

Developing guayule as a domestic rubber crop

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Improved production and response to multiple harvests may lead to successful commercialization

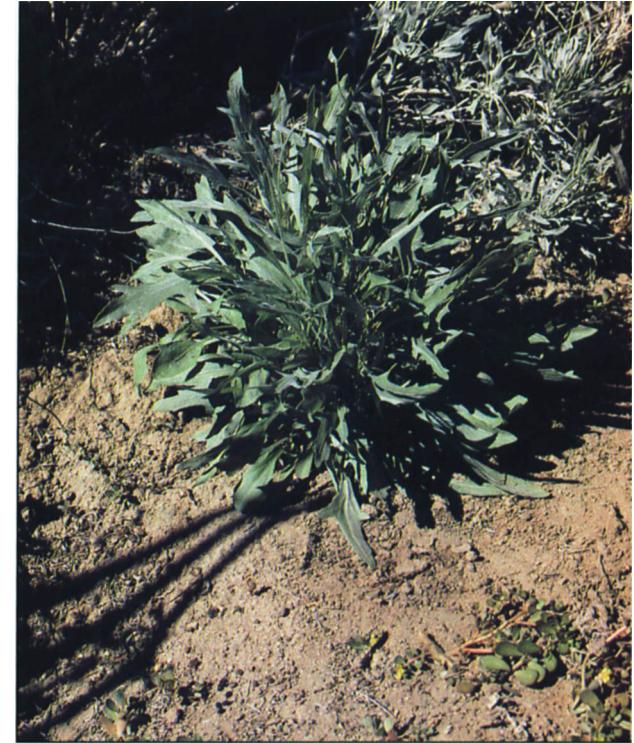
Renewed interest in developing guayule as a domestic source of natural rubber—an industrial commodity of strategic importance—is based on the fact that the United States is totally dependent on foreign sources. This country spends close to \$1 billion annually to import approximately 750,000 metric tons of *Hevea* natural rubber from southeastern Asia. Natural rubber, which constitutes 28 percent of the total domestic rubber market, is indispensable for automobile, bus, truck, and airplane tires.

Guayule, *Parthenium argentatum* Gray, is a perennial desert shrub native to north-central Mexico and southwestern Texas. It is not a new source of natural rubber. In the early years of this century, when no synthetic rubber industry was in existence, wild stands of guayule in Mexico, and *Hevea* plantations in southeastern Asia contributed equally to the supplies of rubber used in the United States. Also, during World War II, the Emergency Rubber Project planted more than 12,000 hectares (30,000 acres) of guayule in California to produce rubber for the war effort.

University of California researchers at Davis, Riverside, and Irvine are active participants in a nationwide research and development effort to commercialize guayule. Basic and applied research on breeding, genetics, agronomy, physiology, biochemistry, and shrub processing are being conducted in California, Arizona, Texas, New Mexico, and Illinois. In January 1988, through the joint efforts of the U.S. Department of Agriculture (USDA), the Department of Defense, and several private organi-

zations, a prototype guayule processing facility began operation near Sacaton, Arizona. The facility will produce about 100 tons of rubber to be used in various application tests by the Department of Defense. It will also be used for shrub processing research.

To succeed as a commercial crop, guayule must become more productive and the prohibitive cost of stand establishment by transplanting seedlings must be reduced. This report presents results of our experiments on the yield performance of improved selections and on the regrowth ability of various sources of guayule germplasm. Cultivars that can regrow after cutting at ground level are expected to make multiple harvest of guayule a reality.



Ability to regrow following harvest improves the commercial prospects of guayule. The plant above shows vigorous regrowth 60 days after being cut at ground level. Guayule field at left is one year old.

Crop establishment

Guayule seeds were washed in tap water for four hours, soaked in a sodium hypochlorite solution (0.5 percent available chlorine) for two hours, and then washed thoroughly and dried. The treated seeds were planted in trays containing a mixture of peat moss and vermiculite in equal volumes. Seven to 10 days after germination, seedlings were pricked into polystyrene seedling trays and grown in the greenhouse for 10 to 12 weeks before transfer to the field.

Seedlings of 24 new selections and four check varieties were transplanted by hand in a completely randomized design with three replications. Each plot consisted of four 11-meter rows 1 meter apart with 0.45-meter plant spacing within the row.

TABLE 1. Rubber and resin yield of guayule plants harvested at 21 months of age in March 1985 and 45 months in March 1987 at Shafter, California*

Guayule entries	Content		Yield		
	Rubber	Resin	Rubber	Resin	Rubber & resin
	mg/g		kg/ha/y		
21 months old:					
C250	77.5 a	75.0 a	908 a	879 a	1,787 a
C254	71.8 a	72.7 a	680 b	694 b	1,374 b
C215	70.8 a	76.0 a	682 b	736 ab	1,418 b
N565	71.1 a	68.3 b	400 c	375 c	775 c
593	56.9 b	50.5 c	325 c	290 c	615 c
45 months old:					
C245	52.4 a	82.3 a	828 a	1,305 a	2,133 a
C250	56.4 a	80.1 a	796 a	1,124 b	1,920 b
C215	48.7 a	78.8 a	701 a	1,135 b	1,836 b
N565	44.2 a	78.2 a	348 b	616 c	964 c
593	42.2 a	45.5 b	362 b	384 d	746 d

* In each column, means followed by the same letter are not significantly different at 0.05 level, as determined by Duncan's multiple range test.

During the first three weeks after transplanting, the field was irrigated lightly every two to five days. Once the plants were established, irrigation frequency was reduced. Each year, from March through September, the field received 12 irrigations of approximately 100 mm (4 inches) each. The field was not irrigated from October through February.

