THE UNIVERSITY OF ARIZONA
Cooperative Extension

az2045 March 2023

Guayule Cultivation and Irrigation Methods for the Southwestern United States

Diaa Eldin Elshikha

Introduction

As water becomes scarce in Arizona there is a desire by growers to grow crops that use less water. With hundreds of acres already planted across the state and the plan to scale to 10,000 acres over the course of three years, guayule has become a more water wise crop than traditional desert row crops like silage corn, alfalfa, and cotton. In this guide, cultivation and irrigation methods will be discussed to increase area under guayule across the state.

A perennial shrub

Guayule (*Parthenium argentatum,* A. Gray) is a perennial shrub, native to the desert north-central Mexico and south-west Texas., It produces high quality natural rubber that is suitable for use in passenger and commercial-grade tires (Eranki et al., 2018). The latex is hypoallergenic, desirable in the medical device market (Rasutis et al., 2015), and resin can be used in a variety of industrial products such as adhesives and coatings (Nakayama et al., 2001; Thames and Kaleem 1991). The primary parts of the guayule plant of economic interest are in the parenchyma tissues of the stems and roots where most of the rubber particles accumulate (Kajiura et al., 2018). However, stems and roots only constitute about 6 and 9% of the total plant dry weight, respectively (Kuruvadi et al., 1997).

Planting (direct seeded)

Research has shown the best seeding method is to plant in 40”-rows using a pneumatic small seed planter. Seeding in dry, raised beds is recommended, 10” wide and 6.0”-8.0” high. After two years of growth, in early trial plots in Arizona (Ray et al., 1999) reported that out of 6 cultivars registered to be grown in Arizona, AZ2 and AZ6 had the highest rubber yield. The AZ2 line is an interspecific hybrid with good seedling vigor and high biomass production (Ilut et al., 2017). AZ6 has less biomass than AZ2 but produces higher rubber content. (Ray et al., 1999).

Germination

Flood, solid-set sprinkler, and gravity drip irrigation methods have been used for germination. Soil surface should be kept wet for about 5-10 days after planting for

seedling germination, as recommended by Dissanayake et al. (2008). After germination, guayule seedlings should be kept well-watered by irrigating several times during the next seven weeks using level furrow irrigation (Martin and Gilley, 1993), a common surface irrigation method used in the Arizona.

Nitrogen, water use, and tolerance to drought

Nitrogen use –

Guayule can be grown with moderate nitrogen applications ranging from 58 to 89 lb N/ac per year (Bucks et al., 1985). It can be injected into the water (fertigation) to guarantee even distribution across the entire field. Cotton and silage corn for example requires about 200 lb N/ac.

Water use –

The amount of water required for germination of direct seeded guayule ranges from 6-15 inches (0.5-1.25 acre-ft), depending on weather and the irrigation method (lower rates under drip and sprinkler, and higher rates under flood irrigation). An example of the irrigation amounts, and number of events are given in Table 1. The flood irrigation data is based on a field study conducted by Elshikha et al., 2022. The table indicates small difference in water use (6.3"- 6.8") during germination with sprinkler and gravity drip. However, germination under flood required more than twice (15") compared to drip and sprinkler. Once established, flood irrigation can be used at a rate of 4.0"-5.8" per event. There are two irrigation events per season, in spring, summer and fall of the first year. In the second year, one of the two irrigations during fall may be skipped. No irrigation is required during winter as the plants go dormant.

The annual water required under flood and drip irrigation is approximately 2.5-2.9 ft/year with the irrigation schedule in Table 1, which is within the probable annual water allocation depth for many Central Arizona growers. The flood irrigation in Table 1 represents a deficit treatment in our recent irrigation study, where we skipped every other irrigation (Elshikha et al., 2022). In this treatment, crop was irrigated approximately every six weeks in summer, which was half the recommended rate for clay soil. No reduction in rubber production was observed in this treatment. This implies that cycles of wetting and drying maybe advantageous for rubber production. The drip irrigation data draws upon a previous study conducted by Elshikha et al. in 2021, with an adjustment to the irrigation frequency (skip every other irrigation).

