Solid Matrix Priming Improves Seedling Vigor of Okra Seeds

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Untreated (no fungicide) seeds of 'Clemson Spineless' okra, *Abelmoschus esculentus* (L.) Moench. were primed in solid matrices to improve germination performance and vigor. Ten solid carriers (6 formulations of clays, 2 formulations of humic acid, and 2 other types of formulations) were evaluated for their ability to improve vigor of okra seeds at 25°C in laboratory studies. Super Absorbent 500 (SA 500) consistently increased (P - 0.05) seed vigor in comparison to unprimed seeds and other matrices; however, several formulations also increased performance compared to the control. There were no significant (P - 0.05) interactions between priming agent, water content of the priming agent, and priming time. Usually, longer priming periods resulted in lower gemination rates and reduced vigor. We often achieved greatest germination performance calculated as vigor indices after a priming period of 3 d compared to longer priming periods. There were no differences in seedling vigor because of water content (30 - 50%) of the matrix used in priming. **© *2000 Oklahoma Academy of Science***

INTRODUCTION

The cultivated area planted to okra, *Abelmoschus esculentus* (L.) Moench, in Oklahoma is about 260 ha with a crop value of $2 million annually (J. E. Motes, personal communication). Delayed and erratic emergence is a serious problem in okra (*1*) that creates problems with fertilizer utilization, post emergence weed control, and uniform harvesting. The hard seed coat of okra inteferes with water up-take and is a major physiological constraint to uniform stand establishment and performance (*2,3*).

Researchers have had limited success in improving germination performance of okra seeds. Techniques used have included scarification with sulfuric acid for two hours (*2*) and increasing the moisture content of seeds by placing them in moistened vermiculite (*3*).

Possible alternative presowing seed treatments include solid matrix priming (SMP), bio-priming (integration of SMP with a biocontrol agent), and integration of SMP with chemicals. SMP has been highly effective in improving the emergence and stand establishment of many crops (*4,5*). In SMP, a solid carrier regulates the imbibition of water by the seeds. Solid matrix primed seeds are allowed to imbibe enough water to complete the pregermination process but not radicle emergence. Wu (*6*) has documented that thiol proteases increase in pine seeds during priming indicates degradation of proteins needed for germination and synthesis of new cell membranes.

The choice of a carrier (priming agent) for SMP has a significant effect on the performance of seeds because of the differences in pH and chemical composition of the priming agent (*4*). The objective of this study, therefore, was to evaluate the effects of different SMP agents at different water contents and priming times on germination performance of "Clemson Spineless" okra seeds.

MATERIALS and METHODS

Priming Agents: Ten priming agents were evaluated in this study (Table 1). They were were selected because they had one or more of the following properties: (1) negligible water solubility, (2) non-toxic, (3) high porosity, (4) easy to remove after priming, and (5) friable over a wide range of moisture contents. In this investigation, we compared the effect of particle size on priming. Clay carri-all, CCA, a small granulated particle was compared to the medium-sized granulated clay 16/30, C16/30, ground by the manufacturer and sized on 16/30 industrial screens, and to the finely-ground auger dust, AD. Likewise, humic acids varied in size from a large granulated product to powdered products, that is, AgG and ESC, respectively. Cat Litter, an inexpensive source of clay, was ground and screened into two sizes of particles, - 1 mm and - 500 µm. Sources of the ten priming agents were American Colloid Co. (Arlington Heights, IL) for AD, ESC CCA, C16/30, and AgG; R.T. Vanderbilt Co. (Norwalk CT 06855) for Pyrax; Balcones Mineral Corp. (P.O. Drawer B, Flatonia ,TX) for SA500; local Wal-Mart store for CL500 and CL1000; and Grantech (Green Bay,WI) for BioD.

Priming: We used the following protocol to screen the priming agents. Weighed amounts of priming agents (1.8 g at a ratio of 3:1 w/w to seed) were placed in polyethylene bags (100 mm x 50 mm) and sterile water was added to achieve 30%, 40%, or 50% moisture content of the priming agent. The agent and water were mixed thoroughly and ten okra seeds were added; the bags were then sealed and incubated for 3,4,5, or 6 days at room temperature (22 to 25°C). Untreated seeds served as the control. The experiment was repeated once, and there were three replicates of each treatment in each experiment.