Rubber and resin yields

In this report, we present results on two old varieties, 593 and N565, and four new selections, C215, C245, C250, and C254. Entry 593 was used extensively during World War II. N565 is a post-war selection made by USDA scientists. Seeds of N565 and 24 other selections were deposited at the USDA National Seed Storage Laboratory, Fort Collins, Colorado, in the 1950s. All entries beginning with the letter "C" are the progeny of individual apomictic polyploid plants (plants with 54 and 72 chromosomes that produce seeds without fertilization), selected by the senior author during 1981 and 1982 for their vigor, biomass production, and rubber content.

Harvests were in March 1985 and March 1987, when plants were 21 and 45 months old, respectively. At each harvest, six plants from the two inside rows of each plot were cut at ground level. After hand removal of leaves and flower heads, plants were weighed, chipped, and sampled for determination of dry weight, rubber, and resin contents. We determined rubber and resin contents by the double-solvent extraction procedure using acetone and cyclohexane to extract resin and rubber from finely ground shrub samples, respectively. Annual rubber and resin yields (kilograms per hectare) were calculated by multiplying shrub dry weight (kg/ha) times the rubber content (or resin content), dividing the result by the plant's age (month), and multiplying that by 12.

Selection for increased rubber yield was effective (table 1). At the age of 21 months, the new selections produced significantly more rubber than the check varieties N565 and 593. In this test, C250, with an annual rubber yield of 908 kg/ha (830 lb/acre), was the highest rubber producer. It yielded 127 percent more rubber than N565. C250 was also the highest resin producer. At age 21 months, guayule plants produced roughly the same amounts of resin as of rubber.

Older plants yielded more resin than rubber (table 1). At 45 months, selection C245, with an annual rubber yield of 828 kg/ha (760 lb/acre), was the highest producer. The resin yield of this selection was 1,305 kg/ha (1,195 lb/acre) per year, which is 57 percent more than its rubber production. Although C250 had a higher total rubber yield at the age of 45 months than at 21 months, its annual rubber yield was approximately 100 kg/ha (90 lb/acre) lower.

Regrowth ability

For the regrowth study, plants at the ages of 21, 23, 33, and 45 months were cut at ground level in March 1985, 1986, and 1987, when they were semi-dormant, and in early May 1985, when they were actively growing. At each harvest date, six plants per replication were cut, and three months later the plants that had survived and regrown in each plot were counted. We analyzed regrowth data as well as rubber and resin yields by statistical methods (analysis of variance and Duncan's multiple range test) to determine significant differences among old and improved selections.

Harvest date was found to be a critical factor in the regrowth of guayule plants cut at ground level. Only 5.5 percent of the plants cut in May, when they were actively growing, survived and produced a limited new growth. When harvested in March of 1985, 1986, and 1987, in a dormant state, 64 percent of the plants survived and regrew vigorously.

Marked differences were observed among guayule entries for their ability to regrow following the severe treatment of the removal of all of aboveground parts of the plants (fig. 1). C250 responded favorably to harvest at ground level: 98.1 percent of the plants harvested in three consecutive years survived and regrew. On the other hand, C255 averaged 12.9 percent survival over the three-year study.

Conclusions

The improved guayule germplasm has the potential of producing 800 to 900 kilograms of rubber per hectare (730 to 825 pounds per acre) per year. Under field conditions at Shafter, California, and over two harvests, the new guayule selections were twice as productive as old varieties. Researchers are currently testing these selections in neighboring states to evaluate their yield potentials in different environments.

At a young age (21 months), guayule produced as much resin as rubber. At 45 months, however, annual resin production

was substantially higher than rubber production. Growing guayule beyond the age of two years did not improve the rubber yield on an annual basis, although it resulted in an increase in the total rubber. The increase in annual resin yield with plant age suggests that it is beneficial to grow guayule beyond two years, if increased resin production is the primary objective. Resin is an important guayule by-product that may provide additional revenue for economic commercialization of the crop.

The finding that some selections respond favorably to harvest at ground level and are capable of surviving and regrowing vigorously may influence the way guayule is commercially harvested in the future. Plants with regrowth potential are essential to multiple harvest, which distributes the cost of stand establishment across several harvest cycles. Multiple harvest in two-year cycles is highly desirable, because it reduces the time guayule growers must wait for a financial return from their crop.

Although the increase in rubber yield during the last five years is substantial, the present level of productivity is not adequate for immediate commercialization, given the current price of natural rubber (\$1.10 per kg). Additional increases in rubber yield, an increase in the price of natural rubber, or both, are needed to bring about successful commercialization. While the price of natural rubber depends on world supply and demand, as well as on global politics, increasing the productivity of the plant remains biologically feasible. The gain in rubber yield reported here was achieved through a short-term plan that exploited the apomictic nature of guayule reproduction. Long-term strategies, such as breeding guayule at the sexual diploid level and the use of high-biomass-producing related species, promise highly productive cultivars within the next 5 to 10 years.

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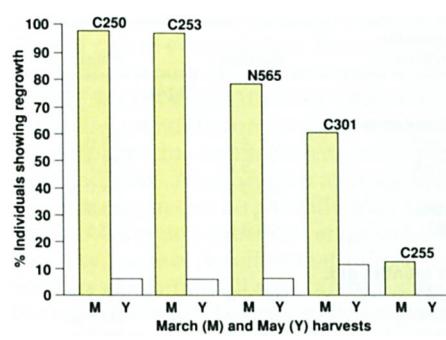


Fig. 1. Five guayule entries harvested at ground level differed widely in regrowth. Harvest date was also a critical factor.