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Short communication

Tolerance of transplanted guayule seedlings to post-emergence herbicides

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ABSTRACT

Guayule (*Parthenium argentatum* Gray) is gaining a wide attention as natural rubber crop that is successfully grow in the arid and semi-arid regions. Genetically improving of guayule germplasm for higher rubber production and maximizing agronomic practices are the prioritized research areas. Among agronomic practices is weed control, where weeds compete with guayule plants and thus could reduce its productivity. To study the effect of herbicides on transplanted guayule seedlings and weeds survival rates, four post-emergence herbicides were tested. Three guayule genotypes were planted in a repeated split plot arrangement and sprayed with the post-emergence herbicides at different concentrations and time intervals. Results showed that after second spray, herbicide type and concentration had significant effect on guayule seedlings survival rate. Paraquat rates were effectively able to control weed growth and viability but affected survival of guayule seedlings. Paraquat at 840 g a.i. ha^{-1} resulted in 96% of guayule seedlings survived, and 97.8% of weed populations were inhibited. More studies with different concentrations for other herbicides are required. The optimal concentration of paraquat herbicide has non-significant effect on guayule plant height compare with control treatment, suggests herbicide effects on guayule plant are most effective during seedling establishment stage. When use new herbicide application caution should be paid to control weed growth in the same time reduce the damage on guayule plants.

1. Introduction

Guayule (*Parthenium argentatum* Gray) is a native plant to Southern Texas and Northern Mexico deserts. Recently, guayule is gaining a wide attention as a supplemental source of natural rubber and bio-products such as hypoallergenic latex, resin, and bagasse (Boateng et al., 2016; Chow et al., 2008; Cornish et al., 1999; Nakayama, 2005; Ray et al., 2005). Since it is a desert shrub, guayule fits well as a new crop in the arid and semi-arid regions of the Southwestern of USA. That interest requires continuous improvement of guayule through genetic enhancement and cultivar development strategies, and in the same time optimizing agronomic practices for maximal biomass and rubber production (Foster and Coffelt, 2005; Ray et al., 2005). New improved germplasm were released and had higher rubber and resin concentrations, faster growth with high biomass and disease resistance (Estilai, 1985, 1986; Ray et al., 1999; Tysdal et al., 1983). In parallel, there are efforts to improve guayule agronomics (Foster and Coffelt, 2005). Guayule transplanting still is the common method of guayule planting and stand establishment (Coffelt et al., 2005; Foster and Coffelt, 2005). Direct-seeding gaining successful rates in research plots, but still need more improvement (Foster and Coffelt, 2005). Other agronomic practices such as irrigation schedules (Hunsaker and Elshikha, 2017), plant population per planted area and planting date (Coffelt et al., 2009), shrub harvesting height, handling and schedule (Coffelt and Ray, 2010; Coffelt et al., 2009) are well studied and established. Weed control is a major challenge in guayule agronomics, where guayule seeding established by direct seeding or transplanting tend to have slow growing rate compare to weeds (Foster and Coffelt, 2005; Foster et al., 1993). There are limited studies on weed control in guayule fields. A limited number of studies have been conducted to evaluate weed control in transplanted guayule fields using pre-emergence herbicides, and fewer studies evaluated post-emergence herbicides (Foster and Coffelt, 2005). There is continued need to evaluate the effect of new registered post-emergence herbicides on guayule plant as well weed control. The objective of the current study was to evaluate the effects of four post-emergence herbicides, as function of different chemical structures and application concentrations, on guayule seedling injury and inhibition of weed growth.

