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Effects of burning on germinability of Lehmann lovegrass

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Abstract

Lehmann lovegrass (*Eragostis lehmanniana* Nees) may be viewed as either an undesirable exotic invader or an important ground cover and forage plant on southwestern rangelands, depending on management goals. Successional responses to management practices intended to control or enhance this grass are highly dependent on the processes of natural revegetation. The effect of seasonal burning on germinability of Lehmann lovegrass in the seedbank was investigated on the Santa Rita Experimental Range in southern Arizona. Samples of surface soil were taken for bioassay immediately after burning in February, June, July, and November for 2 years. Nearly 40% more seedlings emerged from bioassay samples taken from burned than unburned plots. The increase in germinability of Lehmann lovegrass seeds associated with fire may be one of several factors important in its observed ability to re-establish after mature plants are killed by burning.

Key Words: seedling emergence, fire, heat-treatment of seeds, *Eragrostis lehmanniana* Nees

Lehmann lovegrass (*Eragrostis lehmanniana* Nees) is a drought-tolerant, warm-season, perennial bunchgrass native to southern Africa. The grass was introduced into Arizona over 50 years ago and has been seeded extensively for erosion control and forage production (Cable 1971). The species is well adapted to southeastern Arizona and has increased in abundance, now covering approximately 200,000 ha (Cox and Ruyle 1986). Land managers have mixed emotions regarding the grass because it is an invader species and not considered palatable to grazing animals, yet it establishes easily on disturbed sites and provides excellent soil cover. Ranchers are faced with incorporating the new grass into grazing management schedules. On the other hand, preserve managers are concerned with Lehmann lovegrass invasion into native grasslands (Bock et al. 1986). In both cases prescribed burning is often recommended as a management tool. Observations suggest that while hot fires can kill Lehmann lovegrass plants (Cable 1965), new stands quickly re-establish from seed (Cable 1965, Cable 1971, Cox and Ruyle 1986), and cooler fires have little effect (Pase 1971, Martin 1983). Additionally, where native perennial grasses are killed by fire, Lehmann lovegrass seedlings quickly establish and persist on the site (Cable 1965, 1971).

Artificially induced heat treatments may increase both the percentage and rate of Lehmann lovegrass germination (Haferkamp and Jordan 1977, Weaver and Jordan 1985). Heat treatments scarify the seedcoat and increase the rate of imbibition of Lehmann lovegrass seeds (Haferkamp et al. 1977). Jordan (1981) suggested that a rapid germination rate would favor Lehmann lovegrass establishment in Arizona, given the erratic nature of summer precipitation and short periods of available soil moisture. Observations are that fire enhances emergence of Lehmann lovegrass seedlings. An important factor in this response may be the enhancement of germination directly by a natural heat treatment from fire. The purpose of this research was to experimentally determine the effects of seasonal burning on germinability of Lehmann lovegrass seed in the seedbank. We also documented field differences in seedling emergence associated with burning and seedling survival when burning resulted in the death of established plants.

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Materials and Methods

The study was conducted on the Santa Rita Experimental Range 60-km south of Tucson, Ariz. The 3-ha study site was on an alluvial fan at 1,200 m elevation and supported a nearly pure stand of Lehmann lovegrass. Annual precipitation averages 398 mm with 60% falling between June and September. The soil is a coarse-loamy, mixed (calcareous) thermic Typic Torrifluvent of the Comoro series. The site was fenced in January 1984 and subdivided into 48, 15 by 15-m plots, each separated by 2-m fire lines.

Treatments were assigned in a randomized block design and included winter (February), early summer (June), mid-summer (July), and fall (November) burned and unburned plots. All treatments were replicated 3 times and were performed on separate plots in 1984 and 1985. Burn treatments were applied as head fires following initial back firing. Temperatures at the soil surface were constantly monitored during the 1985 burns with 5 thermocouples per burned plot.

Within each treated plot, 5 soil samples, approximately 8 by 15 cm in area by 2-cm deep, were collected immediately following the burn. Unburned plots also were sampled on each burn date. Samples were collected in separate plastic bags for immediate transport to the greenhouse for processing and bioassay. The bioassay technique followed was modified from Young et al. (1981). Soil samples were placed in styrofoam cups over 250 ml of 60-mesh sterile sand. The cups had perforated bottoms and were kept moist by sub-irrigation with tap water. Emergent Lehmann lovegrass seedlings were counted daily for 42 days. New seedlings were removed after emergence.

