Seed Hydration Using the Drum Priming System

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Abstract. Drum priming enhances seed performance without the waste and additional materials associated with conventional osmotic or matric priming techniques. Sweet corn (*Zea mays* L.) *se* ('White D' Lite') and *sh2* ('WSS-4948') endosperm seeds were hydrated using drum priming at 25 °C for 6 hours. During each cycle, 125-g seed samples were exposed to 1.6, 3.2, 4.8, or 6.0 mL of distilled water and then rotated in a drum for 1 hour to ensure uniform uptake. At the end of this period, samples of 100 seeds (each) were removed and moisture content was determined. Drum priming hydrated all seedlots gradually, with increasing time required at reduced water levels for individual seedlots to achieve the desired moisture content (25% to 30%). Drum priming may provide a better alternative to conventional systems of priming.

For many years, seed priming has been used as a valuable tool in improving stand establishment (Heydecker et al., 1973). Priming enhances seed performance by increasing germination rate and uniformity. Furthermore, these enhancements persist under less than optimum field conditions, such as salinity (Wiebe and Muhyaddin, 1987), excessively high or low temperatures (Bradford, 1986; Pill and Finch-Savage, 1988; Valdes et al., 1985), and reduced water availability (Frett and Pill, 1989). For many vegetable species, priming increases seedling vigor and yields, resulting in greater profits that justify the additional cost of these treatments.

Liquid priming is accomplished using osmotica, such as salt solutions or polyethylene-glycol (PEG), that are difficult to handle when large quantities of seed are required (Heydecker and Coolbear, 1977) in addition to producing wastes that require disposal. Solid particulate priming systems use carriers (Khan, 1992) that also must be disposed of. These wastes could be minimized by using only water as the priming system, such as with soaks, humidification, and drum priming. When using seed soaks, care must be taken to avoid radicle protrusion by manipulating treatment duration and temperature (Burgass and Powell, 1984; Coolbear et al., 1987). A process called hydropriming uses a presoak in

water followed by exposure to 100% relative humidity (Fujikura et al., 1993). However, this method may result in nonuniform seed hydration, as well as microbial growth.

The ideal seed hydration system would bring the seeds to the desired seed moisture content using only water. Drum priming has the capability to accurately hydrate seeds without concern for spent solution or solid carrier disposal (Rowse, 1996). Drum priming hydrates seeds to the desired moisture level by using limited amounts of water rather than osmotic solutions or solid matrix materials. Seeds are hydrated in a controlled manner and the duration of the drum priming depends on the absorptive characteristics of the particular species and seedlot, and the desired final seed moisture content. The purpose of this paper is to describe a seed hydrating apparatus that accomplishes the essential elements of drum priming.

A drum priming system has been patented by Rowse (1991, 1992). In this model, the priming drum rests on a scale that determines increases in seed mass created by influxes of

water vapor (Rowse, 1996). This vapor is generated by a boiler and once inside the drum condenses into liquid water. The scale must be sensitive enough to measure the incrementally small increases in seed mass relative to the weight of the apparatus itself. Computer control is required to operate the scale and maintain a supply of water vapor. When the seeds have achieved the desired weight, and no water remains, the hydration phase is completed. The equipment described in this paper provides a simpler alternative to the Rowse model.

Materials and Methods

We propose that seed hydration be controlled by time and volume of water exposure. Since a known mass of seeds is added to the drum, the amount of water needed to hydrate the seed to the desired moisture level can be calculated. The nozzle emits a preset volume of water during each cycle as regulated by a timer attached to a solenoid (Fig. 1). Dividing the total water volume required by the preset volume of injected water establishes the number of cycles. The seed absorptive pattern of the particular species and cultivar must also be known or determined. This determines the time between water injections so that no free water is left before the next injection. Drum priming must occur without excess water accumulation in the drum. The optimal drum priming duration is calculated by multiplying the number of cycles needed to add the desired volume of water by the duration of the cycle, as determined by the absorptive characteristics of the seedlot. Using the drum system, water is injected onto the seeds, and a given period of time is allowed for its absorption; in our research, we determined that a cycle duration of 1 h was adequate for all sweet corn treatments. By the end of each cycle, the seeds have absorbed the water and are surface dry. When the seeds have absorbed water from the final injection, they have reached the desired moisture content and are removed from the drum. We used an injection and absorption procedure because the small size of our proto-

Fig. 1. Wiring schematic for drum primer.

