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A Mulch-Water Harvest Technique for Growing Vegetables in Arid Lands

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Summary. Methods for mulching and water collection around the plant were evaluated to develop an efficient way to grow vegetables where water is scarce. Plastic aprons and gravel mulch produced significantly higher squash yields than plots with no mulch. The plants with plastic performed better than those on gravel. Water conservation seems to be the main factor for increased production. Results indicate vegetable growing is possible under arid conditions with less than 5 inches of water.

INTRODUCTION

Growing vegetables in arid lands is often difficult, if not impossible, because water for growing the crop under traditional cultural procedures is not readily available. Annual rainfall is less than ten inches, with much of it falling during a few short periods. Runoff is great, resulting in much loss of this water. Furthermore, high temperatures and low humidities that exist in arid lands cause much water loss through evaporation. Another problem found in arid lands is the poor quality water.

Mulches conserve soil moisture and provide an environment around the plant more favorable for growth and production. The introduction of plastic films prompted much work on mulching in recent years. Many procedures for mulching with plastic, paper and other materials have been developed (2,3). Gravel has showed promise as a mulch in dryland production (5).

This report deals with mulching techniques that may make it possible and more practical to grow vegetables, especially in household gardens, where water is in minimal supply. It is hoped that these methods will encourage families in developing countries to grow vegetables for improving their own diets. Also under some conditions these findings may make market production more feasible. These developments may have far reaching effects because of the extent of arid and semi-arid lands in the world (4,6). In Arizona these techniques may have application on the Indian reservation.

This project originated when a representative of the Food and Agriculture Organization of the United Nations came to the University of Arizona for assistance in testing a plastic apron for growing horticultural crops with a minimal supply of water. The purpose of the plastic apron (mulch) is to reduce moisture loss from the soil and to act as a miniature collector of rain water for the plant in the center of the mulch. Financial support was provided by FAO during the 1969 and 1970 seasons.

The objective of this ongoing study is to develop a technique for growing vegetables with a minimum amount of water under arid conditions.

METHODS AND MATERIALS

The mulch tests were carried out at the Water Resource Farm at Tucson, Arizona, during 1969 and 1970. Plastic and gravel were used for mulch materials.

The plastic aprons, which were supplied by FAO, were made of vinyl, six mils in thickness and approximately one meter square. At the center of each apron was a 2-inch hole with flap edges which allowed easy seeding yet covered the soil surface next to the plant. Within a 6-inch radius of the plant stem many 1/4-inch holes in the plastic served as entry to the soil and root zone for runoff water from the surface of the apron. These holes are covered with an attached piece of plastic in such a way that the rainwater is funneled through the holes to beneath the plastic apron, but evaporation is inhibited due to the cover over the holes. These aprons were anchored by covering the edges with soil at the rim of the basin. The aprons were a light green color which faded to a dull white.

The gravel was light gray and varied in size from 3/16 to 5/8 inches in diameter. Gravel was used because of its cheapness, availability and success in Colorado (5). The depth of the gravel mulch was about 1.5 inches, covering an area equal to that of the plastic.

Plots were prepared for individual plants by excavating a shallow basin using a vee-shaped sweep on a posthole digger attached to a tractor. The basins were about 3 feet in diameter with a 5 percent slope to the center.

Rainwater collected from a 1/2 acre gravelled plastic catchment as described by Cluff (1) and stored in a butyl covered tank was used to supplement the natural rainfall collected on the plots. It was of high quality. A representative chemical analysis is given in Table 1.

Table 1. Chemical analysis of water used in FAO mulch project

TDS	Ca	Mg	Na	Cl	SO_4	CO_2	HCO_2	FP	NO_3	N	B
138	13	1	27	8	40	0	44	--	5	3.1	-

This auxiliary water was applied by hand in increments of one quart, two quarts and one gallon. In future plots a trickle irrigation system will be used. FAO has some plastic aprons with tubing on the underside which will deliver water to the plants (R. P. Chatelanat, FAO, personal communication).

Cucurbita pepo cv. 'Yellow Straightneck' summer squash was used as the test plant. Three plantings were made -- fall, 1969; spring, 1970; and fall, 1970 -- but because of a serious virus problem the results from the spring, 1970 planting were discarded.

In the fall of 1969 the squash seed was directly planted into the basins prepared for the plastic, gravel and bare soil plots. The seeds were placed in a mound of soil in the center of the mulched area. All plantings were well watered for stand establishment and then thinned to one plant. Ten plants in each treatment were replicated four times.

Two levels of watering were attempted in 1969. Level 1 was to be mainly rainfall, but because of an unusually dry season supplemental water was added as needed. Level 2 was to provide a more optimum supply of water to the plants. The schedules of water application are in Table 2. At these rates the plants on bare soil had difficulties, indicating more water should have been applied. The gravel plots received only Level 2.

