An Agroforestry Demonstration
in Avra Valley of Southeastern Arizona

By

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INTRODUCTION

Production of food and fiber in the world is an age old challenge. Agroforestry, such as the intercropping of trees and agricultural crops, has been suggested as a means of alleviating food and fuelwood shortages, while providing sound ecological use of otherwise marginal lands (Ffolliott and Thames 1983, Weber and Hoskins 1983). Water harvesting, the collection of runoff from precipitation, is an ancient technology which has received renewed attention as other water enhancement options become less feasible (Dutt, Sands, Karpiscak, Foster, and Rawles 1983, Evett 1983, Fink and Ehrler 1983, Flug 1981, Frasier and Meyers 1983, Jain and Singh 1980, Schreiber and Frasier 1978, Shanan and Tadmor 1979). In the study described herein, microcatchments, a water harvesting technique, were used in conjunction with tree-agricultural crop plantings to assess the effects of both water harvesting and intercropping upon survival and production of biomass. The results of this study were analyzed with respect to the desirability of using the water harvesting and intercropping techniques in the production of fuelwood and crops.

Description of Study

The study was designed to determine the effects of microcatchments and the competition between plant species on the first year survival, growth, and yield of mesquite (Prosopis juliflora) and barley (Hordeum vulgare). Furthermore, the study was conducted in such a manner as to minimize capital inputs necessary to achieve successful establishment of the selected crops.
Study Area

The study area is located approximately 40 kilometers west of Tucson, Arizona, in Avra Valley. The site, occupying nearly one hectare is on the southern border of the city of Tucson’s Water Harvesting Agrisystem.

The elevation of the study area is approximately 600 meters. The terrain is relatively level, with a one to three percent slope to the northwest. The soil is a sandy clay loam (Dutt et al. 1983). Average annual precipitation, 300 millimeters, occurs in a bimodal summer-winter distribution pattern. The summer storms that begin in July and last through early September are sporadic, high energy, convective and frontal convectional in nature, providing 66 percent of the annual precipitation. Winter precipitation, from November through the end of March, occurs as evenly distributed storms, associated with well-defined frontal systems. Summer daytime temperatures are as high as 44 degrees C, with winter temperatures rarely below 0 degrees C (Sellers and Hill 1974).

The native vegetation has been disturbed by farming activities. Currently, the site is occupied by invading weeds.

Methods

The study involved three planting treatments: mesquite and barley; barley-only; and mesquite-only. Six replications of each planting treatment were equally divided into subplots, with and without microcatchments, in a completely randomized design (Little and Hills 1978). A total of eighteen subplots within each main plot, main plot A the control and main plot B the microcatchments, was established.

The microcatchment design was a modification of "strip microcatchments" described by Shanon and Tadmor (1979). These authors defined a strip-type microcatchment as a series of sawtooth ridges built by moving soil laterally and longitudinally with a motor grader, increasing the natural slope and forming a contour strip to collect runoff for a parallel cultivated strip. The microcatchment consisted of a catchment, a cultivation area, and an earth berm around the perimeter of each subplot. The four percent slope of the catchment provided maximum runoff while minimizing erosion (Jain and Singh 1980). A grader was used to construct the catchment system. Upon completion of the catchments, the slope was oriented to the west (the desired direction) and to the north, resulting in runoff being concentrated in the northwest corner of the cultivation strips. Therefore, berms were constructed at 10 meter
intervals perpendicular to the cultivation strip to keep the runoff in the desired area.

The catchment-cultivation ratio was 10:1, with the dimension of each subplot being 22 meters by 10 meters. A 2-by-10 meter strip served as the cultivation area, and the 10-by-20 meter area served as the catchment. After catchment construction, subsequent maintenance was accomplished with a tractor. The catchments received no runoff-inducing treatment other than grading and the compaction resulting from the weight of the grader.

Both main plots were located within 15 meters of each other to assure that they were exposed to similar rainfall and solar radiation, and were subjected to similar soil conditions. The control area consisted of three cultivated strips, approximately the dimensions and spacings as the cultivation area in the microcatchment, but with no water harvesting techniques utilized.

Mesquite and barley were selected for the study because of the presence of both species in the area. Easter and Sosebee (1975) reported that mesquite, when stressed for moisture, is an efficient user of water; but, when in areas of high available water, mesquite becomes an exorbitant user of moisture. Tromble (1977) indicated that mesquite is capable of behaving as a phreatophyte. The ability of mesquite to tolerate a wide range of soil moisture conditions makes the tree an ideal candidate for production in the high moisture-flux situations which occur within microcatchments. Barley was selected because of its ability to grow during the winter season.

