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Guayule rubber and latex content — seasonal variations over time in Argentina

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Abstract

Rubber from guayule (*Parthenium argentatum* Gray, Asteraceae) is essentially equivalent to that from the rubber tree (*Hevea brasiliensis*). Increased incidents of 'latex allergies', especially among health care workers, have resulted in a renewed interest in guayule, because it has been shown that individuals sensitive to latex allergies do not react to guayule latex. Little work documenting changes in guayule latex content with plant age, from season to season, or among lines has been reported. To provide some of this information and hence to assist with the commercialization of guayule, a project was initiated to determine rubber and latex changes over time in guayule plants growing in Catamarca, Argentina. Lines G7-14, N-565 and 11591 were sampled every 2 months, whereas lines AZ-5, AZ-3, P2-17, P1-12, P3-11, G10-130 and G1-16 were sampled every 6 months over a 3 year period. Statistically significant differences in plant weight, and in rubber and latex contents, were found among some lines. Plant weights were positively correlated with age. Latex and rubber contents showed little correlation with age. The latex and rubber contents were well correlated (0.73 for all lines). Latex and rubber production among some lines was statistically different. Seasonal effects on latex and rubber percentages were significant only for lines G7-14 and 11591, whereas seasonal effects on latex and rubber production were significant only for lines G7-14 and N-565. The results for the various lines indicates that time of harvest may not be critical to maximize yield. Harvesting the crop throughout the year would require a smaller capacity processing facility than seasonal harvesting and reduce the cost of a processing facility and production. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: *Parthenium argentatum*; Guayule; Latex yield; Rubber yield

1. Introduction

Guayule (*Parthenium argentatum* Gray, Asteraceae) is a rubber-producing shrub native to the Chihuahuan desert of northcentral Mexico and southwest Texas. Natural rubber from guayule is essentially equivalent to that from the rubber tree, *Hevea brasiliensis*. Increased incidents of 'latex allergies,' especially among health care workers, have resulted in a renewed interest in guayule, since it has been shown that individuals

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sensitive to latex allergies do not react to guayule latex (Siler and Cornish, 1994).

At present, guayule is not being commercially grown, nor processed. One of the main reasons for this is shrub availability (Nakayama et al., 1991; Estilai et al., 1992; Ray et al., 1992). Economics, and absence of commercially suitable methodologies to extract the latex are two additional factors. Other questions which must be answered are, which lines optimize latex yield; and whether or not and to what extent yield varies with season, plant age, and growing location.

Nakayama (1991), Angulo-Sánchez et al. (1995) stated that knowledge about morphological changes occurring over a growth cycle can help to determine the best time for guayule harvesting. Nakayama (1991) further noted that although a number of reports documenting guayule rubber content had been published, few studies had followed changes in content over long time periods. Jasso Cantú et al. (1997) monitored biomass and rubber content in three accessions, over 3 years. They found that the biomass, rubber content and rubber yield increased with time, with rubber content oscillating around 4% for the first 18 months, and then increased to around 8% after 3 years of growth. However, no information on seasonal variations was reported.

Thus although some studies have reported on rubber production and rubber content variation in guayule over time, and from season to season, little work on latex changes over time, from season to season, and among lines has been reported. To provide some of these answers, and hence to assist in the commercialization of guayule, a project was initiated to determine both rubber and latex changes over time, from season-to-season, and among various lines.

2. Materials and methods

2.1. Plant material and sampling procedure

Guayule was planted in the province of Catamarca, Argentina, in March–April 1994 using seeds obtained from The University of Arizona, Tucson, AZ and from the US Water Conservation Laboratory, Phoenix, AZ. Catamarca is located in the arid Chaco region of South America, at approximately 28°S latitude and 65°W longitude, at an elevation of 525 m. Soils in the region are adequate in calcium and phosphorous, but low in organic matter and nitrogen with a pH of 7.6.

Seeds from various lines were germinated in a greenhouse, and transplanted after 2 months of age. The plots were laid out in a randomized block design, with four replications. Row spacing was 1 m, with 0.6-m plant spacing within the row.

Two sampling regimes were employed. In one, lines G7-14, N-565 and 11591 were sampled every 2 months from October 1996 through April 1999. In the second, lines AZ-5, AZ-3, P2-17, P1-12, P3-11, G10-130 and G1-16 were sampled every 6 months, from March 1997 through March 1999. Four plants from each line were randomly selected at each harvest, cut above the soil surface, packed in Styrofoam containers, and sent by air freight to the University of Buenos Aires for analysis. Plants harvested in the evening were stored overnight in a refrigerator before being packed for air shipment. When plants were harvested in the early morning, they were packed and immediately shipped. All of the samples reached the University for analysis before noon on the day that they were shipped.