2. Material and methods

Trial was conducted at Maricopa Agricultural Center, University of Arizona at Maricopa, Arizona (33° 04′07″N, 111° 58′18″W, 361 m asl) on Casa Grande series (fine-loamy, mixed, hyperthermic Typic

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Natrargids) soil type. The experimental design was a randomized complete block with three replications in a split plot arrangement with guayule genotype as the main plot factor and factorial combinations of herbicide type and concentration as the subplot plot factor. Three improved guayule genotypes were used in the current study and represent different genetic background and breeding programs including AZ-6 (Ray et al., 1999), CAL-7 (Estilai, A., 1986) that are high in rubber and resin concentration and biomass, and genotype, N-565, USDA line that was used as a standard check in guayule genetic studies (Ray et al., 2005). Seeds of each genotype were planted in a greenhouse then three months seedlings with no visual defect and free of pest damages were transplanted in the field in plots consists of one row 10-m-long with 1 m between two rows, and 0.30 m between plants within a row. Transplanting time was 6 April 2016. Plots were sprayed with four post-emergence herbicides and three concentrations each including paraquat (1′-dimethyl-4,4′-bipyridinium) at 420, 841 and 1261 g a.i. ha^{-1}, carfentrazone-ethyl (ethyl 2-chloro-3-[2-chloro-4-fluoro-5-[4-(difluoromethyl)-4,5-diydro-3-methyl-5-oxo-1h-1,2,4- trizol-1-yl)phenyl] propanoate) at 12, 25 and 39 g a.i. ha^{-1}, fluazifop-p-butyl (butyl (*r*)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoate) at 129, 257 and 386 g a.i. ha^{-1} and pyraflufen-ethyl (ethyl 2-chloro-5-(4-chloro-5-difluoromethoxy-1-methyl-1 h-pyrazol-3-yl)-4-fluorophenoxyacetate) at 7, 12 and 19 g a.i. ha^{-1}. Herbicide treatments and control were sprayed using an aluminum back pack frame sprayer (Bellspray Inc. dba R&D Sprayers, LA) with 1.33 Kg CO_2 cylinder and a two liters plastic bottle with yellow nozzle delivering 0.72 L min^{-1} at 241.31 kPa. Applications were started at beginning of May and then repeated at June and July of the same year. Data were recorded for percentage of alive guayule seedlings and percentage of inhibited weeds. Guayule height (cm) was recorded for all alive plants during May 2017. Analysis of variance (ANOVA) was conducted by SAS software and PROC GLM and least significant differences (LSD) at 0.05 level of significance (Statistical Analysis System, SAS institute, 2003).

3. Results and discussion

Expanding the production areas for guayule, as new crop, required developing of high yielding cultivars and maximizing these cultivars productivity using optimal agronomic practices. Weed control is an important agronomic practice to optimize, where guayule seedlings are having high competition with fast growing summer weeds. There are two strategies to control weeds in guayule fields; cultivation and/or spraying using pre-emergence and post-emergence herbicides (Ferraris, 1986; Foster and Coffelt, 2005; Foster et al., 1993). During seedling establishment, mechanical cultivation is risky, while hand weeding is laborious. Foster and Coffelt (2005) concluded that pre-emergence herbicides treatments are important, but not enough to control weed problems, and there is a need for post-emergence herbicides to control growing weeds. Therefore, continue applying new post-emergence herbicides' recommendations is necessary with changing in herbicide chemistries and tolerance of guayule cultivars.

To test transplanted guayule seedlings tolerance to post-emergence herbicides, four herbicides with different mode of action and rates were used to spray guayule seedlings. Analyses of variance (ANOVA) indicated that second spray treatment (herbicide type and concentration) had significant effect on guayule seedlings survival rate (Table 1), while there was no significant genotypes' effects nor interactions between guayule genotypes and treatments (herbicide types and concentrations). After third spray, genotypes and their interactions had significant effects on guayule seedling survival rates (Table 2). The tested post-emergence herbicides (paraquat, carfentrazone-ethyl, fluazifop-p-butyl and pyraflufen-ethyl) and their concentrations, were not able to suppress weeds growth nor guayule seedlings except paraquat. Different concentrations of paraquat were effectively able to control weed growth and viability but affected guayule seedlings' survival rates (Tables 2 and 3). Results indicated that different levels of paraquat herbicide have different effects on guayule seedlings, for example using 420.3 g a.i. ha^{-1} resulted in 97% of guayule seedlings survived the application, that dropped to 84% after the third application, while using 1260.9 g a.i. ha^{-1}, 83% and 28% of guayule seedlings were survived second and third applications, respectively. More studies with different concentrations for carfentrazone-ethyl, fluazifop-p-butyl and pyraflufen-ethyl herbicides are required, where the current study tended to use low concentrations to minimize their effects on guayule seedlings damage. The present study goal was to reduce the negative effect of herbicide on guayule damage and inhibit weeds growth, it was noticeable that after one week following paraquat first application, weed populations showed chlorosis, but after three weeks were actively growing with less chlorosis spots on the growing leaves and plant tips. The second and third applications were able to inhibit weed growth (Table 3). Despite, paraquat herbicide has significant effect on guayule

