Germination Characteristics of Three Warm-season Turfgrasses Subjected to Matricconditioning and Aging

Gokhan Hacisalihoglu¹

ADDITIONAL INDEX WORDS. bahiagrass, bermudagrass, centipedegrass, seed, vigor

SUMMARY. Many warm-season turfgrass seeds have relatively poor germination percentages. Matricconditioning is a seed enhancement technique with a solid carrier and may be a practical solution to improve the germination characteristics of warm-season turfgrass. The objective of this study was to determine the effectiveness of matricconditioning on three nonaged and aged turfgrass cultivars: 'Pensacola' bahiagrass (*Paspalum notatum*), 'Princess' bermudagrass (*Cynodon dactylon*), and 'Common' centipedegrass (*Eremochloa ophiuroides*). Seeds were matricconditioned with a synthetic calcium silicate (MicroCel E) as a carrier and water at 30 °C for 5 days. Seed, carrier, and water ratio was 1 g, 0.5 g, and 1.5 mL, respectively. Matricconditioning increased final germination to 55% (bahiagrass), 90% (bermudagrass), and 70% (centipedegrass) compared with 92% in nontreated control seeds. Furthermore, matricconditioning decreased mean germination time 20% to 65% in all seeds compared with the nontreated control. Accelerated aging was induced by storing seeds for 0, 7, and 14 days at 42 °C and 95% relative humidity. Germination percentage decreased and mean germination time increased with the aging, especially after 14 days of aging treatment. These results suggest that matricconditioning is an effective technique to improve turfgrass seed performance.

Florida is the nation's second leading state in lawn care services with annual \$5 billion impact and 84,000 jobs per year (Hodges and Mulkey, 2003). There are several warm-season turfgrasses established from seeds, including bahiagrass, bermudagrass, and centipedegrass (Trenholm et al., 2001). Bahiagrass is a low-maintenance turfgrass that is tolerant to salt and drought. Bermudagrass is a medium-maintenance lawngrass that is widely used as sports turf. Centipedegrass is a low-maintenance grass that is common on lawns, especially in northern Florida (Table 1).

Establishing a successful lawn requires good seed quality and subsequent seedling emergence (Trenholm et al., 2001). It has been shown that seed enhancements improve the performance of seeds as a result of increased synthesis of seed hor-

mones and enzymes (Taylor et al., 1998). For example, matricconditioning (MC), or priming seeds through solid carriers with low matric potentials, proved highly effective in improving germination of several vegetable seeds by allowing limited water to start the major metabolic events in seeds (Khan, 1992). MicroCel E (synthetic calcium silicate; World Minerals, Lompoc, CA) has been reported as a superb solid carrier for MC (Khan, 1992; Taylor et al., 1998). Khan et al. (1992) reported increased germination percentage (GP) and emergence of snap bean (*Phaseolus vulgaris*), carrot (*Daucus carota*), tomato (*Solanum lycopersicum*), and pepper (*Capsicum annuum*) when seeds were matricconditioned by MicroCel E only or combined with GA₃. It has been reported that germination decreased with storage (Taylor et al., 1998). Furthermore, priming

may accelerate the effect of seed aging. For example, primed lettuce (*Lactuca sativa*) seeds aged faster than control seeds under 45 °C with 50% relative humidity (RH) conditions (Hacisalihoglu et al., 1999) or 40 °C with 10% RH (Tarquis and Bradford, 1992).

Few studies have been conducted on the enhancement of turfgrass seeds, and even fewer have tested MC as well as storage of turfgrass seeds. The objective of this study was to evaluate the effect of MC on warm-season turfgrass GP and mean germination time under optimum, 7- or 14-d accelerated aging conditions.

Materials and methods

SEED MATERIAL AND MATRICCONDITIONING. Seeds of 'Pensacola' bahiagrass, 'Princess' bermudagrass, and 'Common' centipedegrass were obtained from seed companies or institutions (Table 1) and stored at 6 °C, 33% RH, and small batches were removed as needed. For MC, seeds were mixed with MicroCel E at different matric potentials by altering the water content of conditioning mixture. MC was carried out in 500-mL glass jars by mixing 1 g seeds, 0.5 g MicroCel E, and 1.5 mL distilled water at 30 °C for 5 d. After MC, seeds were washed for 20 s and dried back by air at 25 °C for 2.5 h. The moisture content was determined by drying the seeds in an oven at 130 °C for 1 h.

GERMINATION TEST. Four replications of 25 seeds were placed on filter paper (Whatman, Atlanta, GA) in 9-cm-diameter petri dishes moistened with 3 mL distilled water at 20/35 °C (16-h dark/8-h light) as recommended by the Association of Official Seed Analysts (2002). Seed germination was counted daily until no further germination occurred for 4 d. The mean germination time (MGT) was determined using the following equation:

Biology Department, Florida A&M University, 207 Jones Hall, 1530 S. M.L.K. Boulevard, Tallahassee, FL 32307

I gratefully appreciate the donation of seeds from J. Unruh (University of Florida, Milton, FL) and B. Kresin (Pennington Seed Inc., Orlando, FL), and donation of MicroCel E from World Minerals (Lompoc, CA). Thanks are also due to T. Katsvairo for technical help.

