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The Future of a Prolific Variant of Eastern Gamagrass

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Abstract. Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is currently being selected for higher forage yield. A prolific variant which can produce up to 20 times the number and 3 times the weight of seeds of a normal plant was found in a wild population and is now instrumental in the breeding program. Could this prolific type spread in wild populations? Vegetative vigor of mature plants was assessed by clipping plants to a 7 cm height every two weeks throughout the growing season. The two types did not differ in dry weight of regrowth, suggesting that they tolerate defoliation equally. Seed germination was compared by determining the parentage of 1,043 seedlings emerging near a nursery containing 64% normal and 36% prolific plants. Based on counts of inflorescences and seeds in the soil, variant plants contributed up to 90% of the seeds in the area. However, only 29% of the seedlings established in the area came from prolific plants. The prolific variant was equal in vegetative vigor as an adult plant, and equal or at a disadvantage as a maternal parent. Since the condition is recessive, pollen production is extremely low, and high seed fecundity is offset by poor germination success, the prolific type is not expected to spread in the wild.

Key Words. eastern gamagrass, *Tripsacum dactyloides*, seed germination, resource allocation, forage grass breeding, Oklahoma

INTRODUCTION

General agreement is that when establishing or restoring prairie, it is best to use seeds from local sources, if possible. The goal is to preserve the genetic diversity of prairie species for its own sake, not to try to "improve" on the prairie's innate beauty or productivity. However, some prairie species, especially grasses, have considerable economic value as forage for cattle. In the last few decades selection has occurred for strains of native grasses with higher forage yield, palatability, and nutrition (Harlan 1975). Even more recently, researchers at The Land Institute in Salina, Kansas have begun to domesticate prairie grasses and forbs for grain.

Eastern gamagrass [*Tripsacum dactyloides* (L.) L.] is under intensive selection for forage production at the USDA-ARS Southern Plains Range Research Station in Woodward, OK. A recently discovered form of the grass [*Tripsacum dactyloides* (L.) L. forma *prolificum* Dayton et Dewald), which has the potential to produce 20 times the number of seeds and 3 times the weight of seeds of normal plants (Dewald and Dayton 1985) is instrumental in the breeding program. A recessive major gene at a single locus changes most of the male flowers to female flowers. Little pollen is produced, seeds are more numerous but smaller, and total allocation to reproduction is greater. This condition, referred to here as "prolific," allows plant breeders efficiently to cross normal males onto prolific females and evaluate many progeny per cross. Although not directly related to forage quality, the trait is used as a breeding tool, and is thus common in breeding nursery populations, although found in only one wild population.

How will selection for domesticated traits affect a species' ability to survive and reproduce in the wild? Life history theory predicts that higher allocation to reproduction should be accompanied by a decrease in longevity or ability to withstand stress. Decreases in seed size should reduce seedling establishment. This paper compares the vegetative vigor and reproductive success of normal and prolific forms of eastern gamagrass.

METHODS

Vegetative Vigor

In spring of 1986, normal and prolific plants were established by transplant at the USDA-ARS Southern Plains Range Research Station, Woodward, Oklahoma in a randomized complete block design. On 23 April 1988, plants were clipped back to a height of 7 cm and reclipped every two weeks thereafter. Clippings were dried at 55 C to constant mass. Seed stalks, which began to elongate in early May, were left intact on the otherwise clipped plants.

For each plant, total regrowth over the summer was calculated by adding the weights of all clippings after the first. In order to account for initial plant size, the log of total regrowth was plotted against the log of the dry weight of the first clipping. Normal and prolific plants were plotted separately, and the slopes compared using analysis of variance (Snedecor and Cochran 1980).

Seed Rain and Seedling Establishment

Seedling establishment of normal and prolific plants was assessed by comparing the population of seedlings next to a breeding nursery with the seed source population of adult plants in the nursery. Seeds were assumed to have dispersed from plants on the edge of the nursery. Seed rain, or the proportion of normal and prolific seeds falling in the area, was estimated by counting the number of normal and prolific inflorescences falling into the nursery edge, and multiplying by the average number of seeds per inflorescence. Seeds on the soil surface were swept up with a broom and identified as described below as either normal or prolific. The proportion of normal and prolific seeds in the soil was determined by removing the top 5 cm of soil in 28 plots (112 x 15 cm) placed 0 and 50 cm from the nursery edge, and washing the soil through a 2 mm screen. Propagules remaining in the screen were opened and seeds were counted.

Seedling establishment of the two types was compared by determining the parentage of 1,043 seedlings growing within 2 m of the nursery. The spikelet and rachis segment ("propagule") of seeds from both normal and prolific plants can remain attached to the spent seed for one to three years after germination. Seedlings were carefully dug up and the attached propagule categorized as either normal, prolific-paired, or prolific-solitary. Ninety-two percent of the seedlings unearthed retained the propagule and were identified as either of normal or prolific maternal parentage.

