HortScience 16(5):661–662. 1981.

Lettuce Seed Coatings for Enhanced Seedling Emergence[1]

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Additional index words. *Lactuca sativa*, stand establishment, pelleted seed, activated carbon, germination inhibitors

Abstract. **Lettuce (*Lactuca sativa* L.) seed coatings containing a granular activated carbon layer adjacent to the seed and overcoated with standard coating materials gave faster, more complete and more uniform seedling emergence than did simple coatings with standard materials. Evidence suggests the granular carbon layer acts to speed O_2 diffusion into and adsorb endogenous growth inhibitors excreted from the germinating seeds. Variability of seedling emergence was found to be inversely related to the mean emergence rate.**

A major problem with seed coatings used to facilitate precision planting of small, irregularly shaped vegetable seeds, lies in the stresses induced by the coating on germination physiology. Seedling emergence rates and total seedling stands typically are reduced (1, 4, 5, 6, 7, 9, 12). Growers using coated seeds frequently report slow and erratic emergence, which presumably could result in later and less uniform crop maturity.

Bishop (1) showed that differences in performance of coated and uncoated lettuce, onion and tomato seeds were due to the presence of the coating and not to coating induced injuries. Millier and Sooter (6) speculated that clay coatings interfered with O_2 diffusion into the seeds and Millier (4) later demonstrated that seed coating performance was directly related to coating filler particle size; large particles permitted faster seedling emergence, presumably because the associated larger pore spaces allowed faster O_2 diffusion.

Sharples (10, 11) has shown that germinating lettuce seeds excrete endogenous growth inhibitors that slow or prevent germination if conditions favor inhibitor accumulation. In an inactive germination medium such as vermiculite, inhibitor activity may be reduced or prevented either by increasing the moisture potential to speed inhibitor diffusion or by adding activated carbon to promote inhibitor adsorption. Under field conditions coated seeds may be subjected to a wide range of soil moisture conditions, depending on localized soil moisture potentials and on the proportion of seed coating surface in contact with surrounding soil. Furthermore, powdered silicas, micas and clays commonly used for seed coatings are notably poor adsorbents; based on total internal surface area (2), diatomaceous earth, currently used extensively for commercial vegetable seed coatings, is among the poorest. Thus, there is reason to expect that coated seed field performance might be enhanced by proper combination with a good adsorbent such as activated carbon, provided the requirement for adequate O_2 exchange also is satisfied.

Seed coatings were applied by accretion methods either mechanically in a 46 cm rotary coating pan (25–30 rpm) or manually in a 20 cm kitchen sauce pan using an orbital motion (1–2 cycles/sec). The latter was convenient for applying coating materials with particle sizes greater than about 150 μm. A gum arabic solution (10%) containing 1% glycerine (plasticizer) was used as a binder applied with a paint sprayer operating at 33 KPa (5 lb./in^2) pressure. Binder application rate was constant and minimal for production of seed pellets with reasonable hardness to withstand normal mechanical handling and planting stresses. Seed coatings were built up until pellets could pass a US Standard No. 6 (3.2 mm) sieve but not a No. 7 (2.8 mm) sieve. Pellets were given a finish coating of binder, dried rapidly at 35° C and stored in sealed containers at 5° until planted.

Laboratory performance tests of coated 'Vanguard' or 'Empire' lettuce seeds (92–97% dark germination) consisted of 20 pellets (8–10 replicates) planted 4 mm deep into a 3 cm layer of screened (1.6 mm) and uniformly mixed clay loam soil, the moisture characteristics of which previously had been determined (10). Flats (30 x 20 x 6 cm) containing soil and planted seeds were enclosed in heavy polyethylene bags into which water was introduced to provide the desired soil moisture content by upward capillary movement from below. Bags were sealed and flats were held at 1° C until moisture equilibrium was attained (24–36 hr), then incubated at 23–25° under laboratory lighting. Counts were made daily of seedlings at least 1 cm high; total emergence was recorded on day 9. Performance comparisons were made against similarly planted naked seeds. Seedling emergence from naked seeds began about 40 hr after the start of incubation and was essentially complete after 72 hr. Emergence from coated seeds began 2–10 hr later and was always slower. Thus, percent emergence at 72 hr was used as a convenient measure of emergence rate. The variance of transformed (arcsin $\sqrt{x}$) emergence percentages was analyzed and mean differences were separated by the multiple range test (3).

