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Managing ratooned guayule in the Southwestern United States

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Introduction

In Arizona, sufficient water supply for agriculture has become a growing concern for farmers due to drought and the depletion of groundwater supply. Therefore, crops like guayule that provide economic value while consuming less water will be needed. Since guayule follows a perennial lifecycle, it can be cut and regrown multiple times after the initial harvest with a process called ratooning. In general, ratooned guayule requires less water than replanting as more water is needed at crop establishment to support seedlings than is needed to regrow mature plants. This can result in lower irrigation costs if an optimized irrigation regime is adopted. The following guide leverages data from several years of Arizona grown guayule and provides a specialized irrigation strategy in terms of irrigation amounts and timing to save water and optimize growth for ratooned guayule.

Guayule as a valuable economic crop

The current source of natural rubber is the Hevea tree that grows in Southeast Asia. The production of vehicle tires accounts for almost 70% of the usage of this rubber (Cornish et al., 2001). For tire manufacturing, both natural and synthetic rubber are required. Guayule provides a sustainable domestic alternative for natural rubber production. The rubber is contained in the parenchyma tissues primarily found in the stems of the plant and past experiments have shown that the harvested plants contain anywhere from 2 – 6% of rubber per dry weight (Bucks et al., 1985a, Wang et al., 2022). Guayule also contains two co-products that have further economic value and industrial importance. The resin can be fashioned into goods such as paints, adhesives, and insecticides while the bagasse, which makes up about 85% of the processed guayule, could manufacture hardboards and composite particleboard as well as biofuels like alcohol, jet and diesel fuels, along with heating logs (Nakayama, 2005).

Benefits of ratooning guayule

Considerable farming effort is needed to grow guayule during its initial years before the first harvest. However, once the perennial crop is established, continuing its cultivation for subsequent years has many advantages in terms of farm management and product attainment. The normal practice is to harvest (ratoon) guayule every two years. Past farming experience from industrial growers such as Bridgestone Americas, has demonstrated it can be ratooned every other year, up to six years, with little loss to yield. The potential for more ratooning cycles beyond the six years exists, but further research is needed to confirm. Ratooning has been shown to improve overall farm management efficiency, reducing overall fertilizer, pesticide, irrigation, and tillage inputs. In the current drought situation in Arizona, the most important gains from growing guayule come from reusing established mature root systems rather than re-establishing them with a new crop.

Improved yield and water productivity

In general, larger yields of guayule biomass, rubber and resin are produced with less water during its regrowth cycle compared to the initial growth period. This is typically described as increased water productivity. Experiments conducted at the Maricopa Agricultural Center (MAC), Figure 1, from 2018 – 2022 demonstrated significant yield increases of 28%, 47%, and 35% for biomass, rubber and resin using 59.3 inches less of total applied irrigation (AI) for furrow irrigation and 17%, 27%, and 25% more biomass, rubber and resin with 52.0 less inches of AI for subsurface drip irrigation (SDI) during the ratooning cycle (2020 – 2022) compared to establishment growth period [2018 – 2020] (Elshikha et al., 2021). Thus, in terms of water productivity for rubber production, an increase of 0.114 pounds of rubber per acre-inch of total applied water (irrigation + precipitation) was observed with furrow irrigation at MAC.

Figure 1. Guayule growing at the University of Arizona Maricopa Agricultural Center in Maricopa, Arizona.

Deficit irrigation strategies implemented in a recent experiment on the first growth cycle (Elshikha et al., 2023) will probably have result in even greater water productivity for rubber yield than was observed in the recent ratoon experiment. Nonetheless, more research is necessary to investigate how such strategies impact water use and yield in ratoon guayule.

Irrigation strategy and optimization for ratooned guayule

According to the findings of the experiment conducted at the University of Arizona Maricopa Agricultural Center (MAC) from 2018 – 2022, 26%, and 17% less irrigation water was applied for furrow and SDI during the ratooning cycle (2020 – 2022) compared to the establishment period [2018 – 2020] (Elshikha et al., 2021). Much of this reduction was due to elimination of establishment irrigations that had taken place at the beginning of the experiment but was not necessary for future growth periods following dormancy. For example, with flood irrigation there was an average of 8 irrigation events per month during the first spring, whereas with subsequent spring periods, only 2-3 irrigations per month were required. In general, for ratooned guayule, a smaller number of irrigations are needed but with slightly more water applied for each event. These cutbacks in applied irrigation are a result of a well grown root system that is much more efficient in extracting water in the soil than the initial growth season, where it took time for the roots to become established. To optimize regrowth, a specialized irrigation strategy should be implemented during the two-year ratooning cycle, which is discussed in greater detail in the next section.

