
TMT*REP(ASP)	18	2156.0760	119.7820	0.32	0.9961

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	75	34544.01753	460.58690	2.04	0.0010
Error (# 2)	78	17612.56305	225.80209		
Corrected Total	153	52156.58058			

R-Square	C.V.	Root MSE	BUDAYS Mean
0.662314	28.352692	15.02671	52.99924469

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	10666.0448	2666.5112	11.81	0.0001
SPECIES*ASP	4	3053.8384	763.4596	3.38	0.0132
SPECIES*TMT	12	3248.8115	270.7343	1.20	0.2990
SPECIES*REP(ASP)	24	10814.5928	450.6080	2.00	0.0120

Table B-5 (c). BUDAYS Oregon 1985 : ANOVA Results.

Analysis of Variance Procedure

Dependent Variable: BUDAYS OREGON '85

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	11424.67565	368.53792	2.44	0.0003
Error (# 1)	130	19629.92212	150.99940		
Corrected Total	161	31054.59777			

R-Square	C.V.	Root MSE	BUDAYS Mean
0.367890	15.246286	12.28818	80.59786657

Source	DF	Anova SS	Mean Square	F Value	Pr > F
ASP	1	1987.381	1987.381	13.16	0.0004
TMT	3	1046.352	348.784	2.31	0.0794
REP(ASP)	6	6148.889	1024.815	6.79	0.0001
ASP*TMT	3	102.868	34.289	0.23	0.8774
TMT*REP(ASP)	18	2139.186	118.844	0.79	0.7122

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	75	22557.21442	300.76286	3.04	0.0001
Error (# 2)	86	8497.38335	98.80678		
Corrected Total	161	31054.59777			

R-Square	C.V.	Root MSE	BUDAYS Mean
0.726373	12.333031	9.940160	80.59786657

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	2422.694	605.673	6.13	0.0002
SPECIES*ASP	4	1559.356	389.839	3.95	0.0055
SPECIES*TMT	12	2065.432	172.119	1.74	0.0716
SPECIES*REP(ASP)	24	5085.057	211.877	2.14	0.0055

Table B-5 (d).- Number of days that the Bud remained open during 1986.

LOC	ASP	TMT	P.AYA	SE	P.HAR	SE	P.LAM	SE	P. PON	SE	P.MON	SE	MEAN TMT (ASP)
O	N	C	50.4	8.9	43.3	3.9	76.8	2.1	62.7	5.0	77.2	0.5	62.1
O	N	H	85.0	4.6	48.1	4.1	93.1	4.7	61.7	2.7	65.4	7.0	70.6
O	N	M	74.8	5.7	58.0	7.6	80.9	10.3	55.9	4.1	48.2	3.7	63.6
O	N	S	79.7	7.8	61.5	8.9	90.3	6.3	62.8	5.3	66.9	9.0	72.2
O	S	C	91.0	0.4	38.0	0.6	75.0	14.8	58.6	8.5	59.5	4.9	64.4
O	S	H	88.0	8.3	53.2	3.4	89.8	5.7	49.6	5.2	54.1	0.9	67.0
O	S	M	73.7	6.2	53.8	6.2	81.8	3.4	42.6	3.0	67.0	12.6	63.8
O	S	S	76.9	7.5	26.7	0.3	86.4	4.7	48.6	2.0	87.2	5.6	65.2
MEANS SPECIES			77.4		47.9		84.3		55.3		65.7		

GRAND MEAN = 66.4

Table B-5 (e).-BUDAYS Oregon 1986: ANOVA Results.

Analysis of Variance Procedure

Dependent Variable: BUDAYS '86 IN OREGON

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	7916.383825	255.367220	0.59	0.9536
Error (# 1)	126	54253.889961	430.586428		
Corrected Total	157	62170.273787			

R-Square	C.V.	Root MSE	BDAYS86 Mean
0.127334	31.269437	20.75058	66.36056893

Source	DF	Anova SS	Mean Square	F Value	Pr > F
ASP	1	97.0919	97.0919	0.23	0.6357
TMT	3	923.2783	307.7594	0.71	0.5449
REP(ASP)	6	3875.0039	645.8340	1.50	0.1834
ASP*TMT	3	679.0600	226.3533	0.53	0.6654
TMT*REP(ASP)	18	2341.9497	130.1083	0.30	0.9974

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	75	46056.17816	614.08238	3.12	0.0001
Error (# 2)	82	16114.09563	196.51336		
Corrected Total	157	62170.27379			

R-Square	C.V.	Root MSE	BDAYS86 Mean
0.740807	21.124476	14.01832	66.36056893

Source	DF	Anova SS	Mean Square	F Value	Pr > F
SPECIES	4	28279.3275	7069.8319	35.98	0.0001
SPECIES*ASP	4	2516.9348	629.2337	3.20	0.0170
SPECIES*TMT	12	4755.4512	396.2876	2.02	0.0327
SPECIES*REP(ASP)	24	2588.0809	107.8367	0.55	0.9512

Table B5 (e). continues...

Tukey's Studentized Range (HSD) Test for variable: BUDAYS86

Alpha= 0.05 Confidence= 0.95 df= 82 MSE= 196.5134
Critical Value of Studentized Range= 3.709

Comparisons significant at the 0.05 level are indicated by '***'.