Diatomaceous earth consistently produced pellets permitting faster and more complete seedling emergence than any other material tested (data not shown). Clays and organic materials such as starch and powdered activated carbon were the poorest. The better performance of diatomaceous earth may have been due to the relatively large size and porous structure of diatoms allowing more rapid O_2 diffusion into the seed. Powdered activated carbon, which also is porous, was completely unsuitable either as a coating material or as an additive, a result consistent with the demonstrated particle size effect (4).

Small particles tend to accrete faster than large particles, so that even the best grades of diatomaceous earth produce coatings with a relatively low performance potential, since they contain a large proportion of broken material in the 1–10 μm range. Sand coatings with particle sizes greater than 100 μm increase pellet performance effectively (4, 6), but they erode when handled, have poor flow characteristics and wear out planter parts rapidly.

A proposed model for a seed coating featuring a discrete layer of granular activated carbon adjacent to the seed to provide unobstructed O_2 diffusion and to adsorb excreted endogenous growth inhibitors is presented (Fig. 1). The 0.3–0.5 mm thick carbon layer is overcoated with a standard coating material to provide stability and improve flow characteristics. Performance data are presented (Table 1) comparing emergence from naked lettuce seeds with that from simple seed coatings and from coatings made according to the model.

Preliminary tests had shown that maximum seedling emergence rates could be obtained only if the carbon granules were washed free of fine dust-size carbon particles before application to the seeds. Rapid accretion of these small particles on the seed surface severely restricted seedling emergence. The particle size characteristics of the material used to overcoat the carbon appeared to have little effect on emergence as long as it was not in direct contact with the seed. Compared to naked seeds, the experimental coatings caused no significant reduction in seedling emergence when minimum carbon granule size was 420 μm (35 mesh) or 180 μm (80 mesh). When minimum size was reduced to 150 μm (100 mesh), however, the emergence rate was significantly reduced.

To demonstrate that activated carbon may

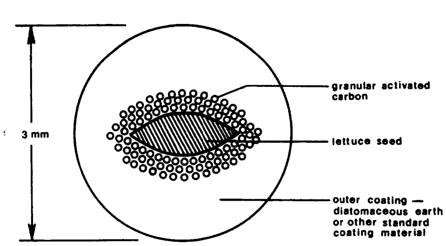

Fig. 1. Proposed model for a lettuce seed coating designed to impose minimum germination stress. Contact between small outer coating particles and the seed surface is not permitted.

[1]Received for publication March 23, 1981. Journal series paper No. 3415, Arizona Agricultural Experiment Station.
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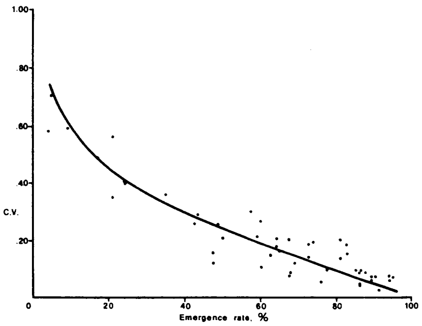

Fig. 2. Coefficient of variation for lettuce seedling emergence from coated and uncoated seeds related to the mean emergence rate (72 hr emergence).

have additional value as an inhibitor adsorbent, graded and washed silica sand was substituted for the carbon in the model. Significantly slower emergence was recorded in each case compared to carbon coatings with respectively similar particle size distributions (Table 1).

Coated seeds may be somewhat sensitive to soil moisture conditions, depending on the hydrokinetic properties of the coating material (5, 8). Simple diatomaceous earth coatings permitted faster lettuce seedling emergence at 17% moisture (field capacity) than at either 15% or 22% moisture, but the rate was always less than that from naked seeds (Table 2). Seedling emergence from coatings made according to the model with 60–80 mesh activated carbon generally was equal to that from naked seeds, but exceeded total emergence from naked seeds at the 15% moisture level.

Commercial users of coated vegetable seeds frequently report poor uniformity of seedling stands. Examination of the variation among replicates of all coated seed tests shows that variation in number of seedlings emerging at a given time is a function of the mean emergence rate (Fig. 2). Seed coatings that slowed emergence the most induced the greatest variation; seedlings from naked seeds exhibited the least. Thus, seed coatings designed to allow maximum emergence rates also should produce the most uniform seedling stands.

Seed coatings made according to the proposed model may be expensive to produce and seed coating machinery may need to be redesigned. However, the data show that seed coating performance may be improved if the physiological requirements of germinating seeds are better understood and coatings are designed to minimize imposed stresses. Further research is needed to assess the field performance of these low stress seed coatings under varying soil moisture, temperature and salinity conditions.