Data from a two-year experiment on ratooned guayule at MAC (2020-2022) indicated that irrigation events should be adjusted during the year to match seasonal water requirements. Tables 1 and 2 display the number of irrigations per week (for SDI - table 1) or month (for furrow - table 2) and the average amount of water applied during each irrigation event.

The trends show that for SDI, a grower should apply 3-6 irrigations per week with 0.3 to 0.5 inch of water applied during each event. For furrow irrigation, it is recommended that growers apply two irrigations per month on sandy loam soil with amounts ranging from 2 to 5 inches per event. Irrigation might be less frequent in heavier soils. Although the specific timing and depth is influenced by soil type, crop maturity, and climatic variability, tables 1 and 2 provide guidance on timing as a function of crop maturity and season.

In general, more water is provided to the guayule during the summer seasons and less during the spring and fall. The exception to this is during the second spring season when the soil profile is replenished after the winter cutback in irrigation and with full guayule canopy cover (tables 1 and 2).

During the summer season water application is high in June to July but may decrease from late-July until mid-September. Even though the air temperature may be high during this time period (July to September) a reduction in crop evapotranspiration (ETc) generally takes place due to high relative humidity and monsoon rainfall. Other factors might include a reduction of flowering, slower overall growth, and leaf losses (Bucks et al., 1985). Tables 1 and 2 show that a reduced amount of water applied during the second summer (2021) compared to the first one (2020). This trend occurred due to an increase in evapotranspiration (ET) that took place with higher air temperatures during the first summer. The summer of 2020 was much hotter and drier than the subsequent year (Figure 3. The takeaway

Table 1. Number of irrigations and applied water for subsurface drip irrigation (SDI) of ratooned guayule during a two-year growth cycle (2020 – 2022).

Growing season	Number of irrigation events per week	Applied water per irrigation event (in.)
Spring 2020	3	0.33
Summer 2020	6	0.39
Fall 2020	4	0.28
Spring 2021	4	0.51
Summer 2021	4	0.49
Fall 2021	3	0.49

Spring (March 21 – June 20), Summer (June 21 – September 20), Fall (September 21 – December 20).

Table 2. Number of irrigations and applied water for furrow irrigation of ratooned guayule during a two-year growth cycle (2020 – 2022).

Growing season	Number of irrigation events per month	Applied water per irrigation event (in.)
Spring 2020	2	2.25
Summer 2020	2	3.75
Fall 2020	2	3.15
Spring 2021	2	4.80
Summer 2021	1	5.10
Fall 2021	2	2.70

Spring (March 21 – June 20), Summer (June 21 – September 20), Fall (September 21 – December 20).