To document differences in seedling emergence associated with burning in the field, seedling density was sampled on unburned plots and plots burned in 1984. Seedlings were counted in fifty 5 by 30-cm quadrats in each plot in August and December 1984 and May 1985. To document the stand renewal ability of Lehmann lovegrass, seedling density on the November 1984 burned plots, where 80% of the mature plants were killed, was tracked from July to November of 1985. Seedlings were counted in 30 permanently marked 0.25-m^2 quadrats in each burned plot. The larger permanently marked quadrats were necessary to assess emergence and mortality over time. To determine if changes in density in these quadrats were associated with recruitment or mortality, all seedlings in 3, 3 by 50-cm transects per burned plot were permanently marked with toothpicks color-coded to the sampling date when first observed. All bioassay and field seedling density data were scaled to number of seedlings per m^2 area. Analysis of variance was used to determine significance of burning treatments in time.

Results and Discussion

Bioassay

There was a significant treatment ($p = 0.06$) and seasonal ($p = 0.01$) response in the numbers of Lehmann lovegrass seedlings that emerged in bioassay samples (Table 1). Season, treatment and year interactions were not significant ($p \geq 0.05$). Overall, bioassay samples from burned plots averaged 342 emerged seedlings/m^2 or 40% more emerged seedlings than samples from unburned plots. Significantly ($p = 0.01$) more seedlings emerged from the samples collected in June before the summer rainy season than from the other

Table 1. Analysis of variance of Lehmann lovegrass emergence (seedlings/m²) in bioassay samples in relation to burning treatment and date of sample collection.

Source of variation	DF	F	P
Treatment (T)	1	3.76	.06
Month (M)	3	20.72	.01
Year (Y)	1	0.59	.41
T×M	3	0.45	.72
T×Y	1	0.01	.92
M×Y	3	1.12	.36
T×M×Y	3	2.17	.11

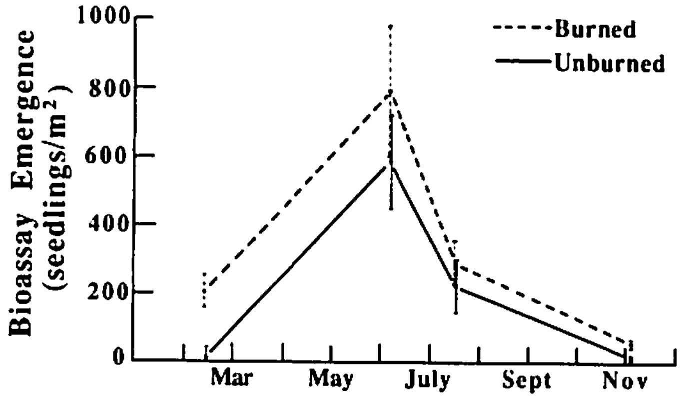

Fig. 1. *Lehmann lovegrass seedling emergence from bioassay samples taken from unburned and burned plots averaged from 1984 and 1985. Vertical lines are twice the standard error of the mean.*

3 collection periods (Fig. 1). Seedling emergence from soil collected in June was more than twice that from any other collection period, averaging 700/m².

Seedling Density

Seedlings were not found in December 1984 or May 1985 but emerged after summer rains and were counted in plots sampled in August 1984 (Table 2). Seedling emergence was much higher on

Table 2. Lehmann lovegrass seedling density (x ± standard error) in August 1984 on seasonal burn and unburned plots.

Treatment	Seedlings/m²
Unburned	20 ± 0.8
February burn	120 ± 4.8
June burn	113 ± 5.2
July burn	80 ± 0.8

burned than unburned plots and was similar among plots burned in February and June 1984. Contrary to results of Martin (1983), 80% of the mature Lehmann lovegrass plants died after the November 1984 burn. On these plots, numerous seedlings emerged after successive rains in July 1985 (Fig. 2). Observations of individually marked seedlings indicated that there was little recruitment after initial emergence and that subsequent changes in seedling density were due to mortality of emerged seedlings. Maximum seedling density on these November 1984 burned plots was 320 seedlings/m² compared to 0.8 seedlings/m² on the unburned plots on 30 July 1985. Seedling density on the burned plots decreased rapidly in August and September with decreased precipitation but leveled off in October and November. Lehmann lovegrass densities on the November burned plots also increased by rooting of nodes

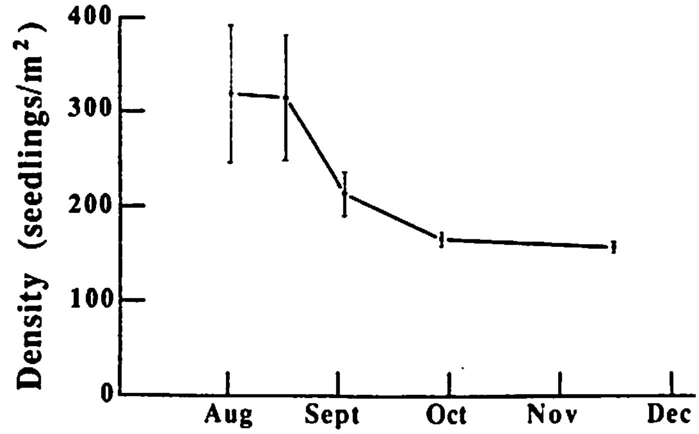

Fig. 2. *Lehmann lovegrass seedling density in 1985 on plots burned November 1984. Vertical lines are twice the standard error of mean.*

from decumbent tillers of mature lovegrass plants that survived the fire. An average of 3.2 new plants/m² were produced from rooted nodes on the burned plots while no rooted nodes were found on the unburned plots.

