ECOLOGY OF *CHRYSOPOGON AUCHERI* AND *CYMBOPOGON JWARANCUSA*. I. GERMINATION RESPONSE

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SUMMARY

The ability of *Cymbopogon jwarancusa* (Jones) Schult. to displace *Chrysopogon aucheri* (Boiss.) Stapf. on Baluchistan grasslands may be related to differences in recruitment potential in addition to differences in palatability and grazing tolerance. A controlled environment study was designed to investigate the effects of different temperature regimes on germination responses of these two dominant range grasses. Cumulative germination and rate of germination (mean germination time) were evaluated at six alternating temperature regimes (5/10, 5/15, 5/20, 10/20, 10/25 and 10/30 °C, 12 h night/12 h day) representing possible temperatures in western Baluchistan during the recruitment period (March - May). In addition to having greater seed fill and viability, *Cymbopogon jwarancusa* had greater and more rapid germination than *Chrysopogon aucheri* at a wider range of temperatures, especially cooler temperatures. These germination responses indicate that *Cymbopogon jwarancusa* is superior to *Chrysopogon aucheri* during the initial stage of the recruitment process.

INTRODUCTION

Chrysopogon aucheri (Boiss.) Stapf. and *Cymbopogon jwarancusa* (Jones) Schult., the dominant, perennial, warm-season bunchgrasses on Baluchistan grasslands, grow on a wide variety of soils over a wide range of elevations (Baluchistan Forest Department 1986). *Chrysopogon aucheri* is readily grazed, whereas *Cymbopogon jwarancusa*

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is grazed only after the former has been heavily grazed. The low palatability of *Cymbopogon jwarancusa* has been related to the oil content in its leaves (West Pakistan Forest Department 1960). As grasslands deteriorate under heavy grazing pressure, *Chrysopogon aucheri* is gradually replaced by *Cymbopogon jwarancusa*. To better understand plant requirements for "prudent" grazing, one must understand the autecology of the plants (Caldwell 1984), including establishment requirements (West 1968).

Plant establishment by seedling recruitment, the dominant form of regeneration for most species on rangelands, is only successful when plant requirements for seed germination, seedling development, and subsequent growth are matched with microenvironmental factors of the seedbed (Grubb 1977, Harper 1977). Variation in seed germination between species and between ecotypes of the same species have been attributed to differences in seed development, dormancy mechanisms, seed size, distribution of safe sites and differential responses to temperature, water, light, and gas exchange conditions (Koller 1972, Mayer and Poljakoff-Mayber 1982, Fowler 1988).

Limited information is available on the germination requirements of *Chrysopogon aucheri*, *Cymbopogon jwarancusa*, and related species in Pakistan. Production of viable, germinable seed has been related to inflorescence development in *Chrysopogon aucheri* (Hussain et al. 1980), and in *Cymbopogon jwarancusa*, *Cymbopogon parkeri* Stapf., and *Cymbopogon oliveri* (Boiss.) Bor (Ahmed et al. 1978). Ahmed et al. (1978) also observed that *Cymbopogon jwarancusa* had the highest cumulative germination and most rapid germination rate of the three *Cymbopogon* species. These germination studies with *Chrysopogon aucheri* and *Cymbopogon jwarancusa* did not simulate the range of temperature and moisture conditions to which seeds of both species are exposed during the recruitment period (March - May) of the growing season in western Baluchistan. The objective of this study was to investigate the effects of different alternating temperature regimes on germination responses of seeds of *Chrysopogon aucheri* and *Cymbopogon jwarancusa* collected in the Quetta Region of Baluchistan.