Propagule Identification

Propagules from normal and prolific plants were distinguished by a combination of spikelet morphology and seed shape. A normal propagule consisted of a single spikelet set into a cupule formed by the rachis. Usually one round seed occurred within it. Two types of prolific propagules have been noted. The solitary type is a single cylindrical spikelet with two flattened seeds. It can be distinguished from a normal propagule by the number and shape of the seeds. Infrequently, normal propagules will hold two seeds instead of one, and prolific solitary propagules will mature only one seed instead of two. In these cases, misidentification will occur. The proportions of one-seeded prolific and two-seeded normal propagules were not quantified in this experiment. The paired propagule type consisted of two spikelets that did not sit within a cupule formed by the rachis, but are relatively free of it. This propagule type is immediately and definitely distinguished from the normal propagule by shape alone.

RESULTS

Vegetative Vigor

Repeated defoliation over the summer caused plants of both types to turn yellow and die back. Individual tillers stopped growing, produced few or no daughter tillers, and some eventually died. The relationship between initial size, measured as the grams dry weight of the first clipping, and total summer regrowth, the total grams dry weight clipped subsequently, was linear when log-transformed. The slopes of total regrowth as a function of initial plant size did not differ significantly for normal and prolific plants (Figure 1), indicating that for plants of a given size, normal and prolific grew back equally well.

Seedling Establishment

Estimates of seed rain agreed with numbers of seeds found in the surface and top 5 cm of the soil (Table 1). Although prolific plants contributed 90% of the seeds falling in the area, only 29% of the seedlings unearthed in the area were from a prolific maternal parent.

Table 1. Percent of normal and prolific genotypes represented in the seed rain, the soil seed bank, and seedling populations of eastern gamagrass.

	Normal	*Pistil*	*Unidentified*
		%	
Source population (nursery plants)	64	36	0
Seed rain	10	90	0
Soil surface	11	89	0
Soil seed bank	19	81	0
Seedlings	63	29	8

DISCUSSION

After being defoliated by an herbivore or mower, grasses must regrow in order to survive. Regrowth requires carbohydrates, nutrients, and water which initially must come from underground reserves (Langer 1979). If seed production draws from these reserves, prolific plants should show a diminished ability to respond to defoliation. This experiment showed no difference between normal and prolific plants' abilities to regrow after defoliation, as measured by grams dry weight regrowth. More detailed analyses of changes in plant size and direct measures of below ground reserves are needed to confirm this result. In natural populations, other factors, such as disease and interspecific competition, could differentially affect normal and prolific plants' survival. Furthermore, clipping by pruning shears does not adequately mimic the uneven tearing and trampling of grazing animals. However, biweekly defoliations nearly killed plants of both types, so the extremes of stress encountered in the wild were matched in this experiment.

Seedling establishment agreed with the general prediction that the smaller seeds of the prolific type should be less successful than seeds of the normal type. However, prolific plants made up 36% of the border plants and 29% of the seedlings, so high seed number was nearly making up for poor seed germination and establishment. In natural populations, where seedling establishment is deterred by competition by other plants, the difference between normal and prolific seeds should be much greater.

Other factors, besides vegetative vigor and seedling establishment, could affect the success of the prolific type in the wild. The heavier inflorescences are more susceptible to damage by wind, rain, hail, or simply their own weight. The more open structure of the glumes appeared to encourage insects, which were found in higher numbers on the prolific type. Pollen production was extremely low, so fitness as a male parent, although difficult to quantify, must have been negligible. Finally, according to population genetics, even if the prolific type were advantageous, it would spread slowly because its inheritance is recessive.

Seeds with the prolific gene are currently being released to farmers for evaluation, and pollen from the breeding nurseries in Woodward no doubt travels far enough to fertilize natural populations of eastern gamagrass in the area. Thus, it is inevitable that the prolific type will appear in natural populations in greater frequencies than it does today. Not because of its low adult survivorship, but because of limited ability to reproduce from seed and pollen, it is predicted that the prolific type will not increase substantially in wild populations.

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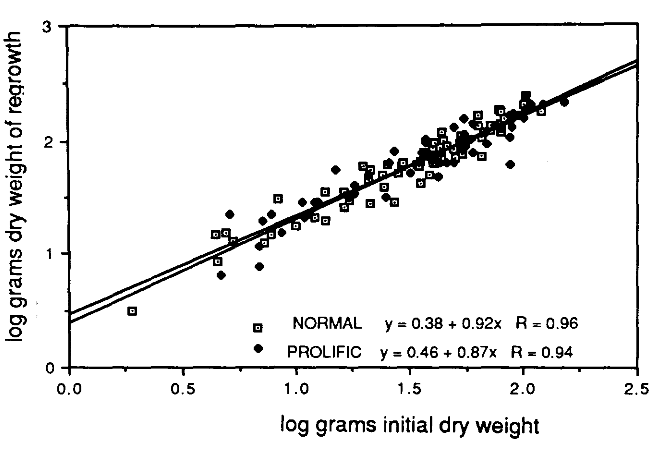

FIG 1. Regrowth after defoliation of eastern gamagrass as a function of initial size.