Table 1. Effect of seed coating composition on lettuce seedling emergence.

	Seedling emergence[z] (% of control)	
Seed coating composition[y]	72 hr	Day 9
Naked seeds (control)	100 a	100 a
Vermiculite[x]	6 e	6 d
Verm/28–35 mesh activated C[w]	94 a	100 a
Talc	19 d	69 c
Talc/28–35 mesh activated C[w]	94 a	100 a
Diatomaceous earth[v]	34 c	86 ab
Diatom. earth/28–35 mesh activated C[w]	92 a	97 a
Diatom. earth/60–80 mesh activated C[w]	91 a	97 a
Diatom. earth/80–100 mesh activated C[w]	55 b	86 ab
Diatom. earth/60–80 mesh SiO_2[u]	63 b	89 ab
Diatom. earth/80–100 mesh SiO_2[u]	48 c	85 bc

[z]'Vanguard' lettuce. Mean separation in columns by Duncan's multiple range test, 5% level. Soil moisture content = 22% (about –0.17 bar).

[y]All coatings bound with 10% gum arabic solution.

[x]Industrial grade 4 ground in ball mill 2 hr.

[w]Darco G-60 (20 mesh), crushed, sieved and washed to remove fines. Granular activated C applied as a discrete 0.3–0.5 mm thick layer adjacent to seed and subsequently overcoated with vermiculite, talc or diatomaceous earth.

[v]Celite 503.

[u]Fisher S-151 Silica, sieved and washed to remove fines. Silica applied as was C in footnote w.

Table 2. Effect of seed coating composition and soil moisture content on lettuce seedling emergence.[z]

	Seedling emergence (% of control at 22% moisture)		
	Soil moisture[y]		
Seed coating composition[x]	15%	17%	22%
72 hr emergence			
Naked seeds (control)	61 c	82 b	100 a
Diatomaceous earth	23 d	42 c	27 d
Diatom. earth/60–80 mesh activated C	68 bc	72 bc	91 a
Day 9 total emergence			
Naked seeds (control)	81 c	91 ab	100 a
Diatomaceous earth	84 bc	91 ab	77 d
Diatom. earth/60–80 mesh activated C	91 ab	87 ab	94 a

[z]Mean of 2 independent tests; 'Empire' lettuce; Means separation in columns and rows by Duncan's multiple range test, 5% level.

[y]Indicated soil moisture percentages are approximately equivalent to the following moisture potentials: 15% = –0.50 bar; 17% = –0.33 bar; 22% = –0.17 bar.

[x]See Table 1 footnotes for details.

Literature Cited

1. Bishop, J. C. 1948. Pelleting vegetable seeds. Effect on germination and rate of emergence. Calif. Agr. 2(5):6, 16.
2. Cassidy, H. G. 1957. Fundamentals of chromatography. Interscience Publishers, New York.
3. Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1–42.
4. Millier, W. F. 1971. Progress report on seed pellets. N.Y. Food & Life Sci. 4:13–15.
5. Millier, W. F. and R. F. Bensin. 1974. Tailoring pelleted seed coatings to soil moisture conditions. N. Y. Food & Life Sci. 7:20–23.
6. Millier, W. F. and C. Sooter. 1967. Improving the emergence of pelleted vegetable seeds. Trans. Amer. Soc. Agr. Eng. 10:658–666.
7. Robinson, F. E. and K. S. Mayberry. 1976. Seed coating, precision planting and sprinkler irrigation for optimum stand establishment. Agron. J. 68:694–695.
8. Roos, E. E. and G. S. Jackson. 1976. Testing coated seed: germination and moisture absorption properties. J. Seed Tech. 1:86–95.
9. Roos, E. E. and F. D. Moore, III. 1975. Effect of seed coating on performance of lettuce seeds in greenhouse soil tests. J. Amer. Soc. Hort. Sci.
10. Sharples, G. C. 1978. Interaction of moisture potential and activated carbon on lettuce seed germination. J. Amer. Soc. Hort. Sci. 103:135–137.
11. Sharples, G. C. and J. P. Gentry. 1980. Lettuce emergence from vermiculite seed tablets containing activated carbon and phosphorus. HortScience 15:73–75.
12. Zink, F. W. 1955. Studies with pelleted lettuce seeds. Proc. Amer. Soc. Hort. Sci. 65:335–341.