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Enhancement of Bean Field Emergence By Seed Moisturization

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A common quality defect of bean seed grown in the West is low moisture content caused by overdrying in the field. Aside from increasing shattering losses and harvest damage, overdrying increases seed susceptibility to mechanical damage during conditioning and planting. Overdrying can also lead to seed injury from rapid water uptake after planting (imbibitional injury).

Although timely threshing can prevent overdrying, remedial action is sometimes needed. Adding moisture to seeds after harvest can improve their field performance and their resistance to mechanical damage during conditioning, handling and planting. This is called moisturization.

Imbibitional Injury

Rapid uptake of moisture by very dry beans after planting can injure the seeds and lead to poor stands. Damage may result from mechanical stresses as very dry tissue swells or from an inability of cell membranes to absorb water rapidly without disruption. Injury appears as delayed growth, massive leakage of cell contents into the surrounding soil and sometimes death. Cold temperatures greatly increase injury. Even when the seed isn't killed outright, it may become more susceptible to soil-borne fungi stimulated to grow by the leaked cell contents.

Common cultural practices help control imbibitional injury. These include planting in warm soil, irrigating the bed before planting to avoid seed contact with free water and using fungicides to help control diseases that attack the weakened seed.

Moisturization also can reduce imbibitional injury, making the cultural practices less critical. Use of moisturized seed may allow earlier planting and minimize seed cracking by the planter. Increased seed moisture helps protect against damage from watering up the crop, but this practice may still cause soil crusting.

Moisturization Methods

Moisturization differs from priming. Priming typically increases seed moisture to a level close to that required for germination (Murray and Wilson 1987). Primed seed is normally redried so that it can be handled and planted conventionally. Moisturization, on the other hand, raises seed moisture to a more moderate level, usually to 10 to 20 percent by weight, depending on the species. This level is too low to metabolically activate the seed, and the seed is not dried after the treatment. Seed is planted while moist, reducing the moisture gradient from soil to seed and resulting in a lower rate of water uptake. Two approaches are used to add small amounts of water to dry seeds — solid matrix methods and vapor phase methods. Direct addition can be harmful.

Solid Matrix Methods

Seeds can be mixed with damp sawdust, vermiculite, perlite or similar absorbents. The absorbent must be sufficiently dry that moisture transfer to the seed occurs slowly. We have used vermiculite containing 30 percent water (air dry weight basis). At this moisture level, the absorbent doesn't feel wet, and several days are needed to transfer water to the seeds. Afterward, the absorbent is cleaned from the seed with an air screen machine or similar device.

The amount of water to add to the seed is calculated from the weight of the seedlot (W), the initial seed moisture percentage (M) and the desired final seed moisture percentage (X):

$$\text{Water needed} = \frac{(X - M) \times W}{100 - X}.$$

For example, to bring 1,000 pounds of beans at 8 percent moisture to about 14 percent moisture, calculate the water needed as follows:

$$\text{Water needed} = \frac{(14 - 8) \times 1{,}000}{100 - 14} = 70 \text{ lb.}$$

Assuming you want to use vermiculite containing 30 percent water (dry weight basis) as an absorbent, you would add the needed water to dry vermiculite weighing 3.33 times more than the water. In the example, the 70 pounds of water would be mixed with 232 pounds of vermiculite (70 × 3.33 = 232) and the moistened vermiculite added to the beans. The final seed moisture content will be less than 14 percent because the absorbent does not release all the added water.

We have not investigated the effect of changing the ratio of water to absorbent. It may be possible to use a smaller amount of vermiculite. This would be more convenient and would lessen the difference between the calculated and the actual final seed moisture content.

Incubation time varies with seed size, kind, initial moisture content, desired moisture content and ambient temperature. With small batches of beans being increased to 14 percent moisture from 10 to 12 percent moisture, we have found that 3 or 4 days is sufficient.

As the final seed moisture increases, solid matrix moisturization grades into a seed enhancement technique known as "solid matrix priming." This will be addressed in a future bulletin.

