between 30 and 35°. The grass plots with clear plastic covers were somewhat warmer than the uncovered plots ranging from 32 to 38° and the bare covered plots were the warmest at 37 to 41°.

The surface soil temperture in all plots was decreasing by 1600 TST and continued to decrease throughout the night. Vegetation in the covered grass plots was severely injured by the near 40°C temperatures during the day. In one of the plots, this injury was more severe than in the other. In this plot, the upwind side of the plot had less injury, probably indicating that some ventilation under the plastic was taking place during the day. Differences in vegetation also caused greater differences between replications in the soil surface temperatures of the grass plots whether covered or uncovered when compared to the bare soil plots.

Soil surface temperatures which were monitored for an hour starting at 0053 TST before the surface plastic covers were removed, showed that all plots were still cooling and temperature differences between treatments had narrowed. The covered bare soil was significantly (5% level) warmer than all other treatments and the covered grass plot was warmer than the grass treatment at the 10% level of significance. The grass plots were at about 10°C, the bare soil between 10 and 12°, the covered grass at about 13°, and the bare covered plots at about 17°. Upon removal of the covers, the bare soil which had been covered showed an immediate response and cooled quickly to below 12°. The grass plot which had been covered showed some acceleration in cooling but at a much reduced level. The bare and grass plots which had never been covered continued the cooling trend observed earlier in the evening.

The average heat flux at the soil surface for each of the 4 treatments is shown in Fig. 2. Considerable scatter was shown in the individual data points and thus, for clarity, only the trend lines are drawn in Fig. 2. the covered bare soil released heat significantly (5% level) faster than all other treatments. The bare soil which had not been covered released heat at a rate twice (significant at the 10% level) that of the grass plot (—6.4 vs. —3.1 mW/cm^2). The grass plot which had been covered released heat at the same or at a greater rate than the bare soil for a short period of time and then dropped below the bare soil rate after about one hour. The bare soil which had been covered, on the other hand, released a large quantity of heat reaching the equivalent of one-half (—33 mW/cm^2) of full sunlight for a very short period of time and staying above —10 mW/cm^2 for the whole 2-hr cooling period. This represents a greater than doubling of heat output when compared to the bare soil which had not been covered.

The bare soil gave off more heat as expected than a grass covered soil at least when a radiant cooling night followed a bright sunny day. It is also evident that covering a bare soil results in a large increase in heat available for frost protection while covering a grass surface results in an amount of heat available for frost protection approximately equivalent to maintaining a bare soil plot uncovered. Welles et al. (7) have calculated that an increase in soil surface temperature of 10°C would reduce the required burn rate of orchard heaters by about 25%. Or, alternatively, for temperature conditions such that the air temperature had fallen to the critical temperature for blossoms, Welles et al. (7) found that a 10° increase in soil surface temperature would save an additional 35% of the blossoms (50% vs. 15% for their specific example). The data reported in this paper indicate that a 10° difference between covered bare soil and uncovered plots is feasible if practical ways of trapping solar energy can be discovered.

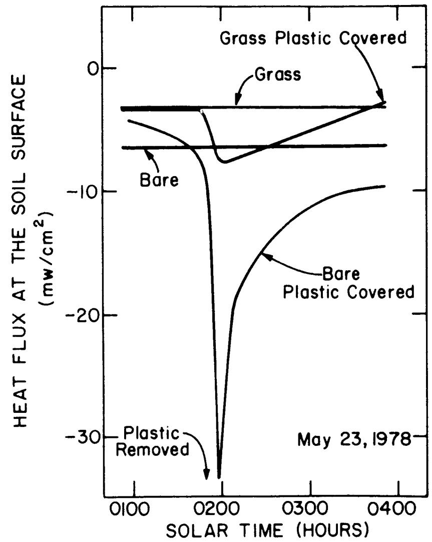

Fig. 2. Soil surface heat flux for a radiation cooling night just before and after plastic covers were removed from bare and grass covered plots.