2.2. Analytical procedures and data analysis

In the laboratory, 25 g samples of stems, 10 mm in diameter, were randomly taken from each shrub. From within each sample, 10 g was randomly selected and used for latex and rubber determination following the procedure described by Kroeger et al. (1996). The remaining 15 g were placed in an oven at 60°C for 3 weeks, and then used for the determination of stem dry weight. The remainder of each plant was placed in an oven at 60°C for 3 weeks. Following drying, the plant was separated into leaves and stems, and weighed separately.

All calculations were made on the basis of branch dry weight, not plant weight. For clarity, two terminologies were adopted, rubber and latex content; and rubber and latex production. The former is used to present the latex and rubber data as a percentage of stem dry weight, whereas the latter is used to present the data in terms of production on a per plant basis (stem dry weight). This was calculated for each plant using the latex and rubber percentages determined from the laboratory analyses, in combination with stem dry weight. Seasons were classified as follows, spring, 21 September–20 December; summer, 21 December–20 March; fall, 21 March–20 June; winter, 21 June–20 September.

Each variable was compared using the Generalized Linear Model analysis of variance technique to assess differences. When the F-value was significant ($P < 0.05$), differences in means were analyzed for significance using Duncan's Multiple Range Test (SAS Institute Inc., 1988a). Correlation coefficients were calculated between parameter pairs using the CORR option within the general purpose regression procedure of SAS (SAS Institute Inc., 1988b).

3. Results and discussion

The detailed analytical results for lines N-565, G7-14 and 11591, which were sampled every 2 months, are presented in Table 1 through 4; the results for the other seven lines that were sampled every 6 months along with the preceding three lines are presented in Tables 5 and 6. The values presented are averages of those values obtained over the course of the study, and are presented in this way since differences among seasons and within lines from year-to-year were inconsistent.

The G7-14 plants were significantly larger than lines 11591 and N-565 (Table 1). However, latex and rubber contents were significantly less. When calculated on a plant basis, lines 11591 and G7-14 were not significantly different in terms of latex production, nor were G7-14 and N-565. Rubber production was significantly different among the three lines, with G7-14 providing the most, and N-565 the least. This relationship corresponds to mean shrub mass.

Among seasons, G7-14 and 11591 exhibited significant differences in rubber and latex contents (Tables 2 and 3), although the differences were not consistent between the two lines. Line N-565 did not show statistically significant differences (Table 4). Latex and rubber production were greatest in the spring for all three lines, although not significantly so in all cases. Latex production was lowest for the fall harvest for all three lines, and significantly lower for line 11591, with rubber production being numerically lowest in the winter for line N565, and in the fall for lines G7-14 and 11591 (Tables 2–4).

The ten lines, sorted by decreasing plant weight, are compared in Table 5. Statistically significant differences among the lines in terms of rubber and latex contents were detected. Those lines with the larger shrubs generally have the lower values. Latex production showed no significant differences among lines. However, rubber production did vary, with the larger

Table 1
Comparison of plant weight, latex and rubber contents, latex and rubber production among three lines of guayule sampled every 2 months in Argentina, averaged over a 2 year and 6 month sampling interval[a]

Line	Plant weight (g)	Content		Production	
		Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
G7-14	1322 a*	2.35 b	4.78 b	20.29 ab	46.87 a
11591	630 b	4.92 a	7.61 a	22.30 a	35.93 b
N-565	488 b	4.45 a	7.29 a	15.90 b	26.32 c
Cr**	216	0.59	0.81	5.42	9.71

[a] *, Means within a column followed by the same letter are not significantly different at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

Table 2
Average seasonal variation in plant weight, latex and rubber contents, latex and rubber production for line G7-14 in Argentina for plants from 2 to 5 years old[a]

Season	Plant weight (g)	Content		Production	
		Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
Spring	149 b*	2.91 a	5.34 a	30.67 a	54.08 a
Summer	1323 ab	2.00 b	5.00 a	14.57 b	42.55 a
Fall	1820 a	1.12 b	3.49 b	14.09 b	49.29 a
Winter	1000 b	3.42 a	5.20 a	23.74 ab	40.10 a
Cr**	677	0.99	1.46	12.14	27.42