Germination: The okra seeds were one year old and had been stored at 5°C. Standard germination (7) of the seeds was 80%. At

TABLE 1. Characteristics and sources of ten priming agents used in this research.

Priming Agent	Type	pH	Source
Agrolig granular **AgG** [a]	humic acid	NA[b]	American Colloid
Auger Dust **AD**	clay/gypsum	NA	American Colloid
BioDac **BioD**	cellulose	NA	Grantech
Cat litter **CL500** **CL1000**	Montmorillonite particles < 500 mm particles < 1 mm	NA	Wal-Mart
Clay 26/30 **C16/30**	pyrophyllite	NA	American Colloid
Clay carri-all **CCA**	crystalline quartz	7.4	American Colloid
Enerosol SC **ESC**	humic acid	11.0-12.0.	American Colloid
Pyrax **pyrax**	pyrophyllite clay	NA	R. T. Vanderbilt Co.
Super absorbent 500 **SA500**	calcined clay	7.0	Balcones Mineral Corp.

[a] Abbreviations used in the text for priming agents.
[b] NA = not applicable

the end of the respective priming periods, seeds were separated from the priming agent by sieving. Seeds from each bag were placed in a petri dish (100 mm x 15 mm) lined with two layers of filter paper. Seeds were allowed to dry overnight in opened dishes on a lab bench at room temperature, and the following day, 5 mL of sterile water were added to each petri dish. Germination was recorded daily for 7 d. A seed was considered germinated when the radicle tip protruded clearly from the seed. There were 720 seeds used per priming agent, a total of 240 seeds used in evaluating priming time and 180 seeds used to evaluate water content.

Water Content: The relation of water potential (ψ) to moisture content (dry weight basis) was determined for each matrix for moisture contents from 30 to 50%. The ψ was measured for each matrix with a chambered in situ psychrometer (Merrill, Specialty Equipment, Logan, UT, USA) and was read with a Wescor HP-115 water potential system (Wescor Inc. Logan, UT USA). All psychrometers were calibrated against KCL standards. The water saturation point was below 60% for some matrices. Each sample was read three times and there were three replicates.

Vigor Index: An index of seed vigor (germination speed) (*8*), expressed as a Vigor Index (VI), was calculated:

$$VI = \frac{G1 + G2 \ldots + GL}{D1 + D2 \ldots + DL}$$

Where:
G1 = Number of germinants (first count)
G2 = Number of germinants (second count)
GL = Number of germinants (last count)
D1 = Number of days to first count
D2 = Number of days to second count
DL = Number of days to last count

The higher the value of the index, the better the seed vigor. All germination data from the experiments were converted to Vigor Index values.

Data Analysis: Analysis of variance tests were performed using Statistical Analysis System software (SAS Institute, Inc., Cary, NC) to compare all possible interactions between the main effects of matrix, water content, and priming time. When appropriate, means were separated with the Student-Newman-Keuls multiple range test (*P* - 0.05).

RESULTS

Priming Agents: Of the ten priming agents tested, only Super Absorbent improved seed vigor (*P* - 0.05) when compared with all other priming agents and the unprimed seeds (Table 2). There were no interactions among size of solid particulate, water content, and priming time (*P* - 0.05). Priming agents Pyrax and BioD were not friable and encouraged bacterial growth. CL (1.0 mm) and CL (500 mm) were friable but caused seed decay and premature germination of the seeds in the bag. AD and C 16/30 were friable but did not show any improvement in the germination performance. Enersol ESC and Agrolig AgG (granulated) were not friable. Finely ground SMP agents did not improve germination compared to the larger sized formulations.

DISCUSSION

Longer priming times usually resulted in lower germination and vigor indices (*P* 0.05) as a result of fungal contamination. This problem was ameliorated by surface sterilizing seeds and heat sterilizing SMP agents (overnight at 70°C) prior to actual priming. We have also had success in priming fungicide-treated seeds.