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HortScience 16(3):296. 1981.

A Method for Harvesting, Cleaning, and Treating Achenes of Guayule (*Parthenium argentatum* Gray)[1]

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Additional index words. plant propagation, seed

Abstract. Procedures are described to mechanize partially harvesting, cleaning, and pretreatment of guayule achenes. Achenes are harvested with a vacuum insect net and cleaned by a series of screening, threshing, and forced air separations, then treated to overcome seed coat impermeability in a semiautomatic system that presoaks, treats with 0.5% sodium hypochlorite, and rinses. Achenes may be sown immediately or dried for storage. Procedures outlined involve commercially available equipment with a minimum of custom construction and are adaptable to small or large operations.

Guayule is a rubber-synthesizing shrub native to portions of the Chihuahuan Desert in Texas and Mexico. Commercial interests and the United States government through the Emergency Rubber Project (ERP) investigated guayule rubber production from 1922 to 1959. A complex interaction of various political and economic forces has resulted in renewed interest in commercial guayule rubber production (6, 7). A major concern is the rubber content, which varies greatly among genotypes. Breed-

[1]Received for publication October, 26, 1979.

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[2]Support of the Southwest Border Regional Commission is gratefully acknowledged. Mention of trade names is made for identification purposes only, and does not imply any endorsement by the Texas Agricultural Experiment Station. All programs and information of the Texas Agricultural Experiment Station are available without regard to race, ethnic origin, religion, sex and age.

ing programs to increase yields are utilizing selections from native populations and improved cultivars from the ERP. Difficulty in manual harvesting, cleaning, and treating achenes is hindering progress in these programs and in the establishment of experimental plots.

Guayule blooms continuously under long days, high temperatures (over 15°C), and adequate available water. Yields of 1.4×10^8 achenes ha^{-1} have been reported under irrigation (4). The capitulum, about 5 mm in diameter, includes 5 fertile ray flowers and numerous infertile disk flowers. The mature achene measures about 2.5 mm by 1.8 mm and is attached to a subtending bract and 2 adjacent disk flowers, which abscise as a unit (Fig. 1). The remaining disk flowers are coalesced and also abscise as a unit (5).

A vacuum-type field harvester was developed during the ERP era that collected a higher percentage of available achene complexes than any other design (9). A gasoline-powered backpack vacuum insect net (D-Vac Co., Riverside, California) is a satisfactory mechanical harvester for small areas. A mean of 135 achene complexes, or 94% of the total available, was harvested in a greenhouse test by this method with little variation among plants (SD = 4, n = 10). The United States Forest Service is developing similar backpack vacuum seed harvesters (11). The mobility of these harvesters allows mechanical harvesting of native populations as well as cultivated plots.

The present achene cleaning procedure was adapted from that developed during the ERP and consists of 3 stages: preliminary cleaning, where a 2-screen vibrating clipper cleaner (A.T. Ferrell, Saginaw, Michigan) is used to remove larger stem and leaf fragments and disk flower clusters; threshing, where a burr clover huller (Forsberg's Inc., Thief River Falls, Minnesota) is used to thresh achene complexes and will fracture complexes at a rate of 200 kg hr^{-1} without damage; and final cleaning (Fig. 2) (4, 10). A gravity table was used during the ERP to separate threshed material into 2 portions, one of empty achenes and chaff and another of filled achenes and small stem and leaf fragments, after which the non-achene fragments in the latter were removed by screens. This procedure was modified to involve manual screening followed by separation in a continuous forced air seed blower (Mater Machine Works Inc., Corvallis, Oregon). Screening removes unbroken achene complexes and disk flowers, but this is done manually since achene lots for research purposes are small and threshing greatly reduces the volume of material. The seed blower separates fine trash and empty achenes.