A related method of increasing seed moisture is blending dry and moist seedlots. A lot too high in moisture can be blended with a lot too low in moisture. Both lots are improved, and no drying facilities are needed to save the moist lot. Final moisture content is adjusted by changing the proportions of the lots.

Vapor Phase Methods

Large scale moisturization is most practical when water is carried to the seed as humid air. This requires a larger capital investment, but eliminates the need to remove spent absorbent. Some vapor phase system designs are proprietary, but probably consist of heating and vaporizing water into the air stream before passing it through the seed. It should be possible to control the rate of water uptake by the seed by adjusting the relative humidity and temperature of the air stream relative to the seed. Merely storing seed in a humid atmosphere will eventually add moisture, but a very long time might be required to add a significant amount to a large bulk of seed.

Field Results

Beans responded positively to moisturization (Table 1). Response to seed moisture was affected by irrigation timing. Planting moisturized seed was more beneficial when beans were watered up than when they were planted into moist soil. Response to seed moisture also was affected by planting date. Increased seed moisture helped produce an adequate stand when seeds were planted into cool soil.

Increased seed moisture was not beneficial only when beans were planted late into preirrigated soil. The apparently negative effect of planting moisturized white seeded lines in preirrigated plots at the June 14 planting date was too small to be reliably detected in this experiment.

Table 1. Average field emergence of beans of four genetic backgrounds when planted dry (7 percent moisture) or moisturized (14 percent moisture) and subjected to various cultural practices.

Planting date	Irrigation timing	Colored seed Dry	Colored seed Moist	White seed Dry	White seed Moist
		%			
5/2/88	pre	68	75	36	43
	post	61	74*	24	40*
6/14/88	pre	81	79	71	64
	post	77	89*	59	72*

Note: Average emergence is the mean of 16 plots. Results were obtained from four pairs of lines near-isogenic for seed whiteness conditioned by the *p* gene. Within a pair, the lines were virtually identical except for the presence or absence of seed coat color. Two pairs of lines were garden beans and two were dry beans. Response to moisturization was not affected by type.

*Significant improvement over dry seed ($p < .05$).

Optimum Moisture Level Experiment

This experiment was performed to determine the optimum level of moisture for reliable stand establishment. Two pairs of garden bean lines were adjusted to five moisture levels using moist vermiculite. Samples were planted on May 11, 1989, into either dry or preirrigated beds. The dry beds were irrigated the same day they were planted.

Moisturizing to 14 percent improved final stand except for colored beans planted into a moist seedbed (Fig. 1). Under these conditions colored beans showed no change in response to seed moisturization. However, when the colored versions of the two lines were protected by moisturization and irrigated after planting, they apparently were able to capitalize on the abundant moisture and produce a very high stand. Preirrigation improved emergence of white seeded lines at all moisture levels.

Storage of Moisturized Seed

Seed deteriorates physiologically and microbiologically in storage. When germination is plotted with respect to storage time, germination maintains a steady

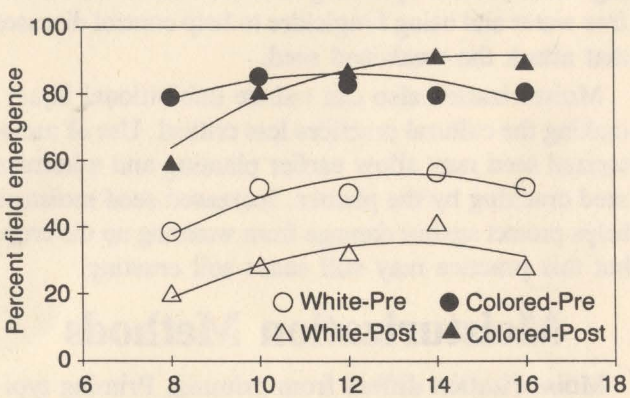

Fig. 1. Final stand averaged over genetic backgrounds for colored and white seeds planted at different seed moisture contents into preirrigated beds or watered after planting (Wilson and Trawatha 1990).

high value for a time then abruptly drops off in a sigmoidal curve to a low value that slowly approaches zero (Fig. 2). This decline is accelerated as seed moisture and temperature increase.