The deficit irrigation study showed that guayule fared well with no detrimental effect other than decreased growth during the hottest and driest summer on record with no irrigations between June and September. With water shortage, and the uncertainty of water supply in some areas, growers may be forced to cut irrigations for several months. Under such circumstances the guayule crop will be an adequate fit, as they begin to grow when water is applied.

Drought tolerance –

Guayule is a drought tolerant crop and can survive extreme moisture stress in the desert south-west, where it remains in a semi-dormant state, until irrigation is resumed. Its ability to survive long periods of drought comes from the capability of its roots to extract moisture from the lower depths of the soil profile (Bucks et al., 1985a). Previous research indicated that even though guayule can withstand long periods of drought, well-watered guayule grown from transplants can have cumulative crop evapotranspiration (ETc) of over 59 inches during its first year of growth, and

Table 1. Irrigation for guayule grown in Arizona (two-year growing season)

Years of growth		Flood	Drip	Sprinkler	No. of events			Month
		(F)	(D)	(S)	F	D	S	
	Germination	5	0.79	0.85	3	8	8	
1st year	Spring	5.1	0.50		2	11		May
	Summer	4.0	0.40		2	22		June-Aug.
	Fall	5.5	0.50		2	22		Oct.-Nov.
	Winter							
2nd year	Spring	5.8	0.55		2	22		Mar.-May
	Summer	5.1	0.50		2	22		June-Aug.
	Fall	5.4	0.50		1	11		Oct
	Winter							
	Total (in.)	71.4	60.2					

over 79 inches during its second year (Bucks et al., 1985a, 1985b; Hunsaker and Elshikha, 2017; Hunsaker et al., 2019). In these studies, when total water applied either matched or exceeded ETc requirements, gave the highest biomass production.

Guayule growers in the U.S. Southwest will likely not meet 100% of ETc (51 to 59 inches per year). When grown on lighter soils, literature indicates an irrigation deficit of 20-25% from full ETc would not reduce rubber yield significantly (Bucks et al., 1985a and b; Hunsaker and Elshikha, 2017; Elshikha et al., 2021). However, on heavier soils there appears to be a greater opportunity to reduce irrigation. A field study on a heavier soil type in central Arizona, Elshikha et al., 2022, indicated that exposing direct-seeded guayule to a pre-determined soil water deficit periods, over a 23 month-long growing season, did not reduce the yield significantly, compared to fully irrigated guayule.

Conclusions

As water efficiency becomes more important to Arizona, growers will resort to produce more with less. With a severe reduction in water stored in Lake Mead, as inflow rates of Colorado river water slows, growers will mine finite groundwater. Guayule is a water wise and profitable crop that provides an in-demand domestic source of elastic and rubber goods. Planting guayule will be one way to avoid the field going fallow during extended drought in the Southwest region of the United States.

NOTE: Information about guayule seeds and planting methods can be obtained from Bridgestone Americas, Inc. at 4140 West Harmon Rd, Eloy, Arizona 85131.

References

Bucks, D.B., Nakayama, F.S., French, O.F., Legard, W.W., Alexander, W.L., 1985a. Irrigated guayule-evapotranspiration and plant water stress. Agric. Water Manag. 10, 61-79.

Bucks, D.B., Nakayama, F.S., French, O.F., Rasnick, B.A., Alexander, W. L., 1985b. Irrigated guayule-plant growth and production. Agric. Water Manag. 10, 81-93.

Dissanayake, P., George, D.L., Gupta, M.L., 2008. Direct seeding as an alternative to transplanting for guayule in southeast Queensland. Industrial Crops and Products 27, 393-399.