[a] *, Means within a column followed by the same letter are not significantly different at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

Table 3
Average seasonal variation in plant weight, latex and rubber contents, latex and rubber production for line 11591 in Argentina for plants from 2 to 5 years old[a]

Season	Plant weight (g)	Content		Production	
		Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
Spring	605 a*	4.98 b	7.46 ab	26.18 a	37.78 a
Summer	721 a	4.95 b	8.35 a	21.13 a	37.42 a
Fall	670 a	3.37 c	6.56 b	19.35 a	32.35 a
Winter	475 a	6.32 a	8.26 a	22.94 a	35.68 a
Cr**	287	1.25	1.76	11.64	19.69

[a] *, Means within a column followed by the same letter are not significantly different at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

Table 4
Average seasonal variation in plant weight, latex and rubber contents, latex and rubber production for line N-565 in Argentina for plants from 2 to 5 years old[a]

Season	Plant weight (g)	Content		Production	
		Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
Spring	571 a*	4.38 a	7.03 a	22.98 a	33.92 a
Summer	448 a	4.78 a	8.22 a	13.26 b	24.02 ab
Fall	506 a	3.79 a	6.94 a	12.50 b	24.70 ab
Winter	358 a	4.77 a	6.83 a	13.57 b	20.36 b
Cr**	224	1.28	1.98	8.44	12.22

[a] *, Means within a column followed by the same letter are not significantly different at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

plants generally producing the greatest amounts of rubber. One exception was line G10-130, which had the second smallest plant mass, but had the seventh highest rubber production.

The plant weights and yields for summer and winter seasons for the ten lines are compared in Table 6. Statistically significant differences were detected in only two lines. Line 11591 had a

Table 5
Comparison of mean plant weight, latex and rubber contents, latex and rubber production among the ten lines of guayule sampled during summer and winter seasons in Argentina over a 2 year period[a]

Line	Plant weight (g)	Content		Production	
		Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
AZ-5	1595 a*	2.65 de	5.34 cd	30.66 a	70.49 a
G7-14	1426 ab	2.01 e	4.44 d	19.21 a	46.21 b
AZ-3	1068 bc	3.50 cd	6.45 bc	27.17 a	51.71 ab
11591	849 cd	4.79 ab	7.96 ab	27.00 a	45.46 b
P2-17	710 cd	5.71 a	8.73 a	31.54 a	49.74 ab
P1-12	671 cd	5.15 ab	8.21 a	23.93 a	39.12 b
P3-11	625 d	4.18 bc	7.10 ab	20.22 a	34.22 b
N-565	570 d	4.49 abc	7.00 ab	20.06 a	30.19 b
G10-130	506 d	5.64 a	8.23 a	25.79 a	36.62 b
G1-16	492 d	5.18 ab	7.92 ab	19.90 a	31.07 b
Cr**	379	1.11	1.54	10.93	20.21

[a] *, Means within a column followed by the same letter are not significantly different at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

significantly higher rubber content at the summer harvest than for the winter harvest, and conversely, line G7-14 had significantly higher latex production in winter than in summer.

The age-weight correlations were all positive, except for line P1-12, and highly significant for lines N-565, G7-14, 11591, AZ-5 and AZ-3 (Table 7). The correlation between latex and rubber contents ranged from a low of 0.73 for AZ-5, to a high of 0.90 for AZ-3. This indicates that by determining either latex or rubber content, a comparison among lines in terms of the other parameter could be made. The correlation coefficients between latex or rubber contents and plant weight were low and generally negative. Only in three cases was the probability greater than 0.05. Latex content was significantly correlated with plant weight for lines G7-14 and 11591, and rubber content was significantly correlated with plant weight for line N565. Thus, the latex and rubber contents are affected by plant weight.

4. Conclusions

Statistically significant differences in plant weight, rubber content and latex content were found among lines. Plant weights were positively correlated with age, but latex and rubber contents showed little correlation. Latex and rubber production among some of the lines were statistically different. Correlation coefficients between latex and rubber contents were greater than 0.73 for all lines. This indicates that either parameter could possibly be used to compare lines. Seasonal effects on latex and rubber content were significant only for lines G7-14 and 11591, whereas seasonal effects on latex and rubber production were found only for lines G7-14 and N-565. In both cases, the results varied between lines, indicating that season does not appear to be a critical factor in terms of harvest schedule.