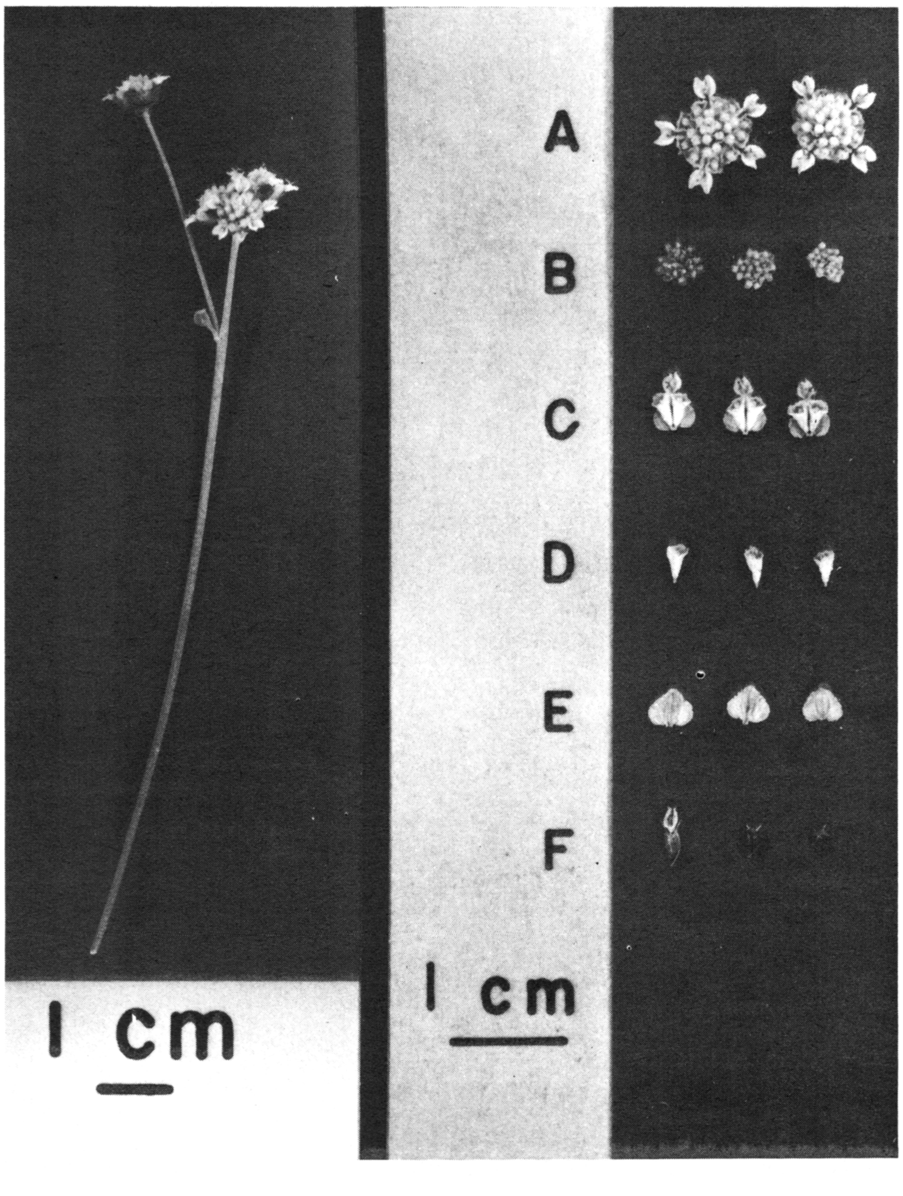

Fig. 1. Inflorescence (left) and fruit parts (right) of guayule: A) Capitulum, B) Disk flower cluster, C) Achene complex, D) Disk flowers removed from achene complex, E) Bracts removed from achene complex, F) Achenes.

Benedict and Robinson (1) reported that guayule achenes exhibit double dormancy. The inner seed coat is impermeable to gas exchange, which may be overcome by a weak oxidizing agent, commonly 0.5% sodium hypochlorite. Embryo dormancy, which is 2 months in duration, may be broken by exposure to light or gibberellin (2, 3). Optimum germination occurs if achenes are presoaked for 8 hr in water, treated with sodium hypochlorite for 2 hr, then rinsed thoroughly to remove toxic sodium chlorate, a byproduct of sodium hypochlorite deterioration (8).