In general, water content was a non-significant factor when we compared all matrices, perhaps indicating that each matrix has unique water content requirements for optimal priming. In other experimentation (*6*), optimal priming was usually obtained at -1.1 milliPascals (mPa) for each SMP agent. Interestingly two of the best priming agents, CCA and SA500 had pH values near 7, which corrresponds to the optimum soil pH of 7.0 for okra production. The other agents, how-

TABLE 2. Germination performance (Vigor Index) of okra seeds after solid matrix priming.

Priming Agent	Mean Vigor Index[a]	
Super Absorbent 500 SA500	12.4	a
Auger Dust AD	10.1	b
Clay carri-All CCA	9.8	b
Biodac BioD	9.46	b
Clay 16/3 C16/30	9.37	b
Agrolig granular AgG	9.21	b
Cat litter CL500	8.6	b
Enersol SC ESC	8.44	b c
Cat litter CL100	8.03	b c
Pyrax Pyrax	7.31	b c
Control	6.7	c
Factors and Interactions		
priming time(d)		
3	11.26	a
4	8.75	b c
5	7.79	c
6	9.3	b
water content	NS	b
Interactions	NS	

[a] Vigor Index (8) Means followed by different letters are significantly different(*P*- 0.05) Student-Newman-Keuls Multiple range test. Means are pooled data of 10seeds/treatment with 3 replications repeated once (total seeds: priming agents = 720 seeds, time = 240 seeds, water content = 180 seeds).
[b]NS = not significant

ever, had basic values (11.0 - 12.0) or had values not determined by the manufacturers. If biological agents are added during the priming process (*4*), pH values of the priming agents are important and might determine whether the biological agents would survive.

The potential applications of solid matrix priming of okra seeds are diverse. Apart from increasing the germination performance of seeds, solid matrix priming may provide a delivery system for selective fungicides and biocontrol organisms to control various soilborne pathogens(*4*). Because okra is sensitive to cool temperature (*3*), solid matrix priming could be used as a pre-sowing seed treatment to improve seed emergence when sown in cold soils. Priming could allow for greater membrane integrity in the embryo and the developing seedling reducing leakage through the membranes resulting in increased germination performance.

Based on the results, we have reached the following conclusions: (1) improved germination performance of okra can be achieved by solid matrix priming, and (2) several types of materials can effectively be used for solid matrix priming, but optimal conditions for moisture content and priming time must be determined for each matrix.

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REFERENCES

1. Anderson WH, Carolus RI, Watson DP. The germination of okra seed as influenced by treatment with acetone and alcohol. Proc Amer Soc Hort Sci 1960;62:427-432.
2. Standifer LC, Wilson PW, Drummond A. The effects of seed moisture content on hardseededness and germination in four cultivars of okra (Abelmoschus esculentus (L.) Moench). Plant Varieties and Seeds 1989;2:149-154.
3. Marsh L. Moisture affects cowpea and okra seed emergence and growth at low temperatures. HortScience 1993;28: 774-777.
4. Harman GE, Taylor AG. Improved seedling performance by integration of biological control agents at favorable pH levels with solid matrix priming. Phytopathology 1988;78:631-637.
5. Khan AA. Preplant physiological seed conditioning. Hort Rev 1992;14:131-181.
6. Wu L. Development of solid matrix priming to enhance loblolly pine (Pinus taeda) seed germination and analysis of its physiological mechanisms. [PhD. Dissertation]. Stillwater (OK): Oklahoma State University; 1997. 191 p. Available from: OSU Library.
7. Colbry VL, Swofford TF, Moore RP. Tests for germination in the laboratory. In: Seeds, yearbook for agriculture, 1961. U.S. Department of Agriculture, Washington, D.C., 1961. p. 433-443.
8. Malvasi D, Stafford M, Lavender DP. Stratifying, partially redrying and storing douglas-fir seeds: effects on growth and physiology during germination. Ann Sci For 1985;42:371-384.

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