Moisturization reduces the time beans may be stored. If moisture is high enough seed becomes moldy, and viability is lost rapidly. Very few species of fungi can grow at less than 75 percent relative humidity, and those that do grow, grow extremely slowly. For all practical purposes, fungi do not grow at less than 70 percent relative humidity.

Fig. 3 shows the relationship between moisture content of pinto beans and relative humidity. Although data are from 21 weeks, only about 2 weeks were needed to achieve moisture levels very close (95 percent) to equilibrium. No mold was observed on any of these samples after 5 months of storage. All other cultivars tested gave virtually identical curves. The curve shows that beans stored at 14 to 16 percent moisture should be safe from mold. However, temperature gradients in large-scale bulk storage may eventually lead to moisture migration and hot spots at borderline moisture levels (14 to 16 percent). Storage in bags eliminates that danger.

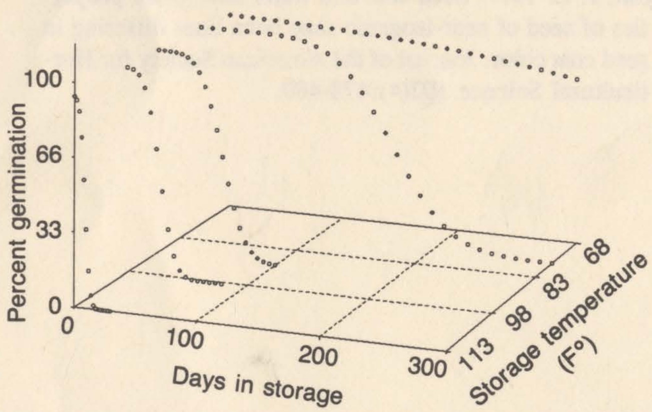

Fig. 2. Loss of viability of Calima beans at 16 percent moisture held at various temperatures according to a probit analysis simulation (Wilson et al. 1989).

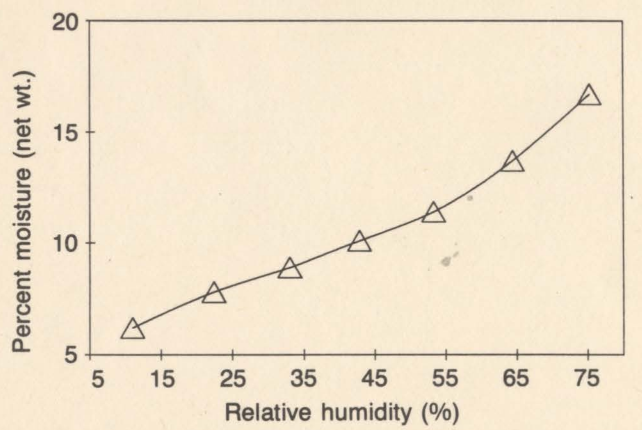

Fig. 3. Pinto bean moisture content after 21 weeks at various relative humidities (Weston and Morris 1954).

At moisture levels too low for fungal growth, stored seed loses viability and vigor physiologically. Fig. 2 shows estimated germinability of Calima beans at 16 percent moisture stored at various temperatures. At cool temperatures germination was maintained long enough for marketing and planting. However, vigor is lost more rapidly than germinability.

Fig. 2 provides overly optimistic estimates of allowable storage times. Fig. 4 shows the time for beans to fall to 50 percent germination based on a 4-day count of normal seedlings. Because only vigorous seeds can reach a countable stage of development in 4 days, Fig. 4 provides a fairly conservative estimate of maximum allowable storage times. This information still must be used with caution. The time estimates greater than 370 days were obtained by extrapolation and may not be reliable.

Under dry conditions vigor is lost sooner than viability, which can persist for extremely long periods. As seed moisture and temperature increase, vigor and viability tend to disappear at about the same time.

Conclusion

Moisturization of beans to 14 percent improved final plant stands. No benefit was realized at seed moisture levels higher than 14 percent. Moisturization was most beneficial under the stress of early planting, irrigation after planting or both. It provided no benefit for colored beans planted in a warm, moist seedbed.