The mesquite seeds were germinated, grown, and harden-off before outplanting the 6-week old stock on September 3, 1984. At the time of outplanting, all seedlings were vigorous and healthy. Each subplot requiring trees was planted with ten trees, which were randomly selected from the planting stock, on a 1 1/2-by-2 meter triangular spacing. Thereafter, the seedlings were checked for survival at varying time intervals. The trees where eventually enclosed, using a chicken wire cages to prevent browsing by wildlife. On December 3, 1984, the barley seeds were broadcast sown by hand, (at a rate of 0.5 kilograms per 2-by-10 meter subplot) and were raked in by hand. No other amendments, such as fertilizers or herbicides, were added to the site.

Biomass estimates were obtained for mesquite by double sampling methods (Reppert, Hughes, and Duncan 1962). Biomass of the mature barley was obtained by destructive sampling of the above ground biomass.

A non-recording rain gauge was employed to record precipitation.

At the time of measurement of either the trees or the
barley, a soil sample was taken within both main plots for to determine soil moisture. These samples were obtained at random locations within the main plots by using a king tube at 0.3 meter and 0.6 meter depths. Soil moisture was determined by the gravimetric method (Brady 1974).

RESULTS AND DISCUSSION

Survival

The survival counts are presented, by date, in Table 1. There was a difference in survival of trees between the microcatchment and the control. This conclusion was substantiated by a chi-square analysis (alpha level = 0.10) of the survival data at five measurement intervals. In all cases, the null hypothesis that survival is independent of treatment was rejected, and the alternative hypothesis that survival is not independent of treatment is accepted. Therefore, the use of microcatchments increased the number of surviving mesquite.

Biomass Production

Mesquite and barley biomass production results between the microcatchment and the control were similar to the results of the survival counts. The control produced no mature, living biomass. Sometime between March and April, the barley that had emerged within the control expired before the crop matured. Because emergence in the microcatchments was distributed throughout the subplots, samples were randomly taken within the subplots.

The results of a two-factor (microcatchments and planting schemes) analysis of variance for total biomass production of mesquite and barley was conducted. Null hypothesis one, factor A, that there is no effect of microcatchments on biomass production, was rejected (alpha level = 0.10). Null hypothesis two, factor B, that there is no difference in biomass production between planting schemes was also rejected. The barley and mesquite, and the barley-only planting schemes produce more biomass than the mesquite-only. Null hypothesis three, factor A x B, that there is no interaction of microcatchments and planting schemes affecting biomass production was rejected.

The above analyses reinforce the findings of the chi-square test, that the microcatchments affect survival and biomass production. In addition to survival and biomass increases, the analyses indicate that biomass production was not the same in all planting schemes; this was not surprising, as first year
### Table 1. Mesquite-Survival Count.

#### Mesquite Survival Count

<table>
<thead>
<tr>
<th>Date</th>
<th>Microcatchment</th>
<th>Control</th>
<th>Microcatchment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Survived</td>
<td>Mortality</td>
<td>Survived</td>
<td>Mortality</td>
</tr>
<tr>
<td>09/03/84</td>
<td>120</td>
<td>0</td>
<td>120</td>
<td>0</td>
</tr>
<tr>
<td>10/08/84</td>
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<td>38</td>
<td>22</td>
<td>98</td>
</tr>
<tr>
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<td>40</td>
<td>21</td>
<td>99</td>
</tr>
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<td>11/13/84</td>
<td>77</td>
<td>43</td>
<td>19</td>
<td>101</td>
</tr>
<tr>
<td>02/14/85</td>
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<td>62</td>
<td>10</td>
<td>110</td>
</tr>
<tr>
<td>04/25/85</td>
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<td>77</td>
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</table>

#### Proportion

<table>
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<th>Microcatchment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>Survived</td>
<td>Mortality</td>
<td>Survived</td>
<td>Mortality</td>
</tr>
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<td>0</td>
<td>1.0</td>
<td>0</td>
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<tr>
<td>10/08/84</td>
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<td>.316</td>
<td>.183</td>
<td>.816</td>
</tr>
<tr>
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<td>.825</td>
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<td>.358</td>
<td>.158</td>
<td>.841</td>
</tr>
<tr>
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<td>.516</td>
<td>.083</td>
<td>.916</td>
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<tr>
<td>04/25/85</td>
<td>.358</td>
<td>.641</td>
<td>.025</td>
<td>.975</td>
</tr>
</tbody>
</table>

Equations used:

**Proportion**

\[
\text{Survived} = \frac{\text{Tree survival}}{\text{Total Trees}} \\
\text{Mortality} = \frac{\text{Mortality}}{\text{Total Trees}}
\]
trees would not be expected to produce as much biomass as a plot of barley.