¹Corresponding author and Assistant Professor of Biology. E-mail: gokhan.h@famu.edu.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
29.5735	fl oz	mL	0.0338
2.5400	inch(es)	cm	0.3937
25.4000	inch(es)	mm	0.0394
28.3495	oz	g	0.0353
(°F - 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

Table 1. Sources, uses, and cultivars of three warm-season turfgrass species used for seed germination, matricconditioning, and aging studies in Tallahassee, FL.

Species	Cultivar	Seed source	Uses in Florida
Bahiagrass	Pensacola	Pennington Seed Inc., Orlando, FL	Lawns
Bermudagrass	Princess	Seeds West Inc., Yuma, AZ	Sports fields
Centipedegrass	Common	Forrester Farms, Columbia, AL	Lawns

$$MGT = \Sigma(n_i \times t_i) / \Sigma n_i$$

where n_i was the number of newly germinated seeds at time of t_i after imbibing, and n = total number seeds emerged.

ACCELERATED AGING TEST. The protocol for accelerating aging was carried out as described previously (Hacisalihoglu et al., 1999).

Fig. 1. Germination percentage and mean germination time (MGT) of 'Pensacola' bahiagrass seeds with three aging treatments. (A) Germination of nonaged seeds, (B) germination of seeds aged 7 d, (C) germination of seeds aged 14 d, (D) MGT of nonaged seeds, (E) MGT of seeds aged 7 d, and (F) MGT of seeds aged 14 d. Accelerated aging was induced by storing seeds for 0, 7, and 14 d at 42 °C (107.6 °F) and 95% relative humidity. Within each box, lines or bars with the same letters are not significantly different at $P < 0.05$.

Fig. 2. Germination percentage and mean germination time (MGT) of 'Princess' bermudagrass seeds with three aging treatments. (A) Germination of nonaged seeds, (B) germination of seeds aged 7 d, (C) germination of seeds aged 14 d, (D) MGT of nonaged seeds, (E) MGT of seeds aged 7 d, and (F) MGT of seeds aged 14 d. Accelerated aging was induced by storing seeds for 0, 7, and 14 d at 42 °C (107.6 °F) and 95% relative humidity. Within each box, lines or bars with the same letters are not significantly different at $P < 0.05$.

Matriconditioned and nontreated control seeds were aged for 7 or 14 d at 42 °C in magenta vessels (77 × 77 × 97 mm; Fisher Scientific, Suwanee, GA). Seeds were placed above the solution on a mesh sieve.

Relative humidity was maintained ≈95% as measured by a thermohygrometer (Fisher Scientific). After aging, seeds were removed from boxes and used in germination experiments.

EXPERIMENTAL DESIGN AND DATA ANALYSIS. The experiments were set up in a completely randomized design with four replications. The experiment was repeated three times. Analysis of variance was used to determine

Fig. 3. Germination percentage and mean germination time (MGT) of 'Common' centipedegrass seeds with three aging treatments. (A) Germination of nonaged seeds, (B) germination of seeds aged 7 d, (C) germination of seeds aged 14 d, (D) MGT of nonaged seeds, (E) MGT of seeds aged 7 d, and (F) MGT of seeds aged 14 d. Accelerated aging was induced by storing seeds for 0, 7, and 14 d at 42 °C (107.6 °F) and 95% relative humidity. Within each box, lines or bars with the same letters are not significantly different at $P < 0.05$.

the effects of treatment using a general linear model procedure (SAS Institute, Cary, NC). The means were separated using least significant difference at $P < 0.05$. The response between germination (percentage)

and time (days) followed a nonlinear sigmoid (SPSS, Chicago). The equation used was $y = a / 1 + e^{-[x - x_0/b]}$, where y = germination, a = slope, X_0 = germination elicits 50% response, b = y-intercept, and x = time.

Results

Matriconditioning and germination

The effect of MC on the germination of turfgrass seeds is summarized in Figures 1–3 and Tables 2

and 3. In all experiments, MC with MicroCel E was successful in increasing GP while decreasing MGT. In each cultivar studied, GP was higher (Figs. 1A, 2A, and 3A) and MGT was lower (Figs. 1D, 2D, and 3D) for matriconditioned seeds compared with nontreated control seeds.

BAHIAGRASS. Final GP increased 55% (from 44% to 68%) in matriconditioned seeds compared with nonprimed control (Fig. 1A; Table 3). Furthermore, MC significantly reduced MGT (20%) compared with nonprimed control seeds (Fig. 1D).

BERMUDAGRASS. Final GP increased 29% (from 70% to 90%) in matriconditioned seeds compared with nonprimed control (Fig. 2A; Table 3). Furthermore, MC significantly reduced MGT (30%) compared with nonprimed control seeds (Fig. 2D).