A seed moisture level of 14 percent should cause no problem for short-term storage, but target moisture levels of 12 or 13 percent should be considered if long-term (6 to 12 month) storage and/or high temperatures are anticipated.

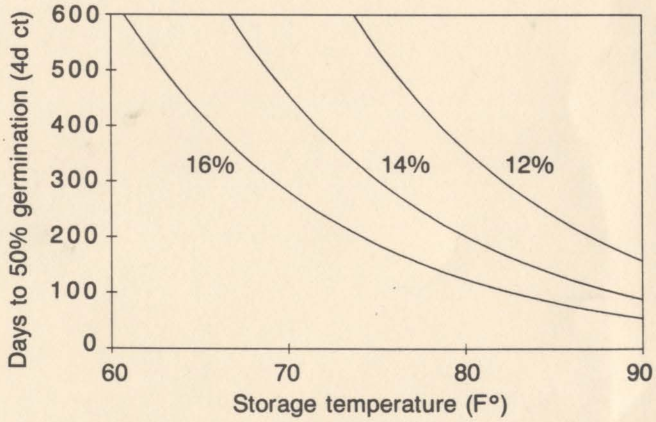

Fig. 4. Effect of storage temperature and seed moisture content on estimated time required for Calima bean seed germination to drop to 50 percent as determined by the 4-day germination test (Wilson et al. 1989).

References

Bakker-Arkema, F. W., W. G. Bickert and S. T. Dexter. 1968. Environmental control during storage to prevent cracking of pea beans — An analysis. Transactions of the American Society of Agricultural Engineers. 11(3):380-383.

Calero, E., S. H. West and K. Hinson. 1981. Water absorption of soybean seeds and associated causal factors. Crop Science 21(6):926-933.

Christensen, C. M. 1973. Loss of viability in storage: Microflora. Seed Science and Technology 1(3):547-562.

Christensen, C. M., and H. H. Kaufmann. 1969. Grain storage: The role of fungi in quality loss. University of Minnesota Press, Minneapolis.

Dexter, S. T. 1966. Conditioning dry bean seed (*Phaseolus vulgaris* L.) for better processing quality and seed germination. Agronomy Journal 58(5):629-631.

Haynes, B. C. J. 1961. Vapor pressure determination of seed hygroscopicity. USDA Agricultural Research Service Technical Bulletin 1229:1-20.

Henderson, S. 1987. Moisture transfer between mixed wet and dry barley grains. Journal of Agricultural Engineering Research 37(3):163-170.

Ishida, N., H. Kano, T. Kobayashi, H. Hamaguchi and T. Yoshida. 1988. The relationship between imbibitional damage and initial water content of soybeans. Agricultural Biological Chemistry 52(11):2771-2775.

Murray, G. M., and D. O. Wilson, Jr. 1987. Priming seed for improved vigor. Bulletin 677. Idaho Agricultural Experiment Station, University of Idaho, Moscow.

Taylor, A. G., and M. H. Dickson. 1987. Seed coat permeability in semi-hard snap bean seeds: Its influence on imbibitional chilling injury. Journal of Horticultural Science 62(2):183-189.

Watts, K. C., W. K. Bilanski and D. R. Menzies. 1988. Design curves for drying grains with bentonite. Canadian Agricultural Engineering 30(2):237-242.

Weston, W. J., and H. J. Morris. 1954. Hygroscopic equilibria of dry beans. Food Technology 8(August): 353-355.

Wilson, D. O., Jr., M. B. McDonald, Jr., and S. K. St. Martin. 1989. A probit planes method for analyzing seed deterioration data. Crop Science 29(2):471-476.

Wilson, D. O., Jr., and S. E. Trawatha. 1990. Enhancement of bean emergence by seed moisturization. Crop Science (Submitted).

Wolk, W. D., P. F. Dillon, L. F. Copeland and D. R. Dilley. 1989. Dynamics of imbibition in *Phaseolus vulgaris* L. in relation to initial seed moisture content. Plant Physiology 89(3):805-810.

Wyatt, J. E. 1977. Seed coat and water absorption properties of seed of near-isogenic snap bean lines differing in seed coat color. Journal of the American Society for Horticultural Science 102(4):478-480.

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