MATERIALS AND METHODS

Seeds (caryopsis and attached lemma and palea) of *Chrysopogon aucheri and Cymbopogon jwarancusa* were collected from three protected sites near Quetta, Baluchistan during June and July, 1987. Prior to germination trails in 1988, seeds of both species from the three sites were tested for the presence of a caryopsis, and for viability. Five replicates of 100 randomly selected seeds from each site were examined for a caryopsis by removing the lemma and palea. Four replicates of 50 caryopsis from each site were placed in a 1% triphenyl tetrazolum chloride solution for 24 h at 22 °C in complete darkness to determine viability (Grabe 1970). Percent viability was determined by evaluating intensity of staining and staining patterns under a 10 x lens. Due to low seed fill and viability of *Chrysopogon aucheri*, seed from the three sites were combined into one lot. Seed of *Cymbopogon jwarancusa* were also combined into one lot.

In a controlled environment, four replicates of 50 filled seeds of each species were exposed to alternating temperature regimes (12 h night/12 h day, light intensity of 250 mol. m^{-2}. sec^{-1} during day period) of 5/10, 5/15 5/20, 10/20, 10/25, and 10/30 °C, which simulated possible temperature regimes on rangelands near Quetta, Baluchistan from March through May. Seeds were placed on two layers of Whatman No.1 filter paper (saturated with distilled water when necessary) in Petri dishes. Petri dishes were wrapped in polyethylene film to reduce evaporation losses and stabilize relative humidity. A seed was considered germinated when it had a radicle greater than 2 mm. Germinated seeds were counted and removed from Petri.fishes every day over a 25-day period, and cumulative germination data were reported as a percentage of the total number of filled seeds in each dish. Germination rates were estimated by calculating mean germination time, i.e. the mean time in days taken for nondormant, for viable seeds to germinate (Ellis and Roberts 1978).

The experiment was arranged in a completely randomized design with four replications per treatment for each species. Cumulative germination percentage and mean germination time data were subjected to analysis of variance, and means were separated by Fisher's least significant difference test ($P < 0.05$ level of significance). Cumulative germination percentage data were transformed prior to analysis using an arsine transformation.

RESULTS

Considerable variability in caryopsis fill, viability, and germination was observed between the two species. *Chrysopogon aucheri* and *Cymbopogon jwarancusa* respectively had means of 25 (SD ± 4.4) and 47% (SD ± 2.3) for seed fill and means of 6 (SD ± 1.6) and 87% (SD ± 2) for seed viability. Germination did not occur in both species at the coldest temperature regime (5/10 °C) (Figure 1). *Cymbopogon jwarancusa* had limited germination at 5/15 °C while *Chrysopogon aucheri* did not initiate germination until 5/20 °C. Germination increased with increasing temperature for both species, reaching a maximum value at 10/20 °C. Germination for both species declined as temperatures increased from 10/20 to 10/25 °C and then increased as temperatures increased from 10/25 to 10/30 °C. *Cymbopogon jwarancusa* germination was significantly greater than that of *Chrysopogon aucheri* at all temperature regimes ranging from 5/10 to 10/30 °C when differences in viability were not considered in the calculation of cumulative germination. However, when the low viability (6%) of *Chrysopogon aucheri* seeds was considered, cumulative germination was not significantly different between the two species at the optimum temperature range (10/20 °C) and at 10/30 °C (Figure 2). Almost all the viable seeds of each species germinated at 10/20 °C.

Mean germination time was significantly slower for both species at colder temperature regimes (5/10 °C for *Cymbopogon jwarancusa* and 5/20 °C for *Chrysopogon aucheri* (Figure 3). Mean germination time of *Cymbopogon jwarancusa* seeds was slightly faster than that of *Chrysopogon aucheri* seeds at temperature regimes with the greatest cumulative germination (5/10 to 10/30 °C); however, this difference was not significant.

DISCUSSION

Differences in one or several environmental factors (temperature, moisture, light, oxygen, etc.) can result in significantly different germination responses of wildland grass species (Ellern and Tadmor 1967), Dwyer and Wolde-Yohannis 1972, Young et al. 1973). Day-night temperature alterations are the normal condition in the field and are required for appreciable germination in many species (Koller 1972). If one temperature is within the upper or lower inhibitory range, the inhibitory effect may be nullified by the other alternating temperature (Gulliver and Hydecker 1973). In the colder temperature regimes, (5/10 to 5/20 °C) the 5 °C low temperature appeared to be inhibitory to the germination of *Cymbopogon jwarancusa* until the upper temperature reached 15 °C (5/15 °C temperature regime) and to the germination of *Chrysopogon aucheri* until the upper temperature reached 20 °C (5/20 °C temperature regime) (Figures 1 and 2). Cumulative germination increased significantly for *Cymbopogon jwarancusa* as the upper temperature reached 20 °C (5/20 °C temperature regime). Thus, considerable germination can occur in cold fluctuating temperature regimes if the soil surface temperature approaches 20 °C during the daytime and moisture is available.