Cleaned achenes are placed in porous-wall containers for treatment. Two containers have been devised for this purpose. Holes 6.35 mm in diameter are drilled in the bottom of 2 plastic 35 mm film canisters (35 mm diameter x 50.8 mm high), which are then cemented bottom-to-bottom with a layer of sheer fabric between. Holes 25.4 mm in diameter are cut into the caps, then small lots of achenes are placed in the canisters, which have layer of sheer fabric under each cap. Larger lots of achenes are placed between 2 or more U.S. standard 40 mesh (0.42 mm opening) brass sieves held together with elastic band clamps.

The following treatment tank system is a possible approach to overcoming seed coat impermeability. Components are widely available and a minimum of custom construction is necessary. The system as designed requires some monitering, but only within a standard 8 hr work day schedule. It consists of a sealed 95 liter galvanized tank equipped with a float valve-controlled water inlet, a submersible recirculating pump, and a solenoid-controlled water outlet (Fig. 3). The solenoid, which must operate at 0 g cm^{-2}, is controlled by a "liquid level" sump float switch controlled by a 24 hr time switch. Sieves are placed over the outlet of the recirculating pump. The float valve fills the tank to the top of the sieves and the pump is turned on. The canisters are sub-

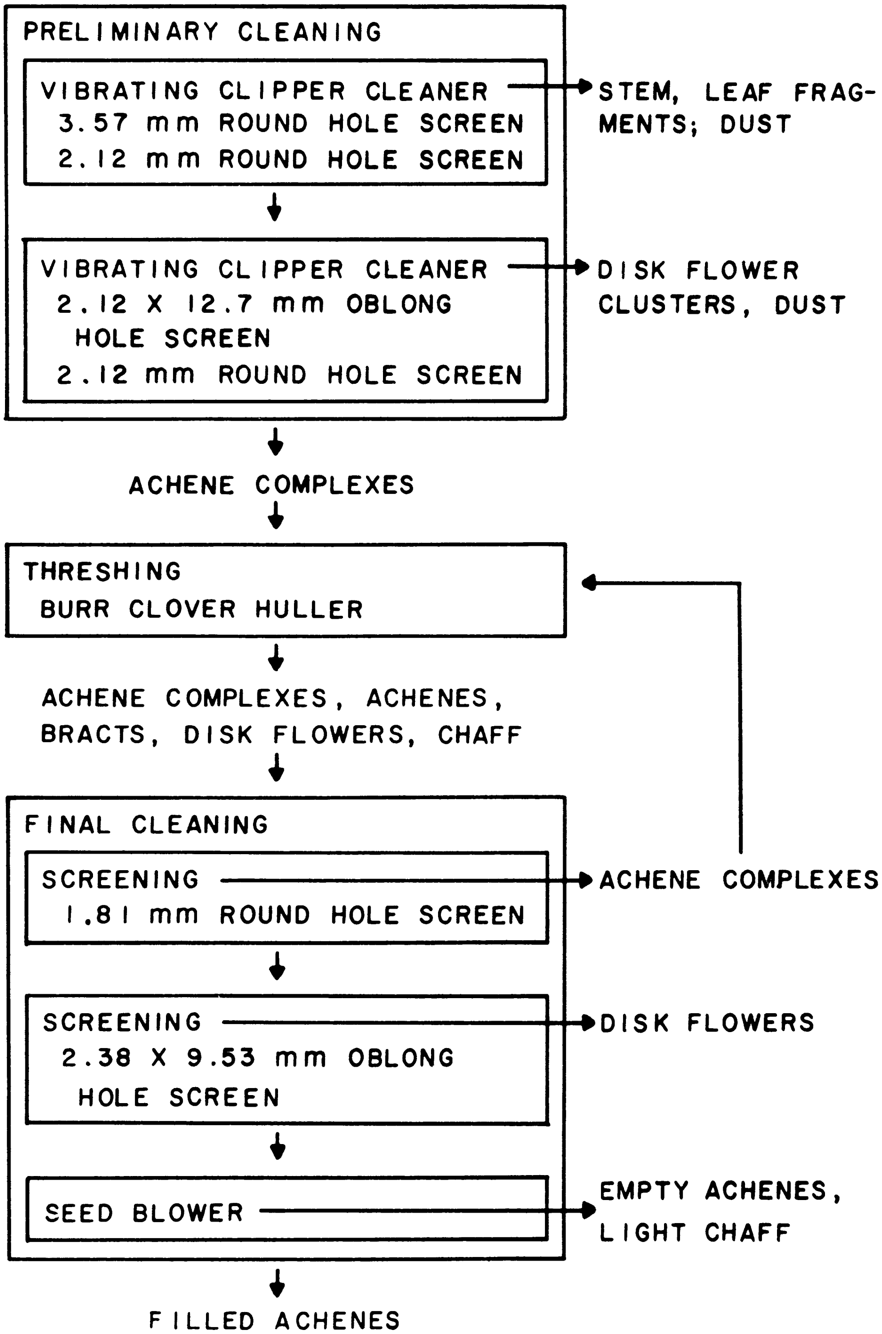

Fig. 2. Outline of guayule achene cleaning procedure. Screen perforations may vary with different achene lots.