CENTIPEDEGRASS. Final GP increased 10% (from 67% to 75%) in matriconditioned seeds compared with nonprimed control (Fig. 3A; Table 3). Furthermore, MC significantly reduced MGT (65%) compared with nonprimed control seeds (Fig. 3D).

Response to aging

Overall, GP decreased with increased aging duration. There were significant differences among turf-

grass cultivars subjected to accelerated aging.

BAHIAGRASS. The 14-d aging treatment, but not 7-d aging treatment, significantly decreased GP. However, matriconditioned seeds had 21% (7-d aged) and 63% (14-d aged) higher final GP compared with nontreated control seeds (Fig. 1). There was no significant difference in MGT between matriconditioned and control seeds after 7 d of aging (Fig. 1E). After 14 d of aging, matriconditioned seeds had a 31% lower MGT compared with nontreated control seeds (Fig. 1F).

BERMUDAGRASS. Both 7-d and 14-d aging treatments decreased GP (Figs. 2B–C). Matriconditioned seeds had 11% (aged 7 d) and 2.5-fold (aged 14 d) higher final GP compared with nontreated control seeds (Fig. 2). There was no significant difference in MGT between matriconditioned and control seeds after 7 or 14 d of aging (Figs. 2E–F).

CENTIPEDEGRASS. Interestingly, there was a higher final GP after 14 d of aging, whereas 7 d of aging reduced final GP (Figs. 3B–C). Matriconditioned seeds had 40% (aged 7 d) and 73% (aged 14 d) lower final GP compared with nontreated control seeds (Fig. 3). There was no significant difference in MGT

between matriconditioned and control seeds after 7 d or 14 d of aging (Figs. 3E–F).

Discussion

Considerable evidence indicates that MC enhances final GP and the speed of germination (Khan, 1992; Taylor et al., 1998). Overall, MC increased final GP 10% to 55% compared with nontreated seeds. Similarly, MC increased the speed of germination (MGT) 20% to 65% compared with nontreated seeds (Figs. 1–3). This is in agreement with a previous report that showed that matric priming improved germination and emergence of kentucky bluegrass (*Poa pratensis*) (Pill et al., 1997).

It has been hypothesized that seed enhancement treatments reduce the longevity of seeds (Parera and Cantliffe, 1994; Taylor et al., 1998). We found that there was little or no decline in GP for the cultivars ‘Pensacola’ or ‘Common’. ‘Princess’ seeds had a 10% decline in final GP after 7 d of aging. Furthermore, 14 d of aging showed more of a pronounced decline in GP for ‘Pensacola’ and ‘Princess’ seeds. Interestingly, ‘Common’ centipedegrass seeds had a higher final GP after 14 d of aging compared with nonaged seeds. This

Table 2. Results of analysis of variance to determine the effect of matriconditioning (MC) and aging on germination of bahiagrass, bermudagrass, and centipedegrass seeds.

Sources of variation	df	Bahiagrass		Bermudagrass		Centipedegrass	
		F	P > F	F	P > F	F	P > F
MC	1	376	< 0.0001	434	< 0.0001	126	< 0.0001
Aging	2	45.1	< 0.0001	218	< 0.0001	27.3	< 0.0001
MC × aging	1	15.1	< 0.0001	84.5	< 0.0001	123	< 0.0001

Table 3. Comparison of regression equation parameters for germination of bahiagrass, bermudagrass, and centipedegrass as a function of time.^a

Treatment	Bahiagrass		Bermudagrass		Centipedegrass	
	Slope	R ²	Slope	R ²	Slope	R ²
Nonaged control	44.1 e	0.97*	63.4 c	0.99*	63.9 d	0.97*
Nonaged MC	66.6 b	0.99*	84.8 a	0.99*	73.7 b	0.99*
7-d aged control	48.6 d	0.95*	64.6 c	0.97*	68.1 c	0.99*
7-d aged MC	70.1 a	0.97*	73.6 b	0.98*	55.5 e	0.96*
14-d aged control	49.1 d	0.98*	27.8 d	0.99*	89.2 a	0.98*
14-d aged MC	59.5 c	0.99*	72.1 b	0.97*	55.1 e	0.98*

^aGermination was fit to the following equation: $y = a / (1 + e^{-(x - X_{50})/b})$, where y = germination (%), a = slope, X_{50} = germination elicits 50% response, b = y-intercept, x = time (d), and R^2 = regression coefficient squared.

*Significant at $P < 0.001$. Means followed by different letters in the same column were significantly different at $P < 0.05$. Matriconditioning (MC) refers to a seed enhancement technique using a solid carrier and water.

result may be explained by the possibility of some other physiological mechanisms that are not analyzed in this work. A similar observation has recently been reported that primed and stored amaranth (*Amaranthus cruentus*) seeds showed no decline after 4 months but with a slight decline after 8 months storage (Tiryaki, 2006). Further studies are needed to evaluate the other mechanisms may be affecting aging in warm-season turfgrass seeds.

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