TMT Comparison	Simultaneous Lower Confidence Limit	Difference Between Means	Simultaneous Upper Confidence Limit
H - S	-8.115	0.106	8.326
H - M	-3.389	4.884	13.157
H - C	-3.383	4.890	13.163
S - H	-8.326	-0.106	8.115
S - M	-3.494	4.779	13.052
S - C	-3.488	4.785	13.058
M - H	-13.157	-4.884	3.389
M - S	-13.052	-4.779	3.494
M - C	-8.319	0.006	8.331
C - H	-13.163	-4.890	3.383
C - S	-13.058	-4.785	3.488
C - M	-8.331	-0.006	8.319

Table B-5 (e) (continues)

Critical Value of Studentized Range= 3.945

SPECIES Comparison				
LAMBE - AYACA	-2.929	6.846	16.622	
LAMBE - PSEUD	8.819	18.594	28.370	***
LAMBE - PONDE	19.182	28.958	38.734	***
LAMBE - HARTW	26.391	36.328	46.265	***
AYACA - LAMBE	-16.622	-6.846	2.929	
AYACA - PSEUD	1.972	11.748	21.524	***
AYACA - PONDE	12.336	22.112	31.888	***
AYACA - HARTW	19.545	29.482	39.419	***
PSEUD - LAMBE	-28.370	-18.594	-8.819	***
PSEUD - AYACA	-21.524	-11.748	-1.972	***
PSEUD - PONDE	0.588	10.364	20.140	***
PSEUD - HARTW	7.797	17.734	27.671	***
PONDE - LAMBE	-38.734	-28.958	-19.182	***
PONDE - AYACA	-31.888	-22.112	-12.336	***
PONDE - PSEUD	-20.140	-10.364	-0.588	***
PONDE - HARTW	-2.567	7.370	17.307	
HARTW - LAMBE	-46.265	-36.328	-26.391	***
HARTW - AYACA	-39.419	-29.482	-19.545	***
HARTW - PSEUD	-27.671	-17.734	-7.797	***
HARTW - PONDE	-17.307	-7.370	2.567	

Critical Value of Studentized Range= 2.813
Minimum Significant Difference= 4.4375

Means with the same letter are not significantly different.

Tukey Grouping	Mean	N	ASP
A	67.135	80	N
A			
A	65.567	78	S

Table B7 (a).- Initial seedling parameters and and root growth capacity.

Species	1 Height mm	2 Diameter mm	3 Volume mm	4 Above ground biomass
	mm	mm	mm	gr dry weight
P. ayacahuite	132.06	3.9b	514.8	2.70
P. hartwegii	20.0c	4.5a	96.0	1.41
P. lambertiana	247.0a	2.7c	642.2	2.25
P. ponderosa	103.66b	2.9c	312.0	2.17
P. montezumae	20.0c	4.1b	82.0	1.29

Species	5 Below ground biomass	6 Ratio 5/4	7 Ratio 1/2	8 Root Growth Capacity
	gr dryweight			cms
P. ayacahuite	1.39a	.514	34.5	28.37c
P. hartwegii	1.18a	.836	4.7	73.33b
P. lambertiana	1.60a	.711	95.8	27.21c
P. ponderosa	1.32a	.608	35.5	98.22a
P. montezumae	0.84b	.651	4.8	107.46a

Table B7 (b).- Root growth capacity test:ANOVA results.

General Linear models Procedure

Dependent Variable: Root Growth

Source	df	Sum of Squares	Mean Square	F value	Pr > F
Model	7	141166.79	20166.6844	12.99	0.0001
Error	111	172314.08	1552.379		
Correccted total	118	313480.87			

R-Square	CV	Root MSE	Growth Mean
0.450320	59.11029	39.400	66.655

Source	DF	Type 1 SS	Mean Square	F Value	Pr > F
Species	4	136454.08	34113.52	21.97	0.0001
Reps	3	4712.70	1570.90	1.01	0.3903

APPENDIX C

DESCRIPTION AND ECOLOGY OF THE MEXICAN PINES

The descriptions and ecological data are based on Martinez, (1948), Eguiluz, (1978) and Capo (1971).

Pinus hartwegii Lindl. grows at high altitudes approximately 2800 m above sea level in the mountains of Mexico, from northern Chihuahua to southern chiapas. It is a tree of 15 to 30 meters in height that grows in pure stands covering several tenths of square kilometers. In the lower limits of its range, it forms mixed stands with other pines, including *P. pseudostrobus* and *P. ayacahuite*. The mean annual temperature of the area where it is found, is about 12 ^{o}C. Rainfall varies from 800 to 1500 mm depending on locations. The rain season is from May or June to September. Maximum and minimum extreme temperatures are 38 and -20 ^{o}C, respectively. Its wood is used for pulp and timber.

P.ayacahuite var. brachyptera grows in northern Mexico at about 2700 m above sea level, where the average temperature is 13 ^{o}C or less. Rainfall varies from 900 to 1100 mm. Extreme temperatures are -15 and 40 ^{o}C. It can grow up to 35 in height. Its wood is used for pulp and saw timber.

P. montezumae is a pine that grows up to 35 m in height, its range goes from northern Mexico to Guatemala. It forms pure and mixed stands at altitudes of 1150 to 3150 m. The location where the seeds for this experiment were collected has an average temperature of 15 ^{o}C and rainfall of 800 mm. Its wood is used for pulp and saw timber. Produces abundant resin. Within its distribution the extreme temperatures go from -14 to 40 ^{o}C. The hot months are March to May and the coldest winter months are January and February, when frost and snowfall can occur.