Table 2. Application of water in inches[1] - fall, 1969

	Plastic covered		Gravel covered	Bare soil	
Date, 1969	Level 1	Level 2	Level 2	Level 1	Level 2
Sept. 11	.15	.15	.15	.15	.15
Sept. 16				.075	.075
Sept. 18	.075	.075	.075	.15	.15
Sept. 19	.15	.15	.15	.15	.15
Sept. 23			.15	.15	.15
Sept. 24	.15	.15			
Sept. 27			.075	.075	.075
Oct. 1		.075	.15		.15
Oct. 6			.075		.15
Oct. 11	.075	.075	.075	.15	.15
Oct. 18		.15	.15		.15
Oct. 21	.17	.17	.17	.17	.17
Oct. 25		.15	.15		.15
Oct. 28	.04	.04	.04	.04	.04
Nov. 9[2]	.44	.44	.44	.44	.44
Nov. 15[2]	.15	.15	.15	.15	.15
Total water in inches	1.36	1.77	1.92	1.55	2.15
in gallons	9.1	11.8	12.1	10.3	14.3

[1]Water application in inches was determined using the area of the plastic apron. The conversion factor was 1 gallon = .15 inches of rain. This relation was used also for gravel and bare soil plots. Levels refer to intensity of water application; Level 2 is greater than Level 1.

[2]Rainfall.

In the fall of 1970 the plastic, gravel and bare soil treatments were compared again, but all plants were first established with the plastic mulch. When a good stand was attained, the plastic was removed from some plots and replaced with gravel or bare soil. Because of heavy rains at the beginning and a good soil moisture situation, all plots received the same additional water (Table 3).

Table 3. Application of water in inches[1] - fall, 1970

Date, 1970	All plots
Sept. 2	.04
Sept. 3[2]	1.92
Sept. 4[2]	.22
Sept. 5[2]	1.61
Sept. 6[2]	.02
Sept. 12[2]	.36
Oct. 1[2]	.02
Oct. 3[2]	.14
Oct. 20	.07
Oct. 26	.15
Nov. 2	.15
Total Water	
in inches	4.74
in gallons	31.6

[1]Water application in inches was determined using the area of the plastic apron. The conversion factor was 1 gallon = .15 inches of rain. This relation was used also for gravel and bare soil plots.

[2]Rainfall.

To help determine soil moisture under the mulch, gypsum moisture blocks were installed on randomly located plots of each treatment. These were placed at two locations: one directly beneath the plant, and the other at the edge of the plot. Four blocks were placed in the soil at each location at depths of 2, 6, 12 and 18 inches.

Fruits were harvested every other day; however, different methods were used each year, accounting for fruit size differences. Analysis of variance was applied to yield data in 1970. Each year frosts in November cut short the growing season.

RESULTS AND DISCUSSION

Both years the mulched plots produced the best yields with plastic aprons doing the better job (Table 4). In 1970 plastic significantly out-yielded the bare plots. Yields, although limited by frost, were equal to more than 350 bu. per acre, a good average yield.

Table 4. Squash yield for treatments used in FAO plantings, 1969-70[1]

	No.	Wt. (gms)	No.	Wt. (gms)	No.	Wt. (gms)
Fall, 1969						
Level 1	18.5	1560	---	---	0	---
Level 2	33.0	2529	8.2	534	0	---
Fall, 1970						
Level 1	34.5	7718	27.7	6311	22.2	4367

[1]Average number and weight of fruit produced by five plants

The plastic, and to a lesser extent the gravel, reduced moisture loss as indicated by water added and the yields obtained in these cases. Also the mulches reduced crusting over germinating seed which was a problem in the bare plots in 1969.

From the data collected it is difficult to appraise the water-collecting property of the plastic apron and the effect of this property of the plastic apron and its effect on plant growth. However, water did condense in droplets on the underside of the plastic aprons. Because of the slight incline toward the plant and the space between the soil and the plastic, the droplets may move closer to the plant. Some of the moisture block readings suggest this to be happening. The block at a depth of two inches was wetter than the three deeper blocks after two days of not having watered the plant. It is possible to consider the plastic apron as a small scale water harvesting mechanism or a "micro-catchment" which concentrates evaporated water on the underside as well as collects water falling on the top side.

The amounts of water used to produce these crops -- about 2 inches in 1969 and about 5 inches in 1970 -- are significant. These results, when compared to traditional agriculture where much more water is used, indicate that water for crop production can be used much more efficiently than present cultural practices.

Studies will continue with these mulches in conjunction with water harvesting techniques and trickle irrigation. Ideas developed in Israel by Shannon, Evanari and Tadmor (7) will also be considered.

CONCLUSIONS

Vegetables can be grown under arid conditions with a minimal supply of water. Mulching, especially with the plastic apron, makes this type of growing possible. A complete system utilizing water harvesting, mulching and trickle irrigation shows much promise for growing vegetables where normally it is very difficult to do so.

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