merged and allowed to float freely. Achenes are presoaked for 8 to 16 hr in water. The tank is then drained, refilled with fresh water and sufficient 5% sodium hypochlorite added to make a 0.5% solution. If the achenes have not been stored for 2 months 0.1% gibberellin may be used in conjunction with sodium hypochlorite. The achenes are soaked for 2 hr, when the timer is set to activate the sump-float switch. The liquid level in the tank drains down to the bottom float through the solenoid valve. The float valve refills the container. This automatic drainage-refilling cycle will continue to rinse the seeds until the time clock is turned off, usually after 2 hr. Achenes may be planted immediately or air dried for storage.

Procedures described here for harvesting, cleaning, and treating guayule achenes are suitable for research activities and adaptable to larger operations to to some degree. It is hoped these procedures may contribute to the development program of this crop by enabling a more rapid increase in achene stocks. Commercialization of guayule as a rubber crop is dependent upon on mechanized cultivation. These procedures provide a basis for further mechanization of the propagation aspects of its culture. These procedures could also be modified for other crops with similar fruiting characteristics.

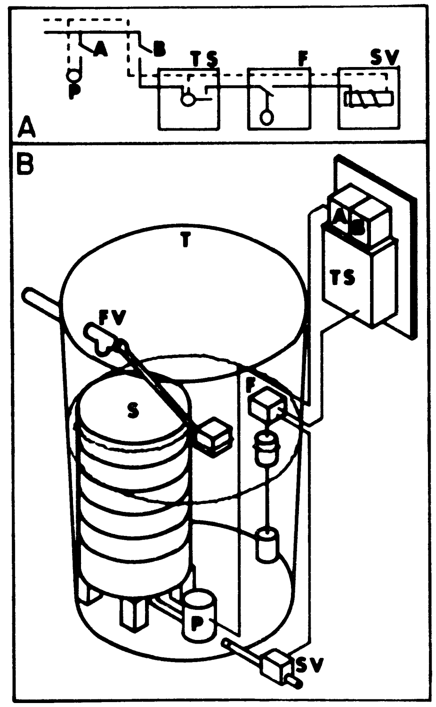

Fig. 3. Electrical diagram (A) and schematic drawing (B) of guayule achene treatment system. C = container, FV = float valve, P = submersible pump, S = sieves, A = toggle switch a, SB = toggle switch b, F = sump float switch, V = solenoid valve, TS = time switch.

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