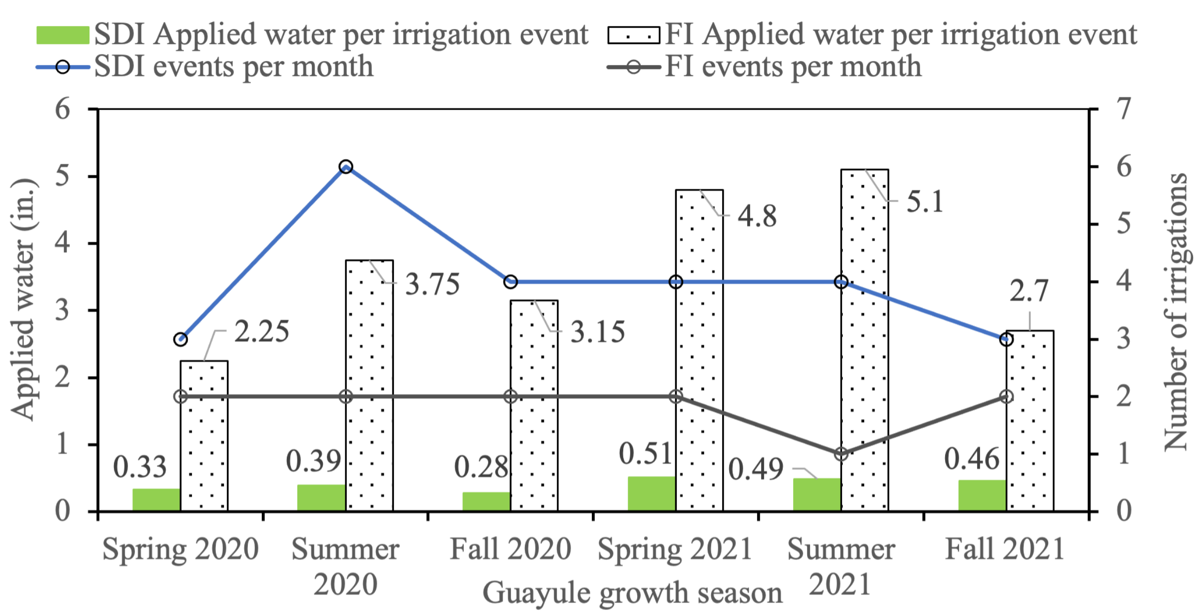

Figure 2: Applied water and irrigation events for ratooned guayule under subsurface drip (SDI) and furrow irrigation (FI) at the University of Arizona Maricopa Agriculture Center in Maricopa, Arizona

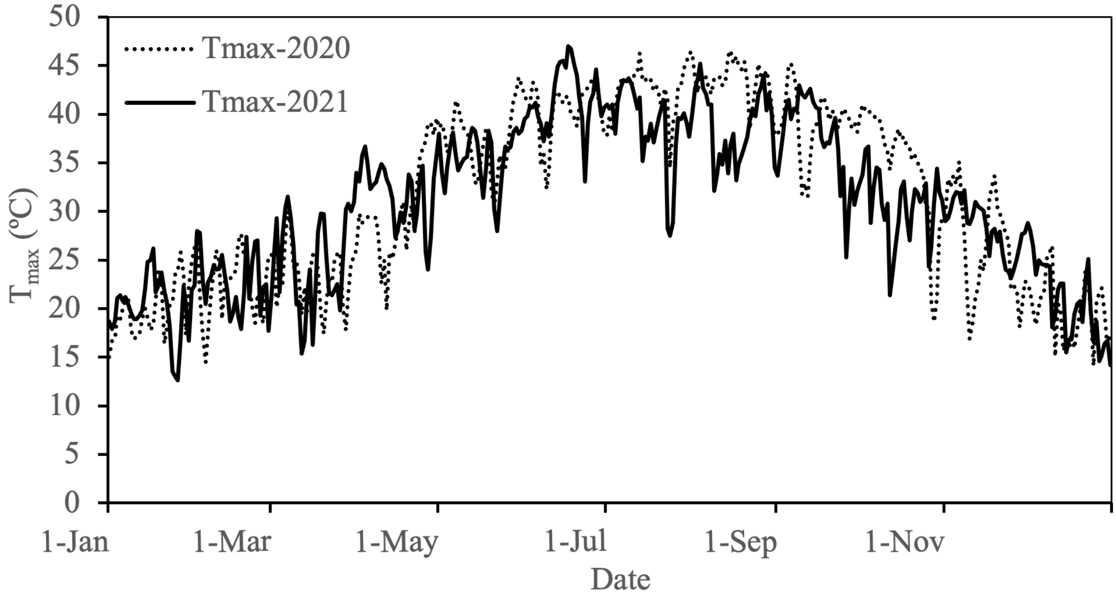

Figure 3: Compared maximum temperatures (Tmax) during years 2020 and 2021 at MAC Agriculture Center, Arizona.

message is that the irrigator should pay close attention to the ETc requirements reported by the local weather station when determining the exact amount of water to apply for each irrigation during the summer season. In addition, the grower might invest in soil sensors or remote sensing data in order to monitor the crop water status.

Conclusion

Unlike other crops in Arizona that have a history of significant production issues surrounding a ratooned growing system (specifically cotton), guayule does not appear to have these same issues. As a native desert adapted shrub, many of the production issues surrounding ratooning non-native crops, such as overwintering insect pests and lingering effects from pathogens both in the above ground plant and in the roots. These issues have not appeared to significantly affect a ratooned guayule production system. Growing guayule as a perennial crop has the potential to reduce water use compared to other crops. This is partly a result of the reduced overall water requirements of the guayule during its ratooning cycles. Less water is applied because the crop has already developed a mature root system that is efficient in extracting water from the soil and eliminates the need for establishment irrigations during the springtime when annual crops are usually planted. Previous research has provided a reliable guide in terms of irrigation frequency and applied water amounts per irrigation event for guayule during its two-year regrowth cycle, but special attention should be given to climatic variability and crop status to tailor irrigation amounts to weather conditions. Increases in biomass, rubber and resin have been shown for ratooned guayule compared to guayule that has been grown in a traditional annual cropping system. A well-managed ratooned guayule production system may possibly present an economically viable option for growers where water supplies are limiting.

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