A multiple comparison test (Tukey's) indicated that there were no significant differences (alpha level = 0.10) in biomass production with the mesquite-only planting scheme within the microcatchment and no differences in the production of biomass in the subplots of the control. Therefore, although there was a significant difference in survival of the mesquite trees, the resulting biomass production of the mesquite-only plantings within the microcatchments and that of all planting schemes within the control was not significantly different. A multiple comparison test also indicated that there was no significant difference, within the microcatchments, in biomass production between the barley only and mesquite and barley mix. The similar biomass production could be due, in part, to the lack of interaction between mesquite and barley in competition for resources during the first year. Or, this is could be due to the dormancy of the mesquite during the active growing season of the barley.

The indication of lack of competition between the mesquite and barley is encouraging. Ideally, in addition to providing fuelwood, the mesquite could provide nitrogen to the interplanted crop. Barth and Klemmedson (1982) found that mesquite fixed nitrogen at the rate of 11.2 grams per square meter per meter of plant height. The nitrogen would benefit the companion crop. However, the interactions of the crops would need further research before any definitive conclusions could be made.

The finding that microcatchments increased survival and biomass production agreed, in general, with the findings of other researchers in Arizona. Schreiber and Frasier (1978) reported increased forage production by one hundred fold using water harvesting techniques. Fink and Ehrler (1983) concluded that Christmas tree production in arid and semi-arid regions is feasible using water harvesting techniques. Powelson (1982) found that vegetable and fruit production was feasible on mine spoils at Black Mesa, Arizona, utilizing water harvesting techniques.

Precipitation

Rainfall occurred in a summer-winter bimodal pattern during the study period. The precipitation for 1984 totaled 480 millimeters, 60 percent above the average, while precipitation for the experimental time frame, September to April, was 270 millimeters, 40 percent above average. Therefore, the study was conducted in a wetter than average season.
Soil Moisture

The emergence patterns within the control and the microcatchment plots, indicated that soil moisture was the limiting factor. Soil moisture within the microcatchment was consistently above that of the control, suggesting that microcatchments effectively increase the amount of available moisture to the plants.

CONCLUSIONS

From the results of the study, the following conclusions can be made:

1. Microcatchments increased survival and biomass production of mesquite and barley, over dryland conditions;

2. Intercropping of mesquite and barley produced no negative effects (due to interspecies competition) on the first year survival or on the production of biomass of either mesquite or barley;

3. Protective measures need to be taken for browsing and weed control;

4. The adaptability of mesquite to the high soil moisture flux characteristics makes the species suitable for production in this type of microcatchment;

5. Use of microcatchments can expand the planting window; and

6. There exists a possibility of a double cropping system in Avra Valley, Arizona.

The water harvesting technique (microcatchment) had a positive effect on survival and growth of both mesquite and barley by increasing the amount of available soil moisture. It should be pointed out, however, that this is a high-risk type technology, as it is dependent upon the amount and distribution of rainfall. Both amount and distribution of rainfall can be variable from year-to-year.

Results from this study indicated little, if any, competition between species. Interspecies competition may be expected in later years as the growth of the mesquite would put additional demands upon available resources.
Browsing and weeds were major problems in the study. As for the browsers, either they must be tolerated or some sort of protection will need to be used to keep them out. Salt treatment of the catchments would solve a majority of weed problems and improve runoff efficiency (Dutt et al. 1983).

The ability of mesquite to tolerate saturated soils and drought conditions makes mesquite an ideal tree for this type of water harvesting system. As the trees were planted in September, at the end of the summer rainy season, it may be implied that use of microcatchments expanded the planting window; this could facilitate tree planting operations by allowing trees to be planted for a greater period of time during the year.

In agreement with Flug (1981), there exists the possibility of a double cropping system in southeastern Arizona. With the bimodal distribution of rain and a climate conducive to plant growth throughout most of the year, it would be possible to have a dual cropping system in Avra Valley. One crop could be grown during the summer rainy season, while another (cold tolerant) crop could be produced during the winter rainy season.

Finally, study indicated that microcatchments are technically feasible for the production of mesquite and barley.

References Cited