The bulk of Lehmann lovegrass seed in the Southwest is produced in August after summer rains and the seed shatters in October and November. Some seed may also be produced during the fall, winter, and spring. Spring temperatures and early-summer moisture conditions are not favorable for seed germination and seedling emergence until summer rains begin, usually in July. Dormancy of Lehmann lovegrass seed decreases with time after harvest (Wright 1973). A large seed reserve and afterripening of seed produced the previous summer may explain why emergence from bioassay samples taken in June was greater than from those taken in February. Lower emergence from bioassay samples collected in July probably resulted from loss of viable seeds from the seedbank through germination and decay associated with the summer rainy season. Low emergence from the November bioassay may reflect the initial dormancy of the current year's seed crop.

Burning apparently increases germination of Lehmann lovegrass seed reserves. Burning may raise soil surface temperatures to 450° C for a fraction of a second (Fig. 3). These natural heat treatments could reduce dormancy in a way similar to artificial heat treatments (Haferkamp et al. 1977) by breaking down the seed coat and increasing imbibition. Lehmann lovegrass only emerges from very shallow depths (Cox and Martin 1984) and may be exposed to high temperatures during burning (Fig. 3). The greater

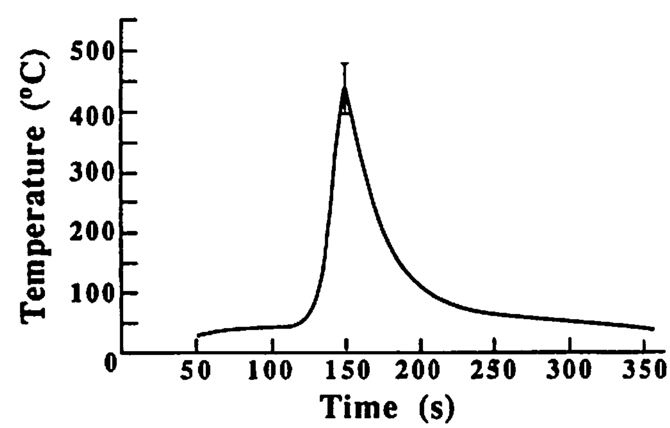

Fig. 3. *Soil surface temperatures during burning of a pure stand of Lehmann lovegrass. Data were similar and therefore averaged for burns conducted in February, June, July, and November for 2 years. Vertical bar at peak is twice the standard deviation of the mean.*

difference in seedling emergence between burned and unburned bioassay samples taken in February than November suggests that burning may increase germinability of seeds that have been in the seed bank a few months more than it does the germinability of newly fallen seed (Fig. 1). Yet the higher germinability of seed in June compared to February bioassays from both burn and control plots indicates that the majority of seeds require an afterripening period to germinate as has been reported by Haferkamp and Jordan (1977). Artificial heat treatments increase the germination of old seeds more than new seeds (Haferkamp and Jordan 1977). Natural heat treatments by fire may be more effective in reducing seedcoat dormancy of older seeds with weaker seedcoats than new seeds with hard seedcoats.

Although seed germinability as indicated by seedling emergence in bioassay samples was much lower after the February burn than after the June burn (Fig. 1), actual seedling densities in August 1984 were similar (Table 2). Seedbank germinability on both burned and unburned plots was low in November 1984 but a high number of seedlings emerged on the burned plots during the next summer rainy season in 1985 (Fig. 2). High seedling densities in August 1984 and 1985 on burned plots that had few seedlings emerge in the bioassay samples immediately after burning reflects the increase in Lehmann lovegrass seed germinability with afterripening.

The increase in seed reserve germinability associated with burning probably does not fully account for the much greater seedling emergence on burned than unburned plots in the field. Burning reduces the mature plant canopy and may result in increased incident radiation and soil temperatures, as well as reduced mature-plant transpiration and longer periods of available soil water for germination and seedling growth. Specific effects of fire on the seedbed environment that result in higher seedling emergence in the field requires future research. Meanwhile, the demonstrated ability of Lehmann lovegrass to renew itself by high seedling emergence after high mortality associated with burning indicates that fire may be used to increase, not reduce, dominance of this grass.

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