The decline in cumulative germination in the 10/25 and 10/30 °C temperature regimes (Figure 1) and the slight increase in mean germination time in the 10/30 °C temperature regime for both species may be attributed to seed variability. The low viability (6%) of filled *Chrysopogon aucheri* seed made it difficult to consistently place a representative number of viable seeds in Petri dishes for the different germination treatments.

The small amount of literature available on the germination characteristics of *Chrysopogon* and *Cymbopogon* species from Pakistan and various range regions support the findings of this study. *Cymbopogon* species appear to have higher germinability than *Chrysopogon* species under a variety of environmental conditions (Mott 1978, Rai et al. 1980, Ghosh and Chatterjee (1981). In one study (Ahmed et al. 1978), *Cymbopogon jwarancusa* had 99% germination after 14 days in a 20-25 °C temperature regime.

The production of viable, germinable seed by *Cymbopogon jwarancusa* and *Chrysopogon aucheri* in Pakistan has been primarily related to inflorescence development. Ahmed et al. (1978) indicated that a relatively high percentage (> 50 %) of sterile florets contributed to low viable seed set (32% viable seed) in a population of *Cymbopogon jwarancusa*. Hussain et al. (1980) reported that *Chrysopogon aucheri* had 60% sterile florets, and considered this sterility value to be a reliable indicator of poor seed set and germination in this species. In both field nursery studies (Ahmed et al. 1978, Hussain et al. 1980), floret sterility was determined morphologically by quantifying the presence of male, female, bisexual, or barren florets. Female florets were absent in both *Chrysopogn aucheri* and *Cymbopogon jwarancusa*; therefore, only bisexual florets were considered capable of seed set. Since nursery growing conditions, floret sterility and seed set were probably more influenced by genetic rather than environmental factors.

Seed fill, viability, and germination data from this study generally support the findings of Ahmed et al. (1978) and Hussain et al. (1980). *Cymbopogon jwarancusa* and *Chrysopogon aucheri* had 47 and 25% caryopsis fill, respectively, and filled seeds had 87 and 6% viability, respectively. It appears that *Chrysopogon aucheri* has an inherently lower potential for producing viable, germinable seed than *Cymbopogon jwarancusa*. Based upon seed fill, and viability data, if 1,000 randomly selected seeds of each species were sown under optimum conditions, only 15 *Chrysopogon aucheri* seeds would haver the potential to germinate whereas 409 *Cymbopogon jwarancusa* seeds could potentially germinate.

The ability of *Cymbopogon jwarancusa* to displace *Chrysokpogon aucheri* on Baluchistan grasslands has been primarily related to differences in palatability (West Pakistan Forest Department 1960). In addition to being less palatable than *Chrysopogon aucheri*, it appears that *Cymbopogon jwarancusa* also has an advantage in recruitment potential. Results demonstrate that *Cymbopogon jwarancusa* seeds not only have higher seed fill, and viability, they also have the capacity for greater germination than *Chrysopogon aucheri* over a wide range of alternating temperatures (Figures 1 and 3). This may allow *Cymbopogon jwarancusa* to germinate in a wide variety of seedbed microsites with different temperature regimes when transient soil moisture is available, especially during cooler temperatures in March.

ACKNOWLEDGEMENT

This research was supported by the Food and Agriculture Organization of the United Nations, the United States Department of Agriculture office of International Cooperation and Development, the Baluchistan Forest Department, and the Pakistan Agricultural Research Council.

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