Table 1
Analysis of variance (ANOVA) for guayule transplanted seedlings survival ratings affected by combinations of four post-emergence herbicides and three concentrations (treatment) after second and third sprays.

	Second spray		Third spray	
Source	Mean Square	Pr > F	Mean Square	Pr > F
Genotype	6.00	0.68	320.13	0.01
Replicate x genotype	11.30	0.57	148.39	0.04
Treatment	201.71	< .0001	4071.32	< .0001
Genotype x treatment	11.04	0.81	106.80	0.02

Table 2
Survival ratings of transplanted guayule seedling affected by four post-emergence herbicide and three concentrations each after second and third sprays.

Herbicide		Guayule plant survival %	
Common name	Concentration (g a.i. ha^{-1})	Second spray	Third spray
Paraquat	420.3	97.1	84.3
	840.6	96.0	66.0
	1260.9	83.0	28.0
Carfentrazone-ethyl	12.5	100.0	100.0
	25.0	100.0	100.0
	39.1	100.0	100.0
Fluazifop-p-butyl	128.7	100.0	100.0
	257.4	100.0	100.0
	386.2	100.0	100.0
Pyraflufen-ethyl	7.0	100.0	100.0
	12.2	100.0	100.0
	19.3	100.0	100.0
Control		100.0	100.0
$LSD_{(0.05)}$		3.7	7.1

Table 3
Growth inhibition of weed population affected by four post-emergence herbicide and three concentrations each after second spray.

Common name	Concentration (g a.i. ha^{-1})	Weed population (%)
Paraquat	420.3	44.4
	840.6	97.8
	1260.9	100
Carfentrazone-ethyl	12.5	0.0
	25.0	0.0
	39.1	0.0
Fluazifop-p-butyl	128.7	0.0
	257.4	0.0
	386.2	0.0
Pyraflufen-ethyl	7.0	0.0
	12.2	0.0
	19.3	0.0
Control		0.0
$LSD_{(0.05)}$		3.5

Table 4
Guayule seedlings height after one year of spraying using four post-emergence herbicide and three concentration each.

Common name	Concentration (g a.i. ha^{-1})	Guayule plant height (cm)
Paraquat	420.3	46.15
	840.6	47.85
	1260.9	44.04
Carfentrazone-ethyl	12.5	50.74
	25.0	53.56
	39.1	51.11
Fluazifop-p-butyl	128.7	50.40
	257.4	50.80
	386.2	51.77
Pyraflufen-ethyl	7.0	46.79
	12.2	46.67
	19.3	49.83
Control		48.44
$LSD_{(0.05)}$		4.97

survival rate, there was none-significant trend to reduce plant height under high herbicide dose compare with control treatment after one year (Table 4). That suggest that herbicide effects on guayule plant are high during seedling establishment stage. Ferraris (1986) indicated that after seedling establishment and closing the plant canopy, mature guayule plants do not required weed control treatments.

4. Conclusions

To reduce the competition between summer weeds and transplanted guayule seedlings, frequent spraying with post-emergence herbicides are required. Post-emergence herbicide paraquat at 840 g a.i. ha^{-1} was able to control weed growth with minimal effect on guayule seedlings, after the second applications. More tests for wider concentrations of paraquat as well other herbicides are needed before applying with guayule direct seeding method. When new herbicide application (chemistry and/or concentration) is used, caution should be paid to control weed growth with minimal damage on guayule plants to keep optimal guayule densities for higher rubber production.

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