Elshikha, D.M., Waller, P.M., Hunsaker, D.J., Dierig, D., Wang, G., Cruz, M.V., Thorp, K.R., Katterman, M.E., Bronson, K., Wall, G.W., 2021. Growth, water use, and crop coefficients of direct-seeded guayule with furrow and subsurface drip irrigation in Arizona. Ind. Crops Prod. 170, 113819.

Elshikha, D. M., G. Wang, P. M. Waller, D. J., Hunsaker, D. Dierig, K. R. Thorp, A. L. Thompson, M. E. Katterman, M. T. Herritt, E. Bautista, D. T. Ray, G. W. Wall, 2022. Guayule growth and yield responses to deficit irrigation strategies in the U. S. desert. Agric. Water Manag. 277, 108093, https://doi.org/10.1016/j.agwat.2022.108093.

Eranki, P.L., El-Shikha, D., Hunsaker, J., Bronson, K.F., Landis, A.E., 2018. A comparative life cycle assessment of flood and drip irrigation for guayule rubber production using experimental field data. Ind. Crops Prod. 99, 97–108.

Hunsaker, D.J., Elshikha, D.M., 2017. Surface irrigation management for guayule rubber production in the US desert Southwest. Agric Water Manag. 185, 43-57.

Hunsaker, D.J., Elshikha, D.M., Bronson, K.F., 2019. High guayule rubber production with subsurface drip irrigation in the US desert Southwest. Agric Water Manag. 220, 1-12.

Ilut, D.C., Sanchez, P.L., Coffelt, T.A., Dyer, J.M., Jenks, M.A., Gore, M.A., 2017. A century of guayule: Comprehensive genetic characterization of the US national guayule (Parthenium argentatum A. Gray) germplasm collection. Ind. Crops Prod. 109, 300–309.

Kajiura, H., Suzuki, N., Mouri, H., Watanabe, N. & Nakazawa, Y., 2018. Elucidation of rubber biosynthesis and accumulation in the rubber producing shrub, guayule (Parthenium argentatum Gray). Planta 247, 513-526.

Kuruvadi, S., Jasso Cantu, D., Angulo-Sanchez, J.L., 1997. Rubber content in different plant parts and tissues of Mexican guayule shrubs. Ind. Crops Prod. 7, 19-25.

Martin, D.L., Gilley, J.R., 1993. Irrigation Water Requirements. Part 623, Nat. Eng. Handbook. USDA-SCS, Washington, D.C, Chapter 2.

Nakayama, F.S., Vinyard, S.H., Chow, P., Bajwa, D.S., Youngquist, J.A., Muehl, J.H., Krzysik, A.M., 2001. Guayule as a wood preservative. Ind. Crops. Prod. 14, 105-111.

Rasutis, D., Soratana, K., McMahan, K., Landis, A.E., 2015. A sustainability review of domestic rubber from the guayule plant. Ind. Crops Prod. 70, 383–394.

Ray, D.T., Dierig, D.A., A.E. Thompson, and Coffelt, T.A., 1999. Registration of six guayule germplasm with high yield ability. Crop Sci 39, 300.

Thames, S.F., Kaleem, K., 1991. Guayule resin in amine-epoxy strippable coatings. Bioresource Technology 35, 185-190.

THE UNIVERSITY OF ARIZONA
Cooperative Extension

AUTHORS

Diaa Eldin Elshikha
Assistant Specialist, Biosystems Engineering

Peter Waller
Associate Professor, Biosystems Engineering

Robert Masson
Assistant Agricultural Extension Agent, Yuma County Cooperative Extension

Jay Subramani
Research Specialist, Maricopa Agricultural Center

CONTACT

Diaa Eldin Elshikha
diaaelshikha@arizona.edu

This information has been reviewed by University faculty.
extension.arizona.edu/pubs/az2045-2023.pdf

Other titles from Arizona Cooperative Extension can be found at:
extension.arizona.edu/pubs