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Fig. 2. Diagram of drum primer.

type made it difficult to achieve a continuous flow of water small enough to avoid excess seed hydration. However, this system could be scaled up commercially. As the apparatus becomes larger, the application of free water to the seeds should approach a continuous flow. Note that these methods describe only the hydration phase, not the duration of time needed for priming to occur.

The drum priming system (Fig. 2) consists of a 25 × 15-cm clear plexiglass pipe bonded at one end to a clear plexiglass plate. The other end is also made of plexiglass, but is removable and serves as a lid. On the interior of the drum is a bead of aquarium sealant that gently tumbles the seeds during drum rotation, providing even seed hydration. The drum is rotated by a variable speed motor (model HD PSC; Robbins and Myers, Southington, Conn.) at ≈15 rpm. Water flows from a tank through a hose to the base axis of the drum where it is emitted. The water is not under pressure and flows into the drum by gravity. Flow is regulated by a solenoid (8280 series; Automatic Switch Co., Florham, N.J.) controlled by a timer (Omron model H3CR-F; Grainger, Columbus, Ohio) that controls the length of the injection and resting periods. A second timer (Omron model H3CR-A8; Grainger) supplies power to the entire unit to control the length of the treatment.

Seedlots of 125 g were hydrated at 25 °C for 6 h. During each cycle, seeds were exposed to 1.6, 3.2, 4.8, or 6.0 mL of distilled water and then rotated in the drum for 1 h to ensure

uniform absorption. Solenoid settings are shown in Table 1. Volumes of water available are approximate and are the average of three cycles. At the end of each cycle, samples of 100 seeds were removed and their moisture content determined. The seeds were weighed after removal from the drum and then dried in an oven at 54 °C for 24 h. The seeds were then weighed again and their percent moisture determined on a fresh-mass basis. One seedlot of each type was soaked in 300 mL of distilled water for comparison.

Results and Discussion

In preliminary studies, drum priming was a successful method of accurately hydrating 125 g of two sweet corn cultivars (Table 2). Seeds in all treatments were hydrated gradually, with moisture contents increasing with time and with increased rates of water applied. Seed moistures from hour 2 to hour 6 are higher than normal due to the removal of seeds at the end of the previous treatment. The apparatus may also allow concurrent seed hydration and application/colonization of beneficial microbes (Bennett, 1996), plus serve as a teaching device for labs on seed enhancements and comparisons with results from aerated liquid priming systems (Akers and Holley, 1986).

Drum priming regulates water uptake into the seed. Seeds of both *se* and *sh2* types reached similar levels of hydration after 6 h of treatment and had significantly lower moisture levels than those in the soaked treatments

(Table 2). Water uptake is restricted by limiting water availability; however, water is evenly distributed over the seed mass. When selecting solenoid settings, it is important to 1) apply only enough water so that it can all be absorbed prior to the next hydration cycle, and 2) limit the duration of the total treatment so it does not promote pathogen development. This technique should be suitable for a number of crop seeds that can benefit from controlled hydration.

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Table 1. Solenoid settings and volume of water added for each of the four treatments.

Treatment	Solenoid setting (seconds open/h)	Volume of water added (mL·h ⁻¹)
1	1	1.6
2	2	3.2
3	3	4.8
4	4	6.0
5	*	*

*Treatment 5 consisted of a soak in 300 mL of distilled water.

Table 2. Percent seed moisture achieved in sweet corn seeds with four drum priming treatments and various durations.

Time (hr)	<i>se</i> cv. White D' Lite ^a					<i>sh2</i> cv. WSS-4948 ^a				
	Treatment				Soak	Treatment				Soak
	1	2	3	4		1	2	3	4	
1	8.8	11.3	15.6	16.0	24.9	15.7	15.7	16.8	17.3	33.0
2	9.7	13.6	17.7	19.8	32.4	17.2	17.4	19.5	20.7	38.9
3	11.2	15.4	21.2	23.8	35.6	18.2	19.6	22.2	24.4	42.8
4	12.4	17.8	24.6	28.1	39.3	19.5	21.4	26.2	28.6	46.2
5	14.5	20.6	28.8	32.6	42.7	21.0	24.8	28.9	32.2	49.4
6	17.2	24.8	34.1	37.8	45.0	23.0	27.7	33.5	37.7	50.1

^aWhite D'Lite^a and 'WSS-4948' seedlots had initial moisture contents of 6.4% and 12.8%, respectively.