The results indicate that in this region of Argentina, minimal differences in latex or rubber yield would occur, whether harvesting took place in the spring, fall, winter or summer. Harvesting throughout the year would favor a smaller capacity processing facility than would be required if production were seasonal. Lower capital investment and continuous operation should result in more cost effective production of rubber and latex.

Table 6
Average seasonal variation in latex and rubber content for ten lines of guayule grown in Argentina over a 2 year sampling interval[a]

Line	Season	Plant weight (g)	Content		Production	
			Latex (%)	Rubber (%)	Latex/plant (g)	Rubber/plant (g)
G7-14	Summer	1312 a*	1.67 a	4.53 a	11.66 b	41.58 a
G7-14	Winter	1597 a	2.47 a	4.30 a	30.53 a	53.16 a
Cr**		740	1.45	1.93	16.31	28.04
AZ-5	Summer	1666 a	2.49 a	5.54 a	27.26 a	78.20 a
AZ-5	Winter	1508 a	2.89 a	5.06 a	34.92 a	60.86 a
cr		1068	1.08	1.74	21.92	61.36
AZ-3	Summer	1083 a	3.01 a	6.04 a	23.57 a	50.16 a
AZ-3	Winter	1047 a	4.23 a	7.07 a	32.12 a	53.85 a
cr		655	1.47	2.08	15.12	26.30
11591	Summer	822 a	4.91 a	8.77 a	26.06 a	47.84 a
11591	Winter	889 a	4.62 a	6.76 b	28.30 a	41.89 a
Cr		442	1.64	1.78	11.51	23.08
P2-17	Summer	685 a	5.38 a	8.34 a	30.21 a	48.07 a
P2-17	Winter	742 a	6.16 a	9.34 a	33.20 a	52.11 a
Cr		365	1.52	1.93	14.51	27.39
P1-12	Summer	644 a	4.88 a	7.18 a	18.69 a	28.28 a
P1-12	Winter	702 a	5.46 a	9.40 a	29.69 a	51.50 a
Cr		583	2.69	4.73	15.88	29.04
P3-11	Summer	478 a	3.70 a	6.59 a	15.49 a	26.95 a
P3-11	Winter	791 a	4.72 a	7.68 a	24.95 a	41.50 a
Cr		662	2.39	3.06	21.56	32.88
N-565	Summer	443 a	4.74 a	7.72 a	16.02 a	25.70 a
N-565	Winter	714 a	4.21 a	6.19 a	24.60 a	35.24 a
Cr		281	1.35	1.80	12.35	15.98
G10-130	Summer	434 a	5.81 a	8.40 a	22.97 a	31.46 a
G10-130	Winter	614 a	5.39 a	7.99 a	29.66 a	43.72 a
Cr		315	1.99	2.48	21.23	28.19
G1-16	Summer	422 a	5.13 a	7.69 a	17.10 a	26.72 a
G1-16	Winter	612 a	5.24 a	8.30 a	24.30 a	37.91 a
Cr		283	1.42	1.85	8.96	14.27

[a] *, Means followed by the same letter are not significantly different between seasons at the 0.05 level. **, Critical range for mean separation using Duncan's Multiple Range Test.

Table 7
Correlation coefficients among age, plant weight, latex and rubber contents, and latex and rubber production for ten lines of guayule grown in Argentina[a]

Line	R^2	R^2	R^2	R^2	R^2	R^2
	Age/plant weight	Age/latex (%)	Age/rubber (%)	Latex/rubber (%)	Latex (%)/plant weight	Rubber (%)/plant weight
N565	0.41**	0.18	0.23	0.85**	−0.18	−0.26*
G7-14	0.37**	−0.03	0.14	0.83**	−0.31**	−0.22
11591	0.57**	0.22	0.31*	0.86**	−0.26*	−0.20
AZ-5	0.88**	0.80**	0.86**	0.73**	−0.29	0.22
P2-17	0.26	0.17	0.21	0.87**	−0.39	−0.23
P3-11	0.35	0.39	0.44	0.84**	−0.16	−0.23
G1-16	0.20	0.21	0.22	0.83**	−0.18	−0.04
AZ-3	0.61**	0.16	0.52**	0.90**	−0.28	−0.23
G10-130	0.19	0.28	0.00	0.84**	0.09	0.00
P1-12	−0.05	−0.16	−0.22	0.81**	−0.44	−0.30

[a] *, Probability >0.